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Exploring the Maintenance Practices and Strategies in the Libyan Cement Industry

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Doctor of Philosophy (by Research)

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November, 2016

Khalid Albarkoly, November, 2016

Khalid Albarkoly asserts his moral right to be identified as the author of this thesis

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Dedication

This thesis is dedicated to the soul of my father who was dreaming to see me holding my PhD certificate. He encouraged me to be the best I can be. This thesis is as much his as mine. I always ask Allah to forgive all his sins and bless him.

To my great mother has been praying for me to finish my research and be successful in my life. I pray that Allah will prolong her age.

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Abstract

The importance of the cement industry in Libya has been growing over the past few decades. Cement has become one of the fundamental materials for the construction industry, which in Libya matters a great deal to both government and people. This is because more than 97% of the construction industry depends on cement or cement based material such as blocks.

Despite this great demand, the Libyan cement industry has suffered and is still suffering from declining productivity and cannot meet even the local minimum requirements for its products. The main underlying reason is the poor reliability of its production systems as a result of poor or insufficient maintenance. Previous studies indicate that cement manufacturing firms are operating at a rate not exceeding 50% of the total designed capacity. This is due to the lack of strategies to implement maintenance properly, since maintenance is considered one of the main pillars for ensuring the reliability of production system components at the highest level and consequently increasing operational efficiency, which ensures continuity and increases production. Thus, this study explores and addresses the barriers facing the implementation of efficient maintenance in the Libyan cement industry, thereby strengthening the reliability of its production systems by introducing a strategy of Reliability Centred Maintenance (RCM) as an option to improve maintenance within the Libyan cement industry. RCM as an approach identifies components whose failure can cause undesirable consequences and directly affect the continuity of production in a factory or institution. Primarily, a new conceptual model is proposed, which will enable a reliability centred maintenance strategy to be implemented in the four targeted Libyan cement factories. Through this model, the level of current maintenance practices can be understood and examined, facilitating the improvement of production systems and thus increasing their reliability.

In order to improve understanding of this field, a comprehensive review of the literature on the topic of maintenance practices, importance and strategies was made. This study explores the history, types and concepts of maintenance and its relationship to the reliability of production systems in the cement companies studied. A review of the Libyan cement industry was also carried out to understand its situation in more depth regarding their practices of maintenance; it was based on identifying the problems affecting this sector as a precursor to the data collection.

Using both quantitative and qualitative approaches, the data were collected from detailed questionnaires, face-to-face semi-structured interviews and direct observations. A total of four case studies were conducted at four Libyan cement plants, so as to compare results and assess the situation in these factories. Conceptual models were developed in line with the obtained results, aiming to increase the reliability of the production systems through implementing the strategy of reliability centred maintenance in these cement factories.

The results of this study show that the level of maintenance practices in the four chosen cement firms was below the minimum required level. The reason was the poor reliability of the production systems as a result of not adopting effective strategies for maintenance, which was evidenced by their inability to reach the targeted level of production. This research contributes to helping Libyan industry in general and the cement sector in particular, to adopt proper strategies for maintenance through which the maximum reliability of their production systems can be attained, thus ensuring continuity of production.

Keywords: construction industry, Libyan cement industry, maintenance, maintenance strategy, reliability, reliability central maintenance.

Table of Contents

Title page	1
Abstract.....	4
Table of Contents	5
List of figures.....	12
List of tables.....	16
Abbreviations	20
Glossary of Terms	21
CHAPTER 1: Introduction and Background	22
1.1 Introduction to the research.....	22
1.2 General Background.....	22
1.3 The Cement Industry in Libya.....	23
1.4 Factories of Alahlia Cement Company (ACC).....	23
1.5 Research Problem.....	24
1.6 Research Questions	25
1.7 Research Aim and Objectives	25
1.8 Research Methodology	26
1.9 The Research Limitations.....	30
1.10 The Expected Contribution to Scientific Knowledge.....	31
1.11 Research Structure.....	31
Chapter Summary	34
CHAPTER 2: Understanding Maintenance in Depth	35
2.1 Maintenance Overview.....	35
2.1.1 Introduction	35
2.1.2 History of Maintenance	36
2.1.3 Maintenance Definition	37
2.2 Classification of Forms of Maintenance.....	38

2.2.1 Introduction	38
2.2.2 Corrective Maintenance (CM).....	39
2.2.3 Preventive Maintenance (PM).....	41
2.2.4 Total Productive Maintenance (TPM).....	42
2.3 Maintenance Strategies.....	45
2.3.1 Introduction	45
2.3.2 Definition of Maintenance Strategy	47
2.3.3 Classification of Forms of Maintenance Strategies.....	47
2.3.4 Reliability-Centred Maintenance (RCM)	51
2.4 The Importance of Maintenance.....	54
Chapter Summary.....	57
CHAPTER 3: Libya: The Context of the Study.....	58
3.1 Introduction	58
3.2 Geographical Features and Population.....	58
3.3 Historical and Political Background.....	60
3.4 The Social System.....	68
3.5 The Economic system	73
Chapter Summary.....	83
CHAPTER 4: Maintenance practices in the Libyan cement industry	84
4.1 Introduction	84
4.2 Cement industry	84
4.3 The Libyan Industry	87
4.4 The importance of the cement industry in Libya.....	88
4.5 The cement industry in Libya.....	91
4.6 Factories of Alahlia Cement Company (ACC).....	92
4.7 Management issues for the factories of Alahlia Cement Company	93
Chapter Summary.....	100

CHAPTER 5: Research Methodology	101
Introduction	101
5.1 Research philosophy.....	101
5.1.1 Pragmatism as a Research Philosophy	102
5.2 Research Approach.....	103
5.2.1 Quantitative and Qualitative Approaches.....	103
5.2.2 Mixed Methods Research	104
5.2.3 Sequential Explanatory.....	105
5.3 Research strategies	106
5.3.1 Survey Research.....	106
5.3.2 Single Case or Multiple Cases.....	107
5.4 Data Types and Data Collection Methods.....	108
5.4.1 Secondary Data.....	108
5.4.2 Primary Data.....	108
5.5 Data Analysis	120
5.5.1 Quantitative Data Analysis.....	121
5.5.2 Qualitative Data Coding and Analysis	122
5.6 Data Triangulation.....	125
5.7 Ethical Issues	125
Chapter Summary.....	127
CHAPTER 6: The Findings from the Collected Data	128
6.1 Introduction	128
6.2 Quantitative Findings	129
6.2.1 Introduction and Characteristics of the Research Population.....	129
6.2.2 Maintenance Practices	135
6.2.3 Management Related Issues	162
6.3 Interview Findings.....	203

6.3.1 Introduction and Characteristics of the Interviewees	203
6.3.2 Profiles of the targeted firms	205
6.3.3 Participant' Background.....	205
6.3.4 Factory A.....	207
6.3.5 Frequency Analysis	212
6.3.6 Factory B	213
6.3.7 Frequency Analysis	217
6.3.8 Factory C	218
6.3.9 Frequency Analysis	222
6.3.10 Factory D.....	223
6.3.11 Frequency Analysis	227
6.4 Findings from the Observations	228
6.5 Cross-Case Studies Comparison.....	229
6.5.1 Cross-Case Studies Findings	229
6.5.2 Frequency Analysis	235
Chapter Summary	236
CHAPTER 7: Analysis of the Key Findings.....	238
7.1 Introduction	238
7.2 Quantitative Analysis	240
7.2.1 Demographic Information	240
7.2.2 Current Maintenance Practices.....	243
7.2.3 The barriers and obstacles that may have an impact on maintenance	246
7.2.4 The level of managerial performance with regard to maintenance	251
7.3 Qualitative analysis	255
7.3.1 Demographic Information	256
7.3.2 Case A analysis	256
7.3.3 Case B analysis.....	258

7.3.4 Case C analysis.....	260
7.3.5 Case D analysis	263
7.3.6 Cross-case studies comparison	265
Chapter summary	270
CHAPTER 8: Discussion and Model Development	272
Introduction	272
8.1 Current Maintenance Practices.....	272
8.2 The Barriers and Obstacles that may have an Impact on Maintenance	275
8.3 Training	282
8.4 Management Performance.....	285
8.5 Production Line Improvements and their Association with Maintenance Practices	292
8.6 Development of the conceptual model	293
8.6.1 Human Factors	296
8.6.2 Training of the Maintenance Staff.....	296
8.6.3 Staff Motivation	297
8.6.4 Staff Satisfaction	298
8.6.5 Production Environment.....	300
8.6.6 The Three Internal Factors	301
8.6.7 Resource Availability	303
8.6.8 External factors.....	304
Chapter Summary	305
CHAPTER 9: Conclusions and Recommendations for Further Work.....	306
Introduction	306
9.1 Meeting the aim and objectives of the research	306
9.2 Contributions to Knowledge.....	308
9.3 Limitations of the research	311
9.4 Recommendations for further research	312

Chapter Summary	313
References.....	314
Appendices.....	336
Appendix 1: Confirmation Letter	336
Appendix 2: Letter for asking the firms to participate in the research	337
Appendix 3: Data collection letter.....	338
Appendix 4: Participant information leaflet & consent form	339
Appendix 4.1: Participant information	339
Appendix 4.2: Consent form	341
Appendix 5: Survey introduction and questions	342
Appendix 6: Interview questions.....	343
Appendix 7: Observation check sheet	352
Appendix 8: Transcribed interviews	353
Appendix 8.1: Transcribed interview (A – 1)	353
Appendix 8.2: Transcribed interview (A – 2)	357
Appendix 8.3: Transcribed interview (A – 3)	360
Appendix 8.4: Transcribed interview (B – 1).....	363
Appendix 8.5: Transcribed interview (B – 2).....	366
Appendix 8.6: Transcribed interview (B – 3).....	369
Appendix 8.7: Transcribed interview (C – 1).....	372
Appendix 8.8: Transcribed interview (C – 2).....	375
Appendix 8.9: Transcribed interview (C – 3).....	378
Appendix 8.10: Transcribed interview (D – 1)	382
Appendix 8.11: Transcribed interview (D – 2)	385
Appendix 8.12: Transcribed interview (D – 3)	387
Appendix 9: Emerging main themes according to codes and sub-themes	390
Appendix 9.1: Main themes, factory (A – 1).....	390

Appendix 9.2: Main themes, factory (A – 2).....	391
Appendix 9.3: Main themes, factory (A – 3).....	392
Appendix 9.4: Main themes, factory (B – 1).....	393
Appendix 9.5: Main themes, factory (B – 2).....	394
Appendix 9.6: Main themes, factory (B – 3).....	395
Appendix 9.7: Main themes, factory (C – 1).....	396
Appendix 9.8: Main themes, factory (C – 2).....	397
Appendix 9.9: Main themes, factory (C – 3).....	398
Appendix 9.10: Main themes, factory (D – 1).....	399
Appendix 9.11: Main themes, factory (D – 2).....	400
Appendix 9.12: Main themes, factory (D – 3).....	401
Appendix 9.13: Main themes (Total)	402
Appendix 10 Conference Paper.....	403

List of figures

Figure 1.1: Proposed research approach and methodologies implemented in the research (Source author).....	30
Figure 1.2: Research Structure (Source: author).....	33
Figure 2.1: Forms of Maintenance (Source: European Standards, 2009, cited in Lind. and Muyingo, 2012)	39
Figure 2.2: RCM program component (Source: NASA, 2009)	52
Figure 3.1: Map of Libya (Source: BBC, 2014).	58
Figure 3.2: Libya’s regions (Source: BBC, 2012).	59
Figure 3.3: The Libyan Government structure from 1969 to 2010 (Source: author).....	65
Figure 3.4: The rate of population decline in Libya between 2000 and 2012 (Source: Index Mundi, 2013).	69
Figure 3.5: Libyan GDP, Annual Rate of Growth – Percentages, 1971-2012, constant prices (Source: Kushnir, 2013).	79
Figure 4.1: Global cement production from 2000 to 2013 (Source: USGS, 2013).....	86
Figure 4.2: The contribution of non-oil activities to the country’s GDP % (Source: World Fact Book, 2014).	88
Figure 4.3: Cement production quantities in Libya from 1990 to 2010 (Source: Industrial Research Centre (IRC), Libya, 2010, cited in Shibani, 2012).	89
Figure 4.4: Libyan cement factories locations (Source: Edwards, 2013).	91
Figure 4.5: Cement production Process (Source: Author based on Graisa, 2011).....	93
Figure 4.6: The organisational structure of the Lebda Cement Factory (LCF) (Source: RPA, 2006 cited in Graisa, 2011).	94
Figure 5.1: Graphic of the Three Major Research Paradigms, including Subtypes of Mixed Methods Research (Source: Johnson et al., 2007)	106
Figure 5.2: Data Collection and Analysis and processes (Source: Author).....	120
Figure 5.3: Data Triangulation (Source: author).....	125
Figure 6.1: Age Structure of Respondents (Source: author).....	130
Figure 6.2: Educational Level of Respondents (Source: author)	131
Figure 6.3: Maintenance Qualification of Respondents (Source: author).....	132
Figure 6.4: Job Titles of Respondents (Source: author).....	133

Figure 6.5: Years of Experience in the Factory (Source: author)	134
Figure 6.6: Years of Experience in the Field of Maintenance (Source: author)	135
Figure 6.7: Ability to deal with the equipment of the production lines (Source: author)	136
Figure 6.8: Type of Equipment that can be dealt with (Source: author).....	137
Figure 6.9: The Availability of Maintenance and Operation Manuals (Source: author)	138
Figure 6.10: The Stoppage of a Production System due to a Technical Failure (Source: author).....	139
Figure 6.11: Number of Breakdowns in the Production Lines in Production Time (Source: author)	140
Figure 6.12: Number of Breakdowns in the Production Lines in Production Time (Source: author)	141
Figure 6.13: The Percentage of Faults that could be Diagnosed (Source: author).....	142
Figure 6.14: Outsourcing in Doing Maintenance Activities (Source: author)	143
Figure 6.15: Maintenance of Equipment According to a Specific and Known Schedule (Source: author).....	144
Figure 6.16: Maintenance Staff's Knowledge of the Equipment that they are about to Fix (Source: author).....	145
Figure 6.17: Knowledge of Maintenance Strategies (Source: author).....	146
Figure 6.18: The Desire to Learn About Maintenance Strategies (Source: author).....	147
Figure 6.19: Known Maintenance Strategies (Source: author).....	148
Figure 6.20: Application of Any Strategy of Maintenance (Source: author).....	149
Figure 6.21: Reasons for Not Applying Strategies (Source: author)	150
Figure 6.22: Maintenance Strategy Adopted (Source: author)	151
Figure 6.23: Basis for Choosing the Current Strategy (Source: author).....	152
Figure 6.24: The Effectiveness of Current Strategy (Source: author).....	153
Figure 6.25: Problems Encountered in Maintenance Work (Source: author).....	154
Figure 6.26: Clear Understanding of the Importance of Maintenance (Source: author).....	155
Figure 6.27: The Availability of Plans to Develop Maintenance (Source: author).....	156
Figure 6.28: Increase the Amount of Production Through Ensuring the Reliability of Production Lines by Maintenance (Source: author).....	157
Figure 6.29: Knowledge of RCM (Source: author)	158
Figure 6.30: The Need to Apply a Modern Strategy such as RCM (Source: author)	159

Figure 6.31: Previous Attempts to Use a Modern Strategy such as RCM (Source: author).....	160
Figure 6.32: The Availability of a Monitoring System (Source: author).....	161
Figure 6.33: The Availability of Programmes to Calibrate the Monitoring System (Source: author)	162
Figure 6.34: Receive Support from Management when Carrying out Maintenance (Source: author)	163
Figure 6.35: Cooperation between the Departments of Maintenance and Production (Source: author)	164
Figure 6.36: Relationship Between Engineers and Technicians (Source: author).....	165
Figure 6.37: Relationship between Engineers and Managers (Source: author).....	166
Figure 6.38: Relationship between Managers and Technicians (Source: author).....	167
Figure 6. 39: The Accumulation of Maintenance (Source: author).....	168
Figure 6. 40: Adequacy of Staff Numbers (Source: author).....	169
Figure 6.41: Proportion of Qualified Staff (Source: author).....	170
Figure 6.42: Availability of Maintenance Tools (Source: author).....	171
Figure 6.43: Maintenance Tools are Stored Properly (Source: author).....	172
Figure 6.44: The Possibility of Reaching the Maintenance Tools Easily (Source: author).....	173
Figure 6.45: Documentation of Maintenance (Source: author).....	174
Figure 6.46: Methods for Documenting Maintenance Activities (Source: author).....	175
Figure 6.47: Reasons for Not Recording Maintenance Activities (Source: author).....	176
Figure 6.48: The Availability of Programmes to evaluate the Effectiveness of Maintenance (Source: author).....	177
Figure 6.49: The extent of Employee Participation in Decisions-Making (Source: author).....	178
Figure 6. 50: Senior Management Interest in Employees' Suggestions and Opinions (Source: author)	179
Figure 6.51: Maintenance Tasks Redistribution for Better Maintenance Results (Source: author)....	180
Figure 6.52: The Clarity of the Factory's Objectives to Employees (Source: author).....	181
Figure 6.53: The Tasks are Assigned to the Employees are Clear (Source: author).....	182
Figure 6.54: The Existence of Privileged Workers in the Factory (Source: author).....	183
Figure 6.55: Reasons for Privileging (Source: author).....	184

Figure 6.56: Increasing the Efficiency of Production Systems through adopting proper maintenance (Source: author)	185
Figure 6.57: Previous Attendance at Training Courses (Source: author)	186
Figure 6.58: Type of Training Offered by Top Management (Source: author)	187
Figure 6.59: Reasons for the Lack of Training (Source: author)	188
Figure 6.60: The Possibility of Improving the Employee's Skills through Training (Source: author)	189
Figure 6.61: The Salary Meets the Employee's Basic Needs (Source: author).....	190
Figure 6.62: Those who Supplemented their Income by Doing Other Work (Source: author)	191
Figure 6.63: Employees Treated Well by Top Management (Source: author)	192
Figure 6.64: The Salary Includes a Performance Related Incentive (Source: author).....	193
Figure 6.65: Received a Certificate of Appreciation (Source: author)	194
Figure 6.66: The Desire to Move to another Job (Source: author)	195
Figure 6.67: The Existence of Recreational Programmes/Trips (Source: author)	196
Figure 6.68: Received Adequate Care after a Work Accident (Source: author).....	197
Figure 6.69: The Availability of Standards of Security and Safety (Source: author)	198
Figure 6.70: Compliance with security and safety standards (Source: author).....	199
Figure 6.71: The availability of an Emergency System (Source: author).....	200
Figure 6.72: Training received to deal with emergency situations (Source: author)	201
Figure 6.73: Pollutants Measured Properly (Source: author).....	202
Figure 6.74: Waste Disposal in an Environmentally Appropriate Manner (Source: author).....	203
Figure 6.75: Frequency of Analysis in Factory A (Source: author).....	213
Figure 6.76: Frequency Analysis of Factory B (Source: author)	218
Figure 6.77: Frequency Analysis of Factory C (Source: author)	223
Figure 6.78: Frequency Analysis of Factory D (Source: author).....	228
Figure 6.79: Comprehensive Frequency Analysis (Source: author)	236
Figure 8.1: The conceptual model to overcome the problems and barriers to the improvement of maintenance in the targeted cement factories (Source: author).	295

List of tables

Table 2.1: Effect of improvement on profit (Source: World Mining Equipment, 1998 cited in Murthy et al., 2002).	56
Table 3.1: The age structure of the Libyan population from 1950 to 2010 (Source: Population Division, United Nations, 2012).	70
Table 3.2: Industrial Origin of Gross Domestic Product at Factor Cost in 1958 (Source: The International Bank of Reconstruction and Development, 1960, p.371).	74
Table 3.3: Comparison of public and private sector investment, Libya, 1970s to 1997, (in percentages) (Source: Dar al-Jamahiriya lil-Nashr, 1999, p.255 cited in Niblockm, 2002, P.63).	75
Table 3.4: GDP Contribution from Various Libyan Industries from 1962 to 1996 (Source: the Secretary of Planning, 1997, pp. 42-48 cited in Mashat, 2005, p.37-38).	77
Table 3.5: Structure of the Libyan economy as % of GDP 1970-2009 (Source: the General Planning Council cited in Assume et al, 2013, p. 529).	78
Table 3.6: Libyan GDP, Annual Rate of Growth % (Source: UN, 2013).	79
Table 3.7: Libyan GDP, Per Capita GDP in US Dollars in the period 1970 to 2012 (Source: UN, 2013).	80
Table 4.1: Global cement production from 2000 to 2013 (Source: USGS, 2013)	86
Table 5.1: Positivism, interpretivism and pragmatism (Source: Wilson, 2014)	103
Table 5.2: Response Rate in Total and in Each Factory (Source: author)	112
Table 6.1: Age Structure of Respondents (Source: author).	130
Table 6.2: Educational Level of Respondents (Source: author).	131
Table 6.3: Maintenance Qualification of Respondents (Source: author).	132
Table 6.4: Job Titles of the Respondents (Source: author).	133
Table 6.5: Years of Experience in the Factory (Source: author).	134
Table 6.6: Years of Experience in the Field of Maintenance (Source: author).	135
Table 6.7: Dealing with the equipment of the production lines (Source: author).	136
Table 6.8: Type of Equipment that can be dealt with (Source: author).	137
Table 6.9: The Availability of Operation and Maintenance Manuals for the Equipment (Source: author).	138
Table 6.10: The Stoppage of a Production System due to a Technical Failure (Source: author).	139
Table 6.11: Number of Breakdowns in the Production Lines in Production Time (Source: author). ..	140

Table 6.12: Ability to Diagnose a Fault in a Production System (Source: author).....	141
Table 6.13: The Percentage of Faults that could be Determined (Source: author).	142
Table 6.14: Outsourcing in Doing Maintenance Activities (Source: author).	143
Table 6.15: Maintenance of Equipment according to a Specific and Known Schedule (Source: author).	144
Table 6.16: Maintenance Staff Knowledge of the Equipment that they are about to Fix (Source: author).....	145
Table 6.17: Knowledge of Maintenance Strategies (Source: author).	146
Table 6.18: The Desire to Learn About Maintenance Strategies (Source: author).	147
Table 6.19.1: Known Maintenance Strategies (Source: author).	148
Table 6.19.2: Knowing more than one Maintenance Strategy (Source: author).....	148
Table 6.20: Application of Any Strategy of Maintenance (Source: author).	149
Table 6.21: Reasons for Non-Application of Strategies (Source: author).	150
Table 6.22: Maintenance Strategy Adopted (Source: author).....	151
Table 6.23: Basis of chosen the Current Strategy (Source: author).	152
Table 6.24: The Effectiveness of the Current Strategy (Source: author).	153
Table 6.25: Problems Encountered in Maintenance Work (Source: author).	154
Table 6.26: Clear Understanding of the Importance of Maintenance (Source: author).	155
Table 6.27: The Availability of Plans to develop Maintenance (Source: author).	156
Table 6.28: Increasing Production through Ensuring its Reliability by Maintenance (Source: author).	157
Table 6.29: Knowledge of RCM (Source: author).....	158
Table 6.30: The Need to Apply a Modern Strategy Such as RCM (Source: author).	159
Table 6.31: Previous Attempts to Use a Modern Strategy such as RCM (Source: author).	160
Table 6.32: The Availability of a Monitoring System (Source: author).	161
Table 6.33: The Availability of Programmes to Calibrate the Monitoring System (Source: author).	162
Table 6.34: Receive Support from Management when Carrying out Maintenance (Source: author).	163
Table 6.35: Cooperation between the Departments of Maintenance and Production (Source: author).	164

Table 6.36: Relationship Between Engineers and Technicians (Source: author).	165
Table 6.37: Relationship between Engineers and Managers (Source: author).	166
Table 6.38: Relationship between Managers and Technicians (Source: author).	167
Table 6.39: The Accumulation of Maintenance (Source: author).....	168
Table 6.40: Adequacy of Staff Numbers (Source: author).	169
Table 6.41: Proportion of Qualified Staff (Source: author).	170
Table 6.42: Availability of Maintenance Tools (Source: author).	171
Table 6.43: Maintenance Tools are Stored Properly (Source: author).....	172
Table 6.44: The Possibility of Reaching the Maintenance Tools Easily (Source: author).	173
Table 6.45: Documentation of Maintenance (Source: author).....	174
Table 6.46: Method Used in Documenting Maintenance Activities (Source: author).....	175
Table 6.47: Reasons for Not Recording Maintenance Activities (Source: author).....	176
Table 6.48: The Availability of Programmes to evaluate the maintenance effectiveness (Source: author).....	177
Table 6.49: The extent of Employee Participation in Decision-Making about Maintenance (Source: author).....	178
Table 6.50: Senior Management’s Interest in Employees’ Suggestions and Opinions (Source: author).	179
Table 6.51: Maintenance Tasks Redistribution for Better Maintenance Results (Source: author).....	180
Table 6.52: The Clarity of the Factory's Objectives to Employees (Source: author).....	181
Table 6.53: Clarity of the Tasks Assigned to the Employees (Source: author).	182
Table 6.54: The Existence of Privileged Workers in the Factory (Source: author).	183
Table 6.55: Reasons for Privileging (Source: author).....	184
Table 6.56: Increasing the Efficiency of Production Systems through adopting proper maintenance (Source: author).	185
Table 6.57: Previous Attendance at Training Courses (Source: author).....	186
Table 6.58: Type of Training Offered by Top Management (Source: author).	187
Table 6.59: Reasons for the Lack of Training (Source: author).	188
Table 6.60: The Possibility of Improving the Employee’s Skills through Training Programmes (Source: author).	189

Table 6.61: The Salary Meets the Employee's Basic Needs (Source: author).....	190
Table 6.62: Those who Supplemented their Income by Other Work (Source: author).....	191
Table 6.63: Well Treated by Top Management (Source: author).	192
Table 6.64: The Salary Includes a Performance Related Incentive (Source: author).	193
Table 6.65: Received a Certificate of Appreciation (Source: author).....	194
Table 6.66: The Desire to Move to another Position (Source: author).	195
Table 6.67: The Existence of Recreational Programmes/Trips (Source: author).	196
Table 6.68: Received Adequate Care after a Work Accident (Source: author).	197
Table 6.69: The Availability of Standards of Security and Safety (Source: author).	198
Table 6.70: Compliance with the security and safety standards (Source: author).	199
Table 6.71: The availability of Emergency Systems (Source: author).	200
Table 6.72: Training received to deal with emergency situations (Source: author).....	201
Table 6.73: Pollutants Measured Properly (Source: author).....	202
Table 6.74: Waste Disposal in an Environmentally Appropriate Manner (Source: author).	203
Table 6.75: Profiles of the Factories (Source author: based on Alahlia Cement Company, 2013). ...	205
Table 6.76: Background of Interviews Respondents (Source: author).	206
Table 6.77: Frequency Analysis of Factory A (Source: author).	213
Table 6.78: Frequency Analysis of Factory B (Source: author).	218
Table 6.79: Frequency Analysis of Factory C (Source: author).	223
Table 6.80: Frequency Analysis of Factory D (Source: author).	228
Table 6.81: Comprehensive Frequency Analysis (Source: author).	236
Table 7.1: The Relationship Between the Research Questions With Regards to the Main Factors (Source: author)	239
Table 7.2: The Relationship between the Research Questions With Regards to the Developed Themes (Source: author)	255
Table 9.1: The unique obstacles and barriers that affect the practices of maintenance in the four Libyan cement plants (source: author).....	310

Abbreviations

ACC	Alahlia Cement Company
AUCC	Arab Union Contracting Company
CBL	Central Bank of Libya
CIA	Central Intelligence Agency
CM	Corrective Maintenance
GNC	General National Congress
GPC	General People's Committee
GPCO	General People's Congress
GCR	Global Cement Report
GDP	Gross domestic product
HRW	Human Rights Watch
IRC	Industrial Research Centre
IMF	International Monetary Fund
LCF	Lebda Cement Factory
LCI	Libyan construction industry
LCC	Libyan Cement Company
LCI	Libyan Cement Industry
MM	Maintenance management
MCF	Mergeb Cement Factory
NTC	National Transitional Council
PM	Preventive maintenance
PdM	Productive Maintenance
RCM	Reliability Centred Maintenance
SCF	Souq Al-Khamis Cement Factory
TPM	Total productive maintenance
UN	United Nations
UNDP	United Nations Development Programme
ZCF	Zliten Cement Factory

Glossary of Terms

British Standards: standards that focus on quality requirements by coding specifications and practice that cover management and technical subjects of a wide variety of industrial sectors and set by the British Standards Institution.

Corrective Maintenance: maintenance carried out after fault accrued and intended to restore an item into a state in which it can perform as should.

Maintenance Management: a combined of scheduled processes to assessing and planning the managerial, technical and financial framework tasks.

Maintenance Manual: technical instructions show a user the steps of how to operate and maintain an item.

Maintenance Plan: structured and documented group of tasks which include needed activities, resources and determine the required time to carry out maintenance.

Maintenance Strategy: a plan covering all aspects of maintenance management.

Outsourcing Maintenance: the use of external providers' services to finish maintenance activities as a required or in a timely manner.

Planned Maintenance: a set of maintenance activities that pre-prepared.

Preventive Maintenance: a work that carried out at pre-planned intervals in order to reduce the probability of and equipment or a device failure.

Productive Maintenance: enhances equipment to improve quality/output.

Reliability Centred Maintenance: a strategy used to avoid potential failure which could have serious consequence on the production process.

Total Productive Maintenance: is an organised approach to make maintenance processes more effective to increase a production system efficiency.

CHAPTER 1: Introduction and Background

1.1 Introduction to the research

This introductory chapter takes an overview of the research topic. It provides a general background to the research area and the problems, aims, and objectives of the research. It also describes the structure of the present study and its methodology, together with the cement industry in general and that of Libya in particular.

1.2 General Background

The recent immense development in technology has put most of the world's industrial organisations under great pressure, as the chance of survival in both the domestic and global markets becomes increasingly remote. The competitors in the world markets know that they must meet the variable needs of customers by competitive prices and high quality. However, to compete, a firm must never allow production to stop; hence, the components of the production system must be highly reliable, always operating, if possible, at the highest efficiency level. To achieve this, the system components should be regularly maintained throughout the life cycle of the system. In the British Standard collection of maintenance terminology (BS EN 13306, 2001) maintenance is "a combination of all technical, administrative and managerial actions during the lifecycle of an item, intended to retain it in or restore it to, a state in which it can perform the required function". Through maintenance, the availability of the production system can be kept constant and the life of the machinery extended. Conversely, poor or neglected maintenance causes equipment to fail more often thus delaying production or causing defects in the products. The Department of Trade and Industry in the UK conducted a study in 1993 which revealed that the cost to UK industry of poor and dangerous maintenance had reached £1.3 billion a year (Al-Najjar, 2006). This number is so big that more attention must urgently be paid to improving maintenance. Another study, by Moubrey (1997), states that British factories spend about £2 billion annually on equipment maintenance or maintenance related work. This total demonstrates the need to integrate maintenance activities into manufacturing and consider it part of the production process.

On this basis, many industrial enterprises rely heavily on the maintenance function to increase the chance of achieving their goals. If they focus on good maintenance strategies they can maintain their machines at the lowest cost without neglecting the quality of maintenance itself, whether this is reactive, proactive or aggressive; they do so by means of a reliability centred maintenance strategy.

1.3 The Cement Industry in Libya

The cement industry, in general, is one of the most important industries in the world. The demand for cement has been increasing over the past few decades, and it has become, next to water, the most consumed substance (World Business Council for Sustainable Development, 2002 & Tourki, 2010). In 2000 the cement plants around the world produced overall about 1.6 billion metric tonne (bmt) of cement. This number rose to 4bmt in 2013 (USGS, 2014). The main reason for this, as reported by the Portland Cement Association (2008) is that cement is the fundamental material for all types of construction, including housing, roads, schools, hospitals, dams, and ports, which are the indispensable basics of life today. Cement is one of the main components for the construction industry, which in Libya matters a great deal to both government and the people. More than 97% of the construction industry depends on cement or cement-based materials such as blocks (Ngab, 2005). The demand for this material continues to grow: some studies estimate that the consumption of cement in Libya reached 9.6 million metric tonne (Mt) in 2013 (Edwards, 2013). The total is so high because of the reconstruction process all over the country where, for example, in 2013 the new government allocated \$27 billion (£16.b currently) to construction and infrastructure (CemNet.com, 2014).

1.4 Factories of Alahlia Cement Company (ACC)

The ACC is the largest cement producer in Libya, and one of the largest cement companies in North Africa. The company produces Portland cement, gypsum, lime, marble and bags of cement in addition to prepared concrete mixtures. The company is designed to produce 3, 33 Mt/yr of cement and 0.1Mt/yr of gypsum. It is located in the north-west, near to the Libyan capital, and has four cement factories. The first factory was created in 1968, near Alkhumes city, 80 miles east of the capital. It is called the Margeb Cement Factory (MCF). It was designed to have a production capacity of 0.33 Mt/yr. The second

factory, named the Souk Al-Khamis Cement Factory (SCF), lies 25 miles south of Tripoli. This factory was founded in 1977 with a production capacity of about 1Mt/yr. The third plant was built in 1979 near Alkhumes city 90 miles west of Tripoli with a 1Mt/yr production capacity. It is named the Lebda Cement Factory (LCF). The Zliten Cement Factory (ZCF) is the fourth factory, with a production capacity of 1Mt/yr. It located in Zliten city about 103 miles east of the capital and was founded in 1984 (Graisa, 2011 & Alahlia Cement Company, 2013).

1.5 Research Problem

ACC factories suffer from many problems in their production systems. This can be seen in the weak performance of its factories, which operate at an average of 50% of total capacity (Alahlia Cement Company, 2013 & World Report, 2004). Management, technical and financial problems are among the most important issues that have led to a productivity decline in this industry (Alghadafi & Latif, 2010). The origins of these problems can be traced back to the centralised government, which once controlled the company's factories. The shop floor takes its orders directly from senior management (Graisa, 2011), but the government gave the senior management no autonomy. This weakened the administrative structure and therefore undermined performance, with a consequential decline in productivity. Essmui et al. (2013) in their study of 207 Libyan industrial companies found that the performance of more than 83% of them was very weak. The centralisation of power in the hands of government mainly resulted from the traditional social structure of Libya, in which managers and even ordinary employees are recruited on a tribal basis. This resulted in a disregard of specific criteria for the selection of directors as well as the recruitment of incompetent workers. Hokoma et al. (2008) believe that the ACC lacks the expertise of technically trained personnel due to the unsystematic selection of managers. This has led to an insufficient understanding of maintenance in terms of its requirements and conditions, together with the types of strategy that are needed to practise a high standard of maintenance. As a consequence, a maintenance strategy that can be relied upon to ensure the success of maintenance is missing. To remedy this, more attention should be given to maintenance and research into strategies by which the reliability of the production systems can be improved as far as possible. At the same time, programmes should be devised to educate the staff in all factories about maintenance and its role in achieving the

company's goals. As part of this mission, the present study explores the maintenance practices and strategies in the Libyan cement industry and suggestion the strategy reliability centred maintenance strategy (RCM) as one of the solutions by which they can achieve the highest level of reliability of their production systems.

1.6 Research Questions

The continuity of production is often associated with the reliability of the production system which means that the components of this system should be maintained regularly and efficiently. According to Oakland, (2003) the reliability of a production system usually reflects the ability of an industrial organisation to perform satisfactorily over a determined period of time. Ensuring the reliability of the production system through adopting of an effective maintenance is an essential factor since the success of maintenance is the key to reducing failures and increase the performance efficiency of the production system. This study focuses on investigating the maintenance practices and its influence on the reliability of the production system of the Libyan cement industry. Therefore, five research questions have been formulated to be answered in this study which are:

- 1- What maintenance strategy is currently in place in the four cement factories?
- 2- What is the awareness level of the related maintenance staff in terms of maintenance, its practices and its importance?
- 3- What are the barriers and difficulties affecting maintenance within the targeted factories?
- 4- What factors are likely to affect productivity from a maintenance perspective?
- 5- To what extent is the level of adopted maintenance can be effected by the managerial performance?

1.7 Research Aim and Objectives

The aim of this study is to explore the current maintenance practices and propose a new strategy that will raise the level of maintenance efficiency in order to achieve the maintenance objectives of the Libyan cement industry. This mission is considered as a part of increasing the reliability of the production systems as much as possible.

The research aim will be accomplished through attaining the following objectives:

- 1- To explore maintenance and understand its theoretical basis, history, types, strategies and its applications in industry.
- 2- To investigate as a case study the barriers and difficulties affecting maintenance within the factories of Alahlia Cement Company in Libya.
- 3- To investigate the impact of the managerial performance on the level of maintenance practices.
- 4- To study the factors which should be included when improving the current maintenance.
- 5- To develop an appropriate model to improve maintenance for the Libyan cement factories taking into account the possibility of circulating this model to other industries that have the same operating conditions.

1.8 Research Methodology

Research methodology considers the ways of systematically collecting and analysing data using all the possible methods with which a researcher/s can deal with a subject to answer the research questions and thus achieve the research aim and objectives. Research methodology involves research reasoning, research methods, and approaches, the research strategy, the unit/s of analysis and analysis of the data (Collis & Hussey, 2009 & Saunders et al., 2015). Research methodology helps people to increase their knowledge in the research field in a systematic way; therefore it is an essential part of any empirical research (see Aouad, 2013 & Chandler, 2014).

From the above, it is clear that the research methodology has a significant impact on the validity, quality and reliability of the research, as have the selection of the research design. Therefore, it is very important to have a clear and obvious investigation of research methodology. Most of the current literature discusses the methods that should be followed when conducting research so as to make more effective in attaining its goals. Reiter et al. (2011) state that the decision-making processes in the selection of research methods is determined mainly by the research aim, in the sense that the research results should meet the research hypotheses. This requires the researcher/s to study what has already been written in the chosen research field and take particular note of structured data which can be compared with the literature results to validate the study.

According to Saunders et al., (2009) there are two types of research, exploratory and descriptive or explanatory. Descriptive research usually describes phenomena as they exist and therefore tends to look at a specific problem, discover what is happening and learn about the specific characteristics of the problem. Exploratory research is designed to find new insights into phenomena, to ask questions about phenomena and evaluate them in a new light (Panneerselvam, 2004 & Hair et al., 2011).

Equally, research can be classified into basic or pure research and applied research. Pure research results mostly from an academic agenda and is widely undertaken in the universities, where, for example, it increases knowledge in a scientific field. Applied research is usually undertaken by researchers when a particular problem needs to be solved (Saunders et al. (2015).

Research reasoning can take one of two general approaches, namely, deductive and inductive reasoning (Pathirage, et al. 2008). Deductive reasoning is the kind through which theory is tested; it goes from the general to the specific. Inductive reasoning focuses on building a theory and goes from the specific to the general (Saunders et al., 2009). Inductive reasoning concerning on understanding of problems from multiple viewpoints (Yin, 2009). It is a process of developing or building a theory (Hyde, 2000). The inductive reasoning used when a theory emerged from analysing data that related to the research subject and have been collected by a researcher (Saunders et al., 2009). It, therefore, can be said that inductive reasoning is adopted when the research begins with collecting information such as interviews and observations. The nature of the present research is building theory rather than testing of improving an existing theory. Therefore, the logic of this study is mainly inductive.

There are two main schools of thought in the literature on research methodology. According to Williamson (2002), the first is named the positivism philosophy. In this philosophy, researchers attempt to apply research methods used in the natural sciences to the social sciences; the second is called the interpretivism philosophy (sometimes written as 'interpretive'), where researchers emphasise the meanings made by people as they interpret their world. Each philosophy builds on five philosophical assumptions: epistemological, ontological, methodological, axiological and theoretical. James (1909) identified pragmatism as another philosophy of research which is considered as a responsible and logical way to deal with the problems that exist in particular situation instead of relying on ideas and

theories. However, in the social sciences, positivism and interpretivism are usually represented by two sets of research methods respectively, one quantitative and the other qualitative (Easterby et al., 2012). While Johnson and Onwuegbuzie (2004) have described pragmatism as the philosophical dimension for mixed methods research. According to Burns & Grove (2010), the qualitative approach is “a systematic personal approach to describe the experience of life and give it meaning.” The qualitative research adopts methods of generating data which are sensitive to the social context. It usually emphasises words rather than numbers in the collection and analysis of data (Phillips & Pugh, 2000). This approach is used when the intention is to extract the opinions of experts and specialists in the field of research. It uses inductive reasoning to generate ideas or to get them from the data (Thomas, 2003). In contrast, the quantitative approach usually assumes the existence of objective reality. This kind usually focuses on accuracy of measurement through the use of numbers to explain a particular phenomenon and asks particular questions which seem immediately suited to being answered (Thomas, 2003). Quantitative research relies on deductive reasoning which uses the theory of study to develop a hypothesis and then collects and analyses the data through which the hypotheses can be tested (Guindo, 2011). These two approaches could be combining under mixed method to provide a better understanding of the research problem and tackle the research question from any angle. This research is carefully designed in order to meet the time scale of a PhD thesis. Therefore, mixed method is seen as the more suitable approach to collecting data for this research.

There are two ways conduct a case study: single case study which takes all its data from one organisation and multiple case studies in which the data come from two or more organisations. This research adopts multiple case studies because the targeted problem involves four factories, all of which will be examined.

Quantitative data was collected through a survey. The targeted sample of the questionnaire is the shop floor staff includes the engineers, technicians and technicians’ helpers. This survey is designed to collect information, from the point of view of the prospective participants, about the current practices of the maintenance in the four cement firms and related issues such as management Interest regarding maintenance and the attitude of the shop floor workers.

Qualitative data was gathered through face-to-face semi-structured interviews. 12 employees were selected from the four factories includes the managers of maintenance and production departments, and the general supervisors of maintenance and production. Direct observations on the shop floor were adopted as additional input of the data collection.

As mentioned above, both quantitative and qualitative method were adopted to collect the primary dates using questionnaire survey, semi-structured interviews and direct observations. This means that data triangulation used in this research. (Easterby- Smith et al., 2012) stated that triangulation of the collected data usually refers to gathering these data using multiple sources. The main reason behind using data triangulation approach, as explained by Easterby- Smith et al., 2012 and Saunders et al., 2009, is to improve the reliability and validity of the research.

The collected data were analysed using descriptive statistics as a method to summarise and describe the quantitative data which recommended (Saunders et al., 2015) and qualitative data were analysed using thematic analysis method which can provide the systematic processes and methodical (Collis and Hussey, 2009). As a part of the results evaluation in this study, a comparison is made of both quantitative and qualitative with other results from literature review to find the position of the Libyan cement industry. Upon this, a model to overcome any obstacles or difficulties that may hinder the success of maintenance was suggested.

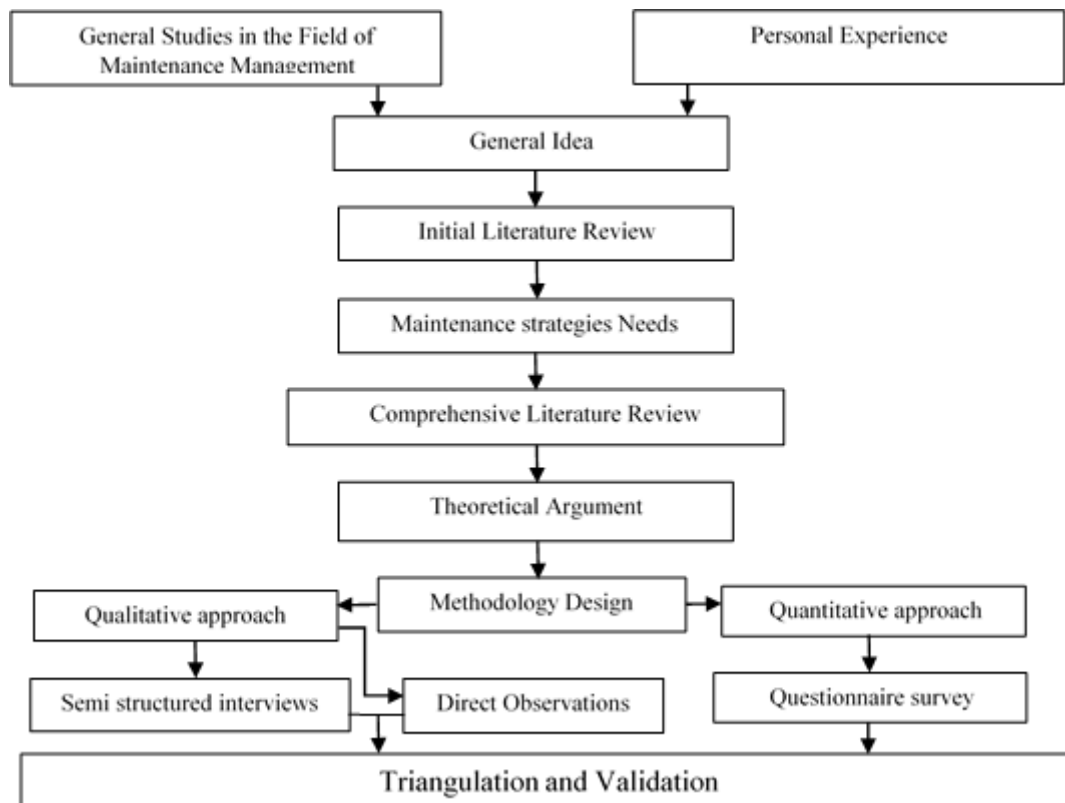


Figure 1.1: Proposed research approach and methodologies implemented in the research (Source author).

The general idea of this research, as shown in figure 1.1, generated from a general study of the field, together with the researcher’s practical experience. This idea was supported by an initial review of the literature. Then the research aim and objectives were defined, based on the need to apply for maintenance strategies in targeted cement factories, and also on initial theories about the possibility of improving maintenance through suggestion in these factories.

1.9 The Research Limitations

This study is limited to the formal and organised documents through which details on maintenance can be obtained to help in evaluating the current maintenance practices. Therefore, these details are collected using other sources such as papers and articles. In addition to that, the lack of effective electronic communication, especially internet facilities which can be represented in emails or social networking such as Facebook, makes the process of obtaining more needed data is extremely difficult. In other words, any missing data cannot be obtained from a distance due to insufficient of these tools.

1.10 The Expected Contribution to Scientific Knowledge

The results of this thesis are expected to be of a great scientific value in the field of engineering management in general and in maintenance management in particular. As this research has taken place in Libya, hence it would promote the development of maintenance programmes in the Libyan cement industry in particular and generally in the Libyan industrial sector, and similarly for developing countries, it will contribute in the following ways:

- 1- It will increase understanding and knowledge in this field by defining the importance of improving maintenance strategies and hence increase the reliability of the production systems of industrial organisations.
- 2- It will assist staff in the maintenance sector (managers and workers) to develop the performance of their organisations through improving maintenance activities.
- 3- The findings of this thesis will allow the shop floor staff of maintenance and production, and their managers in the industrial sector to verify that improving maintenance has a significant positive impact on the reliability of production systems and in turn on increasing productivity.
- 4- The findings of this thesis will give organisational managers a good sense of the importance of improving the maintenance strategy in their plants. This will improve the possibility of being more competitive against other firms, whether local or global.

1.11 Research Structure

This research is divided into nine chapters.

Chapter 1

This chapter, Introduction, presents an outline of the study as a whole. It gives a background to the nature of the research and then moves on to identify the research problem. It also illustrates the aim, objectives, and methodology of the research, in addition to presenting the expected contribution to knowledge, and ends by outlining the structure of the study.

Chapters 2, 3 and 4

These chapters discuss the review of the literature through the available information in the research field. It's started by chapter two, Maintenance Issues in Libyan Cement Industry, which provides a

background on maintenance in terms of its history and definition and then moves into a study of the types and strategies used in the implementation of maintenance. It finally addresses the importance of maintenance in the industry. The third chapter, The Libyan Context. This chapter presents an overview of conditions in Libya and the country's cement industry, providing a contextual background of the geographical, economic and political factors that influence the cement industry in Libya. Maintenance issues in the Libyan cement industry are presented in the chapter four aims to get an overview of the current level of maintenance and its practices in the Libyan cement industry. It's expected that this information would help to overcome any obstacles and problems which might hinder the implementation of maintenance properly.

Chapter 5

In chapter five, research methodology, the methods of collection data are discussed, then a suitable approach of who to collect and analysis the needed data for this research is offered.

Chapter 6

The collected data is separately presented in the chapter six which named Presenting of the Finding of Collected Data. This mission is to get, from the point of view of prospective participants, in-depth the needed information about maintenance and its related issues in the targeted cement factories. This part consists of two sections. The first one presents the findings of quantitative data which representative in the survey questionnaire. The second section illustrates the results obtained through the qualitative data using face to face semi-structured interviews.

Chapter 7

Analysis of the Key Findings is presented in chapter seven. A comprehensive analysis of the collected data, questionnaire and interviews, is the main aim of this part of the research. This is to draw a full and clear picture of the current situation of maintenance and its practices in the four Libyan cement firms. In doing the analysis the literature will be considered in this chapter.

Chapter 8

Discussion part, chapter eight, is an attempts to evaluate the level of practised maintenance and touch in depth any obstacles and/or problems that might hinder the success of maintenance in the four case

studies. The aim of this evaluation is to propose a model based on the results of the comprehensive analysis through which some suggestions and solutions to improve maintenance in these factories will be presented.

Chapter 9

This final chapter consists of the thesis conclusion. It talks about the achieved outcomes and the problems of the study, moreover, this chapter gives suggestions for future research work.

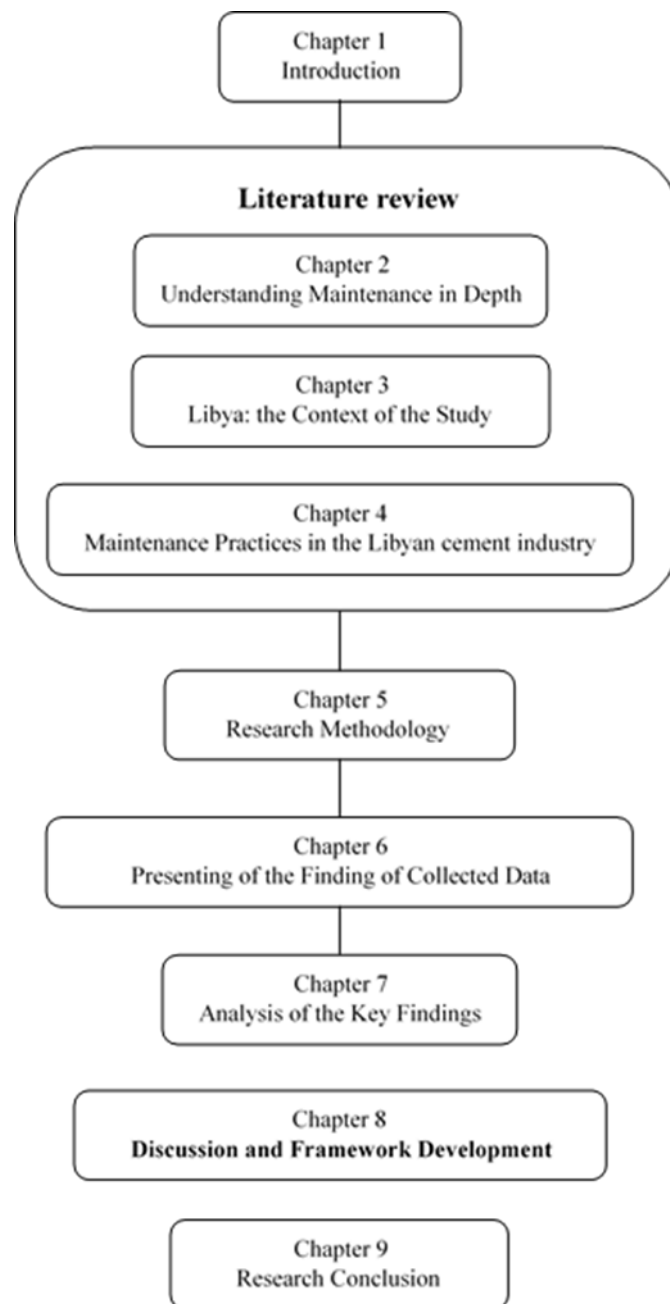


Figure 1.2: Research Structure (Source: author).

Chapter Summary

This introductory chapter has provided an overview of the research. It highlighted the background to the study. The research problem, aim, objectives and five research questions were presented. An induction of the methodology to be adopted has been provided. The chapter ended by highlighting the expected contribution to scientific knowledge and the structure of the research.

CHAPTER 2: Understanding Maintenance in Depth

2.1 Maintenance Overview

2.1.1 Introduction

The recent huge development in technology puts the world's industrial organisations under great pressure, as the chance of survival in both the domestic and global markets becomes increasingly remote. The competition in the world markets has become dependent on meeting the variable needs of customers by competitive prices and high quality.

However, to compete, a firm must never allow production to stop; hence, the components of the production system must be highly reliable, if possible, operating at the highest efficiency level. To achieve this, the system components should be regularly maintained throughout the life cycle of the system. Through maintenance, the availability of the production system can be improved and the life of the machinery extended. Conversely, poor maintenance or none causes equipment to fail more often thus delaying production or defects in the products. The Department of Trade and Industry in the UK conducted a study in 1993 which revealed that the cost to UK industry of poor and dangerous maintenance had reached £1.3 billion a year (Al-Najjar, 2006). This number is so big that more attention must now be paid to improving maintenance. Benjamin (1997) contends that maintenance cost is steadily increasing; it was, for example, £120 million in 1979 and reached £360 million in 1989. This increase demonstrates the need to integrate maintenance activities into manufacturing and consider it part of the production process. Maintenance can be applied in many forms, such as Corrective Maintenance, Preventive Maintenance and total productive maintenance. Through these concepts, the objectives of maintenance can be achieved and in turn the overall goals of the organisation. By embracing them a company can enhance its capacity to deal with the losses previously attributable to poor maintenance, thus improving its competitiveness. This study aims to provide the reader of with a background to the types of maintenance and the practice of it, outlining some of the advantages and disadvantages of the different types.

2.1.2 History of Maintenance

Maintenance is a word derived from the verb ‘to maintain’. Different synonyms are used in different contexts – for example, to maintain good health and to maintain a certain shape. Maintenance has been practised since antiquity; it was a simple task when people merely had to keep their hunting tools sharpen and their cooking pots clean (Telang & Telang, 2010). In the 18th century, as the industrial revolution got under way, great cities appeared and many factories sprang up. Hundreds of thousands of miles of canals, roads and railways were built. This development has led to an increased amount of time being spent on maintenance, which now takes a number of forms (BBC History, 2013).

Before World War II, most machinery was quite rugged and slow to operate. Measurement and control systems were relatively simple. Because production requirements were not very severe, failures of production equipment were not critical and it was sufficient to maintain it on a breakdown basis. In 1950, however, industries were in need of rebuilding. Competition in the market had begun to intensify and the cost of labour had begun to increase, which led to further mechanisation and automation. Production equipment had become lighter and quicker. As a result, the reliability of production systems declined. This led to some manufacturers to recommend that the focus should change to maintaining the components of the production system, for this, some Japanese engineers found a new concept of maintenance called “preventive maintenance” (PM). This trend received encouragement from factory managers, supported by mechanics, electricians and other specialists and was considered a programme of maintenance developed to prevent equipment failure (Hausband 1976 and Al-Muhaisen & Santarisi, 2002). In 1996, in the course of industry’s evolution, a new term of maintenance was developed and named “Productive Maintenance” (PdM). This concept determined a more professional approach, in which everyone connected with maintenance became responsible for design and reliability of the production equipment and the plant itself. After a decade, with the start of the globalisation of the market came a new concept in this field, called “Total Productive Maintenance” (TPM). This term first emerged in the United States but began to be used effectively in Japan and is now current again in the USA. TPM

built mainly on the theory of continuous development. This type seeks the involvement and participation of everyone in the organisation in improving its output (Wireman, 2004).

2.1.3 Maintenance Definition

Maintenance is defined in the Cambridge Dictionary Online (2014) is “activity of keeping a building, vehicle, road, etc. in good condition by checking it regularly and repairing it when necessary”. In the European Standard collection of maintenance terminology (BS EN 13306, 2001), maintenance is “a combination of all technical, administrative and managerial actions during the lifecycle of an item, intended to retain it in or restore it to, a state in which it can perform the required function”. However, many researchers have defined maintenance and its applications in various industrial areas. According to Chanter and Swallow (2008,p20), cited by The Committee on Building Maintenance in 1972, maintenance is “a set of tasks that aims to keep, restore and improve any part of facilities or its services, or its surroundings at the required level and to maintain the facility value during its life cycle”. This definition is very clear and can be applied to many other engineering fields. Ajukumar and Gandhi (2013, p34) say, “Maintenance is a desirable activity in plant operation and it is the most efficient way to retain or restore the system to a desired level of performance”. They add that maintenance should fulfil other requirements such as pollution prevention, personnel safety and waste disposal. In this sense, the various activities of maintenance should involve several sectors within the facility or within the work environment. Others, such as Bhadbury & Shenoy (2003), Stepelberg (2009) and Chen (2012), see maintenance as an ongoing and needed task for the purpose of enabling equipment to operate under required conditions or to restoring equipment which has failed to its original state.

Here it can be summarised that the maintenance of a thing is intended to keep it in good condition during its lifecycle so as to meet its intended purpose. Hence maintenance is, ideally, a method of maintaining or restoring system performance to its intended condition. In a broad sense, maintenance is a mixture of technical and administrative activities and related actions such as safety in order to keep an item in or restore it to the situation that will enable it to implement whatever is required at high

efficiency (Amit, 2010). This is more in line with the aim of maintenance strategy which considers the internal and external environment of the industrial organisation.

However, most definitions usually specify maintenance in two fields, technical and administrative. The first kind is called technical actions and comes under the purview of Maintenance Engineering (ME). The second is called Administrative Actions, which are linked to the actions of management. Both technical and administrative actions come under the heading of Maintenance Management (MM). The most efficient interaction possible between technical and administrative tasks is necessary to achieve the best results (see Telang & Telang, 2010).

MM sets the appropriate maintenance strategies, which is a very important prelude to maintenance actions. It allows managers to formulate the way in which the previous maintenance definitions should be applied within their organisations (Sandy, 1997). On this basis, a maintenance management team is responsible for identifying the strategy of maintenance on the basis of such factors as business strategy, available resources and maintenance cost.

Finally, it may be said that maintenance is organised engineering, a series of technical, administrative and financial activities which guarantees the continuation of the production process thus meeting the organisation's objectives. It can contribute to maximising the value of a facility through helping to produce something which meets customers' needs at an affordable cost in a timely manner.

2.2 Classification of Forms of Maintenance

2.2.1 Introduction

As discussed above, maintenance has gone through various stages. 'Run to failure' used to be the most often practised, meaning that a piece of equipment used to be maintained only when it broke down. Maintenance has been developing since the industrial revolution and appears in many forms. Some writers such as Al-Najjar (1996) and Albert & Tsang (2002) have divided maintenance into three forms: Unplanned (or Breakdown) Maintenance, Planned (or Scheduled or Preventive Maintenance) and Condition Monitoring Based (or Predictive) Maintenance. Others such as Dixit (2007); Artiba & Riane (2005) and Wirman (2004) find four forms of maintenance: Predictive, Corrective, Preventive and Reactive. Figure 2.1 shows how maintenance is divided by European Standards EN 13306.

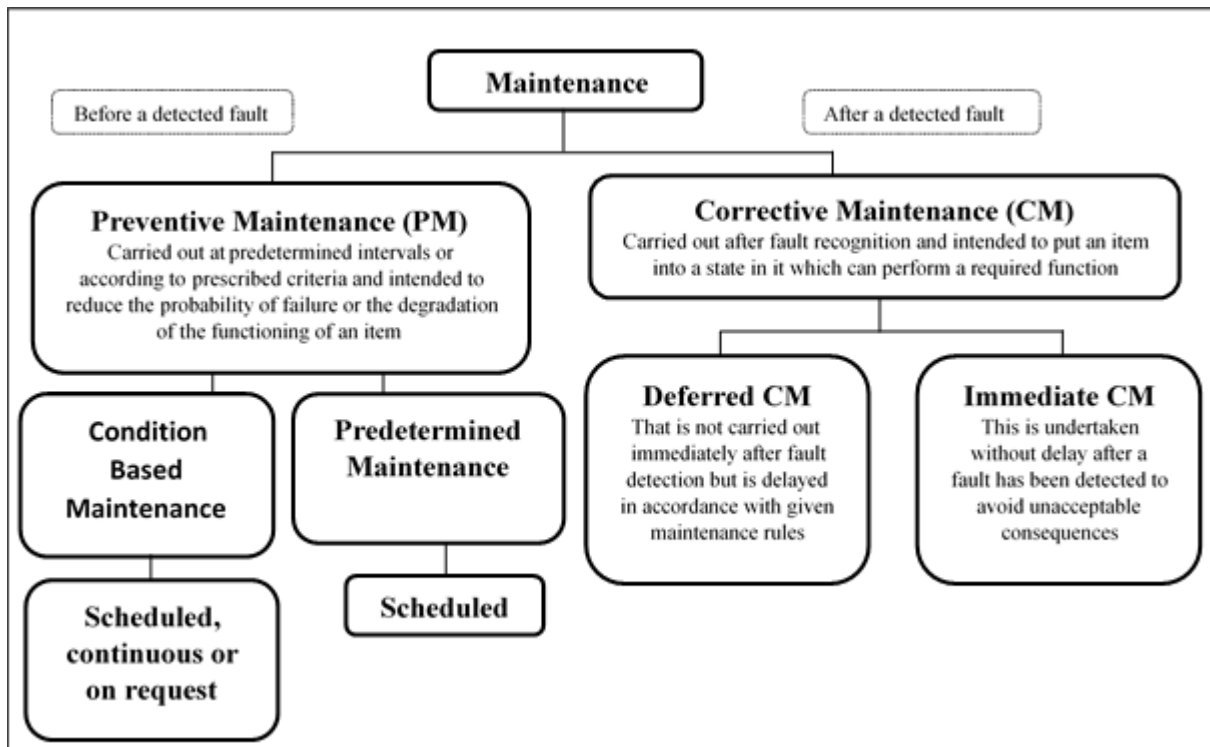


Figure 2.1: Forms of Maintenance (Source: European Standards, 2009, cited in Lind. and Muyingo, 2012).

For the sake of clearer organisation, it would be better to set out the forms of maintenance as follows:

2.2.2 Corrective Maintenance (CM)

Telang & Telang (2010) agree that corrective maintenance is an action which is required to bring a system back to working order when part of it has worn out or failed or been damaged and the system cannot work until this problem has been dealt with. This means that repair work can be done only after the equipment or item stops functioning. Theoretically, the cost of CM is very low because no action is needed until a failure occurs. But the volume of unexpected failure is usually unknown. This being the case, the repair may take a long time, which in turn delays the end of production downtime.

Mays & Tung (2002) define CM as a set of actions taken after a system failure to rectify this failure. Often a quick solution is necessary in order to ensure the continuity of production. Such action is often the most expensive because it may call for extra spare parts or time spent by many workers on it. The process of corrective maintenance, in this case, is a combination of activities that should be done at the same time, such as changing or replacing, cleaning and oiling the parts that caused the failure. In

addition, the time that the maintenance takes and the cost can often not be determined, which is considered a great disadvantage (see Kumar & Suresh, 2012). In contrast, some administrative and economic analysis which has sought to justify the use of this form indicates that since CM can be implemented quickly, it saves more time and cost than other forms do. The reason for this is that other types, such as preventive maintenance, usually requires all the equipment in a system to be closed (Passman, 2003).

Grady (2010) adds that it is better to keep a tabular list (an electronic database, if possible) by the maintenance engineer of the corrective maintenance time allocated for all units included in a maintenance program. He also suggests making an agenda which includes the CM requirements with a report form, where all the data for the equipment should be recorded during maintenance. These data should then be analysed to prevent errors from occurring later. The target is to improve the efficiency of this approach to make it more useable. CM may be defined as a remedial action carried out due to failure or deficiencies discovered during preventive maintenance, to restore an item of equipment to its operational state.

According to Dhillon (2002, p63), CM is “an unscheduled maintenance action, basically composed of unpredictable maintenance needs that cannot be pre-planned or programmed on the basis of occurrence at a particular time”. This action needs an immediate reaction to remedy the failure. Thus it may be said that CM refers to a remedial action which has been taken because of deficiencies identified in equipment.

Because CM is carried out only after an item breaks down, it is easy to see its limitations. Equipment failure necessarily leads to the suspension of production, which is costly for business in most cases. In addition, the cost of replacing the equipment can be very substantial, if the equipment needs to be totally or partly replaced. Moreover, in many cases, it is not easy to recognise the failure and its occurrence at the time because this form is unplanned and this leads to increased production downtime (Resolve, 2007).

From the above definitions it can be deduced that in some situations, sometimes emergencies, corrective maintenance is an urgent action to restore an item to working order when it has unexpectedly broken

down or suddenly failed during operation. CM can be justified in small factories because production downtime there is non-critical and correcting system failure costs less than other forms of maintenance do. It can be effective for items which have a short life and, by avoiding unnecessary repairs, it can also save money.

2.2.3 Preventive Maintenance (PM)

Preventive maintenance has many definitions, most of them moving in the same direction. Smith and Hinchcliffe (2004, p20) define PM well, as “the performance of inspection and/or servicing tasks that have been pre-planned (i.e., scheduled) for accomplishment at a specific point in time to retain the functional capabilities of operating equipment or a system”. One of the characteristics of such maintenance is its pre-planning. This gives maintenance staff the chance to prevent failures and increases the reliability of the equipment, and hence of the whole production system. In contrast, some maintenance is carried out at specific intervals and even when it is not needed. This incurs extra, undesirable cost.

PM is a set of actions carried out at specified predetermined times or according to specific criteria and aims to reduce the likelihood of failure in the equipment or the degradation of its performance (Márquez, 2007). This explanation is in line with the previous definition, but it should be added that the criterion of production has a key role in such maintenance. Preventive (or planned) maintenance is a process performed to repair or replace a piece of equipment before the failure occurs (Lind & Muyingo, 2012). The word ‘planned’ indicates that there is an intention to prevent failure. In other words, this approach assumes the production system components are to be with as good as new.

However, PM has been defined as considering three actions at the same time: repairing, replacing and servicing multi-components, based on availability. This can be applied in all areas of engineering, for example, servicing from the mechanical standpoint includes checking, lubrication and cleaning. Servicing is undertaken to ensure the continuity of machine operation with the desired efficiency. The aim of repairing is to restore a machine from a degraded state to its original condition. It is known as a refurbishing action in the field of maintenance. Replacement means restoring an item of equipment or

of a facility to its original condition by changing one or more of its parts (Tsai et al., 2004). Smith & Hinchcliffe (2004) claim that maintenance costs can be reduced by using such methods. They recommend setting out a plan before starting maintenance such as determining the time it should take and define the responsibilities and tasks for technicians as well as the spare parts and tools required for completion maintenance. All these procedures are placed in a scheduled report, for use when needed (for example, when carrying out the next maintenance or for reviewing the problems which have already appeared). In fact, this type is more costly than CM because it requires all the components of a system to undergo maintenance, even those in good condition, which means money spent unnecessarily.

According to Castro and Lewis (2012, p177), “PM is a simple or minor preservation operation for the replacement of standard parts not involving complex assembly operations”. From the standpoint of an engineering overview, preventive maintenance should be under administrative control to keep maintenance applicable and inexpensive. This means that communication between departments should be at a high level.

The purpose of preventive maintenance is to maintain the system's operational efficiency at a high level while it is functioning. On this basis, it can be said that preventive maintenance is a subjection of production equipment to maintenance at specified times, regardless of its condition. It starts with disclosure and then changes the parts which are supposed to be corrupted or eroded even if they are still in good condition. In this type the reliability of the production system can increase and hence production may increase. Ongoing maintenance can also increase the lifespan of the components. However, it needs skilled training and catastrophic failures are still likely to occur because of the need to keep the equipment operating continuously.

2.2.4 Total Productive Maintenance (TPM)

The great advances in the industry over the past few decades have led to an increased focus on developing the concepts of traditional maintenance, such as preventive and predictive maintenance. The purpose of this was to increase productivity and enhance the reliability of production systems through discovering alternatives to the traditional concepts (Robinson & Ginder, 1995; Garg & Deshmukh,

2006; Sharma et al., 2006; Ahuja and Khamba, 2008). The main aim of TPM is to reduce the number of breakdowns and enhance the equipment effectiveness (Kigsirisin et al., 2016)

Hansson et al. (2003) state that the quality of applied maintenance very important, due to its impact on the efficiency of the equipment in performance, and thus on the quality of the final product.

On this basis, Total Productive Maintenance appeared as a new concept of maintenance.

TPM is a development of the PM program. It was used for the first time in Japan in the 1970s by Nippondenso Co., Ltd. of the Toyota group. Seiichi Nakajima, an expert in the Japanese Institute of Plant Maintenance (JIPM), describes TPM as the participation in maintenance of everyone through a small team combining the concept of maintenance with that of production. This approach was adopted by the JIPM as a form of advanced Productive Maintenance (Robinson & Ginder, 1995) which includes all aspects of the organisation.

The Japan Institute of Plant Maintenance suggests eight pillars of TPM, as follows:

Planned Maintenance, Early Equipment Management, Autonomous Maintenance, Overall Equipment Effectiveness, Quality Maintenance, Safety and Health, Environment and Office team. These pillars substantially increase labour productivity through controlled maintenance, reducing production system downtimes and maintenance costs (Aspinwall & Elgharib, 2013).

TPM has been defined by many experts and specialists. For example, Almeanazel (2010) cites Edward Willmott, the managing director of the Willmott Consulting Group, who has been pioneered TPM in the UK. He defines TPM (1994) as follows: “TPM seeks to engender a company-wide approach towards achieving a standard of performance in manufacturing, in terms of the overall effectiveness of equipment, machines and processes, which is truly world class”. He builds this definition on his study of the Japanese examples of TPM and sees it is more suited to Western manufacturing. Smith & Mobley (2011) define TPM as a companywide equipment maintenance system involving all employees, from top management to production line workers and building custodians. They see that TPM leads to total equipment effectiveness in pursuit of profitability. The total maintenance system includes maintenance prevention, maintainability and total participation.

Shirose & Kyokai (1995, p2) give a very good definition of Total Productive Maintenance that “TPM is the activities aimed at (a) eliminating breakdowns, defects, and all other equipment losses, (b) gradually increasing equipment effectiveness, (c) improving company profits, and (d) creating a satisfying workplace environment”. This definition simply but clearly defines the aims that can be achieved by implementing TPM. But it does not indicate how this approach can be applied to achieve the above aims. TPM can be defined as an approach to creating a partnership between maintenance and production in order to improve product quality and reduce waste and maintenance cost, in addition to increasing the availability of the production system (Ahmed, et al., 2005).

TPM as a philosophy means a comprehensive management maintenance programme of items designed to integrate all maintenance activities and turn them into manufacturing actions. All employees should participate in maintenance. For example, the production department gives an order to operate a machine. If a problem occurs before, during or after the operation, the operator has to inform the maintenance department which is obliged to take the necessary action to restore the machine to operation status. This procedure is coordinated between the Operation and Maintenance Department and top management. The main task of the top management is to define everyone’s responsibilities in line with the working conditions (Terry, 1992).

Clearly, the application of TPM would lead in the long term to improved production systems and would contribute to the overall improvement of the facility, for example, improved reliability, quality and productivity and reduced expense. This would enhance the competitiveness of the organisation (Fang, 2000; Ahuja & Khamba, 2007; Bamber et al., 2003; Arca & Prado, 2008).

Yet integrating maintenance and production is not easy, because the relationship between them is conflict- filled, according to Weinstein & Chung (1999). This is confirmed by Baglee & Michael (2010) and Ahmed et al., (2004), who consider that the implementation of TPM is a major challenge, for medium and small companies in particular if they are still applying a reactive maintenance concept. In addition, it is a challenge for some countries, such as certain developing countries which misunderstand the concept and applications of maintenance. Fang (2000) and Ireland & Dale (2001) believe that the

process of implementing TPM is an arduous journey and not all organisations can implement it successfully.

The above suggests that Total Productive Maintenance is an integrated programme which allows all to highlight their skills through their participation in maintenance. In other words, everyone should be responsible for maintaining production equipment. This leads to the creation of competition between all the relevant workers and thus achieves the goals of maintenance.

From the above, it can be concluded that maintenance has passed through various stages of evolution, from Reactive Maintenance and Corrective Maintenance (CM) to Preventive Maintenance (PM) and finally to Total Productive Maintenance (TPM). Understanding these stages could play a major role in the success of maintenance. It can save money by reducing the amount spent on maintenance activities if they are properly done. High-quality products which can compete in the market can also be assured. Companies which seek to enter a competitive market should consider maintenance as part of the production requirements which can earn them profit.

2.3 Maintenance Strategies

2.3.1 Introduction

Maintenance, to achieve its desired objectives, such as reduced cost, increased reliability and an ensured quality of output, must be well organised. In other words, well-chosen maintenance – i.e. successful maintenance – will achieve these objectives. It cannot be made without a maintenance strategy, which is a guide for undertaking maintenance. According to Bashiri, al., (2011), competitiveness between manufacturing systems has increased due to the rapid changes in the manufacturing environment. Many industrial companies have been investing a good deal of money in improving their performance, thus raising product quality and reducing cost, in an effort to be world class companies. But this effort can be affected by many problems to do with equipment and building location, for example, or the type of maintenance strategy used and of manufacturing technology chosen. Maintenance programmes, as a system, can play a big role in meeting the organisation's objectives, such as raising product quality and reducing price and delivery time, by making maintenance or new equipment cheaper or minimising

equipment downtime. Therefore, manufacturing expenditure can be controlled by choosing the best maintenance strategy.

Cooke (2003) in his study of some UK firms cites evidence for this. In the GLASSUK Company, about 32% of working hours were spent on plant maintenance work, 41% on repair/improvement requests, 12% on emergency work and 15% on project work. The proportion of time spent on repair/improvement requests, which may be considered very high, is evidently due to a backlog of work, attributable to the lack or poor quality of the company's maintenance strategy. Most of the maintenance activities were planned by managers on the basis of their experience only. This suggests that if there had been a specific and clear maintenance strategy for all the employees who were involved in maintenance work, it would have been more successful and would have achieved the company's goals. The main purpose of the strategy is to give those involved some sense of direction in approaching the desired objectives.

The term strategy is derived from the Greek word "strategos" which means "generalship" or the "The General's Way". This concept was used in the military context and transferred to the business field in the 1960s (Sloman, 1999 & Robson et al., 2013). Howard & Howard (1962) explain that Liddell Hart presented a simple definition of Strategy, which he then paraphrases: "The art of distributing and applying military means to fulfil the ends of policy". They go on to say that; the experience of the past century, when the concept of "grand strategy" was introduced into Western countries in order to refer to political, financial, industrial and social aspects of war, which became very prominent in the twentieth century. They have shown the inadequacy of this definition. Robson et al. (2013) found in his studies centring on a strategy that there is still considerable debate about how strategy is formed; he points out that, while some authors think the strategy is developed deliberately, others, in contrast, see everything as the result of chance. The first opinion has prevailed, since strategy requiring planning, goals and objectives, has been shown to succeed.

On this basis, he concludes that building successful strategies depends on knowledge and on the internal and external factors of an organisation, such as its political, economic, environmental and financial circumstances (Robson et al., 2013).

2.3.2 Definition of Maintenance Strategy

According to European Standards (EN13306: 2001), maintenance strategy is a “management method used in order to achieve the maintenance objectives”. This definition gives a clear indication of the importance of management in the success of a maintenance strategy since this requires many things to be considered, such as the most suitable type of maintenance, workforce, time and place for achieving the objectives of this activity.

This is what Alsyuof (2007) clarifies, remarking that maintenance strategies mainly depend on a set of organised processes, such as search and selection, before decisions are implemented. These processes must take into account a combination of factors such as the work environment, the nature of production, product quality level and production quantity, in addition to what is being targeted in maintenance. As evidence of this studies conducted in the UK for over 20 years have shown the need to implementation maintenance policies in better ways. This is shown by the £20 billion per year spent on maintaining production systems in the industrial organisations of the UK (Baglee & Knowles, 2013).

Moubray (1970) realised that the right selection of strategy to develop a good maintenance strategy depends on identifying a company’s maintenance requirements for all its assets in the context of its operation.

2.3.3 Classification of Forms of Maintenance Strategies

Kans & Ingwald (2008) uses EN13306: 2001 in a maintenance overview to classify maintenance strategies as Reactive, Predictive or Preventive. Predictive and Preventive are both varieties of Proactive Maintenance Strategy, reflecting the level of progress made in the field of maintenance and also associated with the great development in technology during the past few decades. He describes these subsets of strategy as follows:

Reactive Maintenance Strategy is carried out after a failure occurs. This means that this strategy cannot be planned and is, therefore, more costly, requiring spare parts and workforce to be available at any time. Hence, this strategy is not considered a good option for large and medium-sized industrial organisations which want to achieve the highest level of reliability for their production systems.

Because no special data are required for this strategy, there is no need to develop a maintenance management system.

Predictive Strategy, called by some “Condition-Based Maintenance”, is based on the prediction of failure before it happens, depending on the degree of deterioration in the equipment. Jonge et al. (2016) summarised that this strategy is well scheduled approach for maintenance. It monitors the status of this component using advanced techniques and technology. It must, of course, update the taken data continuously during the period of the equipment’s operation in order to ensure effective monitoring. One of the advantages of this strategy is the possibility of obtaining more information about the condition of the components, making it more accessible and flexible than compared with Reactive Maintenance. But it is also considered more expensive because it requires advanced techniques of monitoring, in addition to skilled workers who will deal with the monitoring devices (Kans & Ingwald, 2008).

Ömür & Orhan (2009) summarise what Swanson (2001) and Bateman, J. (1995) have found in this regard; they call the three subsets of maintenance strategy Reactive, Proactive and Aggressive Strategy.

Reactive Strategy works by letting a component operate until it fails and then repairing it. Occasionally this strategy fails with serious consequences; in many times it causes collateral damage to other components. This increases the cost of maintenance and, thus gives less chance to save money.

Proactive Strategy divides into the Predictive and Preventive types, which help to avoid equipment breakdowns before they can happen.

Preventive Maintenance (PM) aims to reduce or eliminate the accumulated deterioration by carrying out regular maintenance activities of equipment at pre-selected times. This increases the reliability of equipment or production systems. Ömür & Orhan (2009) divides Preventive Maintenance into two types, namely, Condition Based and Time-Based Preventive Maintenance. In the former, the action depends on the condition of the system and is usually taken after each inspection. The latter brings the equipment or production system back to its original state and is carried out at pre-set times.

Preventive Maintenance has many advantages, such as extending the useful life of a production system by reducing the incidence of failure or breakdown of the system components, ensuring a safe workplace for staff and improving the product quality by increasing the efficiency of the production system.

Predictive Maintenance, otherwise known as “Condition-Based Maintenance”, uses monitoring techniques to determine the condition of the equipment status during its operation time, for instance, measuring temperature, noise level, vibration and corrosion. Maintenance action is undertaken to restore a component to its original condition when one of these indicators reaches a specified level. In this case, the equipment or system is allowed to run until clear evidence shows that it has begun to deteriorate.

Total Productive Maintenance (TPM) is included under Aggressive Strategy; by using TPM, system performance can be improved while continuing to avoid system breakdowns (Ömür & Orhan, 2009).

Swanson (2001) describes the three types of maintenance strategies well: Reactive maintenance, he says, is carried out only after equipment fails; the approach here may be described as a kind of fire-fighting. In other words, the problem is solved only after it occurs. Using this type, quick or impermanent maintenance can be carried out to restore the operation of the system, leaving permanent repairs for a later date. With this strategy, both manpower and spending on overall maintenance can be reduced. However, it cannot predict the time when failure will occur time and thus production capacity fluctuates, causing either a stoppage in production or defective products. In addition, it is possible for a major failure to increase the cost of maintaining the equipment itself. This strategy is more appropriate and feasible for small facilities, because it cannot succeed where production quantities are large, and the losses in case of failure will usually be small. With proactive strategy, the rate of deterioration in equipment is monitored and minor repairs are enough to restore the equipment to the required condition before any failure can occur. This method demands the ability to predict failure before it happens, thus reducing the possibility that the equipment will collapse unexpectedly.

Preventive Maintenance, sometimes called “Use-Based Maintenance”, requires regular and well-known intervals of time and depends on the probability of that failure will occur within a specific time-frame. The kind of work that this covers is lubricating, replacing parts, cleaning, adjusting or calibrating and

it does not need to stop the production process. Its purpose is to extend the life of the equipment and thus of the system as a whole; moreover, it avoids unexpected failure, which is usually costly.

Predictive Maintenance, otherwise called Condition-Based Maintenance, measures the physical condition of the production equipment using diagnostic tools such as vibration, corrosion, noise and heat. When one of the monitoring indicators reaches a specified level. The purpose of Predictive Maintenance is to bring back the equipment to the required condition. In this case, the production system will be stopped only when a problem with one of the system component is clearly indicated; thus, like Preventive Maintenance, it reduces the likelihood of faults. It has the added feature that the maintenance process is set in motion only when there is a need for it. Although Predictive and Preventive Maintenance follows different criteria in determining the need for maintenance, both are based on the same principle which is to maintain the system before it fails.

Ultimately it can be inferred that Proactive Strategy is effective in large facilities, in that it suits continuous production and ensures consistent output quality where the costs of failure are frequently very high, i.e. when an organisation has a complex production system. In addition, such companies are often bound by contracts with clients who require on-time delivery and specific quality. Thus, any failure will affect the organisation in two ways: the maintenance cost itself and the costs of delayed production.

Aggressive Strategy is part of TPM and adopts the principle of improving the overall efficiency of the system through all employees joining together to pre-empt failure and improve the availability of the system. TPM may be considered a philosophy of maintenance management which depends on the establishment of a cooperative relationship between production and maintenance and through which maintenance work is performed. Here the TPM team involves a range of different staff working in maintenance, production and management. Any team which is involved in carrying out maintenance work can play a role in the monitoring and maintaining of equipment. This could motivate everyone and make them all more effective in doing their work. The effectiveness of this system is usually high because the expertise of the maintenance workers and the technical skill of the engineers and system operators are gathered together in the same team. A team can improve the ways in which maintenance

can be performed through considering the full range of solutions which can be used as needed. Using this strategy can even reduce maintenance costs and increase equipment efficiency, thus improving the availability of the production system (Swanson, 2001).

2.3.4 Reliability-Centred Maintenance (RCM)

The need to improve the reliability of assets (production systems) and promote uptime and availability has become one of the most important factors in the growing importance of improving maintenance; in addition, increasing maintenance costs is considered one of the most important reasons for seeking more effective ways of maintaining production assets. Although many people believe that maintaining more than one item of equipment at once makes the production system more reliable, often the opposite happens because maintenance work accumulates and consequently maintenance is inadequate. From this has emerged the need for using more sophisticated strategies such as Reliability Centred Maintenance (RCM).

RCM is a technique to develop Preventive Maintenance; it emerged in the 1960s in the aircraft industry as a substitute for PM. It depends on the theory of preventing potential failure which could have serious consequences and originated in response to the large increase in maintenance costs after wide-body jets were brought into service, which made the aviation industry uneconomical. After this, RCM moved to the armed forces and was then considered by the nuclear energy sector and later used in the offshore oil and gas industry. When experience showed that RCM could make very significant savings in maintenance costs and ensure the availability of production systems, many other industries started to apply it (Rausand, 1998; IAEA report, 2007 & NASA, 2008).

Airlines, for example, noticed that the availability and reliability of their planes improved with the application of every effort on RCM, given that failure could cause serious problems.

RCM was structured to balance benefits with costs, remembering that it can never prevent all failures, as Preventive Maintenance aims to do. Therefore the potential consequences of each failure had to be identified and the probability of failure estimated. Accordingly, Rausand (1998) summarises the

concept of RCM as an improved programme of PM which, to be applicable, requires answers to the following questions:

1. What are the functions and associated performance standards of the equipment in its present operating context?
2. In what ways does it fail to fulfil its functions?
3. What is the cause of each functional failure?
4. What happens when each failure occurs?
5. In what way does each failure matter?
6. What can be done to prevent each failure?
7. What should be done if a suitable preventive task cannot be found?

According to NASA (2008), all the other strategies such as Preventive, Proactive and Reactive Strategy are integrated optimally in RCM, with their respective advantages, in order to achieve the highest level of equipment reliability and thus that of the whole facility component. In addition, it reduced the cost of the equipment’s lifecycle, by reducing spending on unnecessary maintenance programmes. The following figure, Figure 2.2, shows how these strategies work under the heading of RCM.

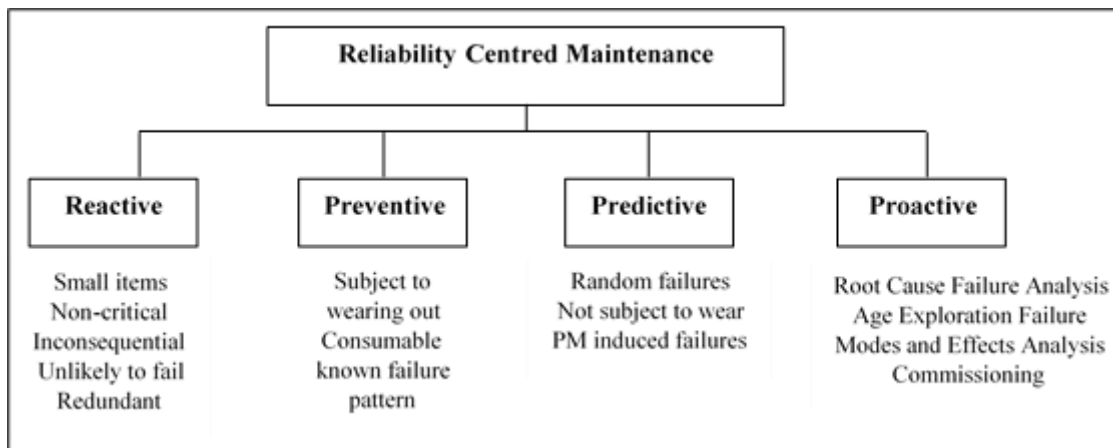


Figure 2.2: RCM program component (Source: NASA, 2009).

The ABS report, (2004) has given a definition of RCM as follows: it is “a process of systematically analysing an engineered system to understand:

- I) Its functions.
- II) The failure modes of its equipment that support these functions.

- III) How then to choose an optimal course of maintenance to prevent the failure modes from occurring or to detect the failure mode before a failure occurs.
- IV) How to determine spare holding requirements.
- V) How to periodically refine and modify existing maintenance over time.”

Holmberg (2010) has given another definition of Reliability Centred Maintenance: that it is a disciplined and highly structured approach to ensure a high level of performance and safety of assets. Furthermore, they point out that RCM follows a very strict framework to determine the probability of failure in any item of equipment. In this way, this method is a new style of thinking, meant to avoid the consequences of failure, rather than avoiding failure itself. They continue that RCM combines all other strategies, such as the proactive, reactive and aggressive strategies, which achieve reliability at the lowest cost. The disadvantage of this strategy is that it is not easy to obtain adequate data on the equipment because it is maintained before it fails and in addition, reliability is sometimes not considered the primary focus of an organisation.

Given the foregoing definitions and descriptions of the RCM concept which are very similar, due to its huge success among many industrial concerns, it is clear that RCM can be seen as a modern and developed theory of maintenance because it requires an organised maintenance programme. Such programmes are usually based on the sequence of needs for equipment maintenance according to their importance. RCM also organises the available human and financial resources according to the importance of the equipment, that is, according to the losses or risks that could result from its failure. Therefore, this strategy is used to obtain greater efficiency by improving the reliability of the equipment. Although many people believe that maintaining more than one item of equipment at a time means that the production system will be more reliable, the opposite often happens because of maintenance failure as a result of the accumulation of maintenance tasks.

2.4 The Importance of Maintenance

Many industrial organisations are now under great pressure because of the huge advances in technology which have led to fierce competition, whether local or global. Customer needs vary, while working conditions are constantly changing and the possibility of controlling prices and need to maintain output quality require high levels of performance from the production system. This has led to a more intense spotlight on maintenance strategies as key to ensuring the highest efficiency of the production system. According to the British standard Institution (2001) maintenance is “the combination of all technical, administrative and managerial actions during the lifecycle of an item intended to retain it in, or restore it to a state in which it can perform the required function”. Through this definition it is clear that the tasks involved in the production process, such as the operational requirements, the quality requirements, associated administrative processes and work environment are interdependent and that the importance of maintenance over time has increased. Obamwonyi & Gregory (2010) similarly point out that the importance of maintenance continues to grow because of its influence over areas of work involved in the production, such as the production rate, quality of products or services and system availability, which can directly affect the performance of the organisation. Benjamin (1997) believes that, with the introduction of new technology, production systems in general are becoming more complex, which has increased the operating costs of these systems. This means that not only has the importance of maintenance costs themselves increased, but so has the importance of maintaining the production system to meet production requirements. In other words, they believe that maintaining the availability of production systems is necessary but increasingly expensive; it can be reinstated by giving more attention to maintenance programmes. Cecille & Gunaskeran (1998) endorse this, emphasising that the importance of maintenance lies in its ensuring the effective functioning of business enterprises. Their evidence is the increasing reliance of most business organisations on modern technology. Moreover, they point out those improving maintenance strategies aims to enable these facilities to provide products or services of high quality and reliability. Hence, it is fair to say that maintenance has become one of the most important functions to be addressed in the life of an organisation. Selecting the ideal maintenance strategies adds value to the production activities that can be undertaken.

Bamber et al. (2000) find through their review of expert studies that companies in the UK can only remain competitive if they are of top quality. They can keep up their standards simply by adopting a policy of continuously improved performance from their production systems, but this means that industrial organisations must support every effort to become more competitive on a solid basis in order to maintain the level of performance at its highest point. Thus production systems must be run with the greatest possible efficiency, maintaining in turn every part of the system at the required level of performance. The key to achieving is, of course, a more intense focus on maintenance programmes. Bamber et al., (1999) and Al-Najar (1996), for their part, approach the importance of maintenance by reflecting that if the desired product is the most important output of the production process, the need for maintenance can be considered the secondary output. This is because maintenance ensures the continuity of productivity through an optimum operation of the production system. They see maintenance itself as one of the product inputs, which greatly support productive capacity. On this basis, the importance of maintenance lies in its impact on production, since good maintenance can raise the production capacity and enable management to control the quantity and quality of products. This approach does much to clarify the value of maintenance; and it is better to present it as a basic function of the company which supports the production process and helps to attain the company's objectives.

Although many writers find the importance of maintenance in its impact on the working environment, starting from inputs and ending with products, some researchers approach the importance of maintenance from the standpoint of maintenance costs themselves. For instance, Venkataraman (2007) believes that the significant increase in maintenance costs imposed on firms by senior management are justified, in that paying more attention to maintenance programmes can maintain assets such as equipment, buildings and so on. He considers that the importance of maintenance recognition started to grow about 20 years ago, as one of the core concerns in the success of any industrial organisation. Maintenance costs have continued to rise because most industrial companies in every country have failed to define the role of maintenance in their business organisations. Spending on maintenance is treated as a percentage of earnings, increasing or decreasing like any other line of the company's budget. But in fact, the direct costs of maintenance can be determined and controlled if the administration

focuses on it more attentively. He also points out that maintenance costs in one of the companies in his study amounted to 40% of its total expenditure (excluding direct materials). Such a figure confirms the possibility of savings through organised maintenance, but this should be run as a business in its own right.

For one thing, it is mistaken to suppose that recognising the importance of maintenance gives firms a chance to save money by reducing their spending on this work. The savings come from improving product quality and increasing productivity through the optimum operation of production systems which cannot run efficiently unless they are properly maintained. Some international studies show that 15% to 40% of the value added by firms can result from improving maintenance. This suggests that great improvements in the organisation (in output) can be achieved by any improvement in maintenance activities (Juan & Adolfo, 2012). The table below 2.1 shows how much benefit accrues from a small improvement in maintenance.

Table 2.1: Effect of improvement on profit (Source: World Mining Equipment, 1998 cited in Murthy et al., 2002).

Improvement (1% area)	Effect on Profit (%)
Productivity	3.0
Availability	3.0
Reduced operating costs	0.5-3.5
Reduced interest rates	0.7-1.2
Product price increase	0.5-0.9

It can be concluded, therefore, that maintenance has greater importance than is often thought, because of its major role in achieving a company's objectives, which are usually to maintain its assets by getting more reliable and available equipment and to provide high-quality outputs, whether services or products. It can also help to keep a company competitive by increasing the operational efficiency of its production systems; proper maintenance can save money by reducing the amount spent on maintenance activities. The importance of maintenance can be summarised in the following points:

- 1- The possibility of maximising the benefits from the fixed assets of an organisation.
- 2- Extended life for its production system.
- 3- Reduction in its maintenance costs.
- 4- Guaranteed quality in its output.

Chapter Summary

The history of maintenance and its major definitions of maintenance have been discussed in this chapter. This chapter highlighted the classification of forms of maintenance including corrective, preventive Maintenance and total productive maintenance. The strategies of maintenance also have been discussed. This chapter provides a wide review about the reliability-centred m as it the proposed approach to be implemented in the Libyan cement factories. The Importance of Maintenance has been focused on by the end of this chapter. The following chapter is concerned the Libyan context in which this research fieldwork takes place.

CHAPTER 3: Libya: The Context of the Study

3.1 Introduction

To address issues and problems that related to maintenance within the Libyan cement industry, it is very important to review and understand the general background of the country. This is because these issues cannot be studied in isolation from the surrounding environment and geographical, political, social and economic aspects. Understanding these aspects may help in determining and explaining the factors that affect the practice of maintenance in the Libyan cement industry and therefore the possibility to overcome.

3.2 Geographical Features and Population

Libya is a developing country in North Africa extends over 1,759,540 square km and a Mediterranean coastline of nearly 1800 km. To the west lie Tunisia, 459 kilometres distant and Algeria, 982 km; on the south are Niger, 354 km and Chad at a distance of 1055 km. Sudan is situated 383 km to the south-east and Egypt, 1115 km to the east (Foreign Affairs, Trade and Development, 2011; Library of Congress–Federal Research Division, 2005). It ranking seventeenth in the world and fourth in Africa, in terms of area. The desert covers nearly 90% of its total area. Libya’s population reached 6,000,000 in 2013, nearly 51% of whom are men (Central Intelligence Agency, 2014). Figure 3.1 shows the country’s location.



Figure 3.1: Map of Libya (Source: BBC, 2014).

Libya’s big land area is sparsely populated. Most people live near the coast. In particular, in Tripoli and Benghazi, where an average of 50 inhabitants obtains per square km., whereas the rate in the other

regions falls to less than one person per square km, by reason of the prevalence of desert or semi-desert, where hardly anyone can live. Urban dwellers represent more than half the population, 96% of the people are Arab and 4% are Berbers, Arabic is the main and official language and the Berbers speak their own language, called Tamazight. Some people can speak Italian and English as well (Foreign Affairs, Trade and Development Canada, 2011).

Libya's climate is either Mediterranean, along with its northern coast or a dry desert climate in the interior and southern regions. In the north the weather is hot in the summer with high humidity, sometimes reaching up to 90% and moderate in the winter. The summer temperatures rise to the thirties and sometimes above forty degrees. In the winter, the temperature averages 22°C, but can at times drop to 5°C. In the south of the country, however, the average temperature is 35°C in summer and can vary from 15°-20°C in the winter but, on some days can be less than 5°C (UNESCO,2012; John,2012; World Weather and Climate Information,2016).

Libya is traditionally divided into three zones: the first is named Cyrenaica, located in the north-east; Tripolitania is the second, situated in the north-west; and Fezzan in the south-west is the third. Figure 3.2 shows the internal borders of the zones and the main city of each one.



Figure 3.2: Libya's regions (Source: BBC, 2012).

In the desert or semi-desert regions of Libya, the temperature is very high in summer and very low in winter. Natural water sources are few. The large land area led to the difficulty of movement between the regions. This geographical feature forced the population to concentrate in those areas where the basic requirements of life can be found, which made it difficult for conditions to evolve. In contrast, the location of Libya is excellent location; it has links with both Europe and Africa, in addition to a very

long coastline and borders with seven Arab African countries. These factors have had a significant impact on the environment and the social, economic and political life of Libya. According to the Secretariat of the United Nations (UNCCD, 2001, p15-20), research on the country must focus on geographical factors and their impact on social, political and economic conditions.

From the reviewed of the geographical features of Libya in terms of size, location and climate, which could have a positive or negative effect on the industrial sector in Libya. What makes life difficult in many areas is the mostly desert character of the territory, its high temperatures and its small population, as well as the difficulty of movement between regions which can support life. This is one of the barriers that could face the development of industry in Libya. At the same time, it is remarkably well situated, a factor which it hardly begins to exploit.

3.3 Historical and Political Background

Libya's industrial development has been closely linked to human evolution since ancient times (Peter, 2013). Therefore, the history of Libya should be outlined briefly. The first mention of Libya occurs in Egyptian texts relating to the Libo tribe, which inhabited this area in the thirteenth century BC (John, 2012; Library of Congress–Federal Research Division, 2005). Although Libya has a very long and distinct history, it is considered an underdeveloped country due to the harshness of its natural features. However, many nations and empires have controlled Libya, such as the Phoenicians, Carthaginians, Greeks, Romans, Spaniards, Vandals and Byzantines (Library of Congress–Federal Research Division, 2005).

The Libyan tribe mentioned above was so strong that it ruled Egypt from the tenth century to the eighth BC. Then the Greeks subdued Libya in the seventh century BC and extended this name to the whole region of North Africa (Hall, 2002). But the Phoenicians came to Libya from the Levant and the eastern shore of the Mediterranean in 7th century BC gradually invading much of the Libyan coast. Their power extended to the borders of Cyrenaica in the east and monopolised trade in the region. They established major cities such as Tarabulus or Oia (which eventually became Tripoli), Leptis (Lebda) and Sabratha. Their trading activities grew rapidly, due to the ease with which they made their way to the middle of Africa, with its gold, ivory and ebony, in addition to the slave trade (Toyin et al., 2012). At the same

time, the Germanic tribes from Northern Europe began moving to the hinterland of Libya towards its borders with Africa. Because they controlled all the roads leading to Africa, their convoys could carry goods from Africa to the north of Libya and trade with the Phoenicians. They bought goods from the Phoenicians traders such as silver, tin and olives. The Garamantes continued to control the markets in Libya for more than 1000 years (Go, P.2012). The Persians, in their turn, ruled the Libyan eastern region after their occupation of Egypt in 525 BC, seizing it from the Greeks, but before long the same region was ruled by the Ptolemies, a Greek dynasty which occupied Egypt in 331 BC (Toyin et al., 2012; French, 2008).

However, by this time the Romans were establishing a very powerful empire. They destroyed what was known as the Carthaginian Empire, which had been founded in 814 BC in Tunisia. In 146 BC they entered Libya and ruled most of its coastal regions, except the east coast which remained under the dominion of the Greeks, the power in Egypt at the time (Hall, 2002).

In 96 BC the Ptolemies lost control of Cyrenaica (the eastern region) to the Roman Empire which controlled Libya until the fourth century AD. During this century, the Roman Empire disintegrated and the Byzantine Empire took over Libya. The Christian religion was recognised for the first time as the official religion and the only permissible one. The Byzantine rule, however, did not last long but broke up in chaos and civil war. The tribes of Vandals (originally part of the Garamantes, from the Scandinavian area) exploited this situation and occupied Libya in the fifth century, destroying everything indiscriminately (Nikshoy, 1973).

In 642 AD, Islamic armies entered Libya as part of what was known as the Islamic conquests, which was seeking to expand the influence of the Islamic nations to the wider outside boundaries of the Arabian Peninsula. The Muslims encountered very little resistance in Libya due to the chaos and disorder wrought by the invasion of the Vandals. After taking entire control of Libya, the Arab Muslims began to establish security and consolidate their rule all across the country. From this time Arabic became the spoken and official language and Islam was recognised as the only religion (Malcolm & Losleben 2004; Hall, 2002). In 1551 AD Turkey or what was known as the Ottoman Empire at the time occupied Libya. Their rule included all regions: Tripoli, Cyrenaica, and Fezzan. The Ottoman rule lasted

until 1912 AD. In the era of their rule, they have done profound changes in Libya, such as economic and administrative reforms, encouraged the resettlement of nomads and developed agriculture. In 1911 began the Italian invasion of Libya. They occupied Libya under the pretext of protecting their interests and those of their nationals in Africa. In fact, Italy wanted to expand its empire as other European countries had. Libya was the only country in North Africa still under Ottoman Turkish rule in 1911. The Ottomans attempted to resist the Italian army, but could not, and were therefore compelled to conclude a treaty with the Italian government, under which the Turks ceded Libya to Italy. During its rule of Libya, Italy imposed the use of Italian codes instead of Turkish, but the Islamic system of law (Sharia) remained as it was during the rule of the Turks. The Italians ruled Libya until 1943 when they were defeated in World War II (Thomas, 2013; Waniss & Erling, 2007).

The Italians faced stiff resistance because they were not accepted by the Libyan people. The struggle was led by Omar Mukhtar. Libyan fighters staged short, fierce attacks against Italian strongholds. Nevertheless, the balance of power was with the Italian armies, because they had developed weaponry such as tanks and aircraft. All the Libyans across the country fought the occupying forces and responded to the call to resistance (Jihad); volunteers from the Arab and Islamic world flocked into Libya to aid them in their struggle, making the Italians' invasion of Libya not as easy as they had expected. The Libyan struggle continued until the outbreak of World War II (Gábor & Bruce, 2009; Marshall Cavendish Corporation, 2003; Philip, 2007).

During World War II, which began in 1939 between the Allies led by Britain and the Axis led by Germany, the Libyans joined the ranks of the Allies after Britain explicitly promised that Libya would no longer be under the Italian control. This was seen by the Libyan people as an opportunity to get rid of the occupying power (Toyin et al., 2012). During the war, the Libyans were sceptical about the intentions of the British, which became clear after the defeat of fascist Italy and its partners. Tripoli and Cyrenaica then fell under British rule, while French took control of Fezzan. Thus, the country entered a new era of occupation (Ali, 2007).

At the end of World War II (1945) the United Nations was established. The most powerful countries agreed that Libya should remain under the guardianship of one of these states, but this was incompatible

with the interests of other major powers in the United Nations. Therefore, it was decided to bring the issue to vote by the UN General Assembly. Libya was granted conditional independence with territorial integrity in 1949. At this point, Libya formed a committee of 60 members drawn from the three Libyan provinces. In 1951, this committee submitted its report to the UN, demonstrating the final shape of the Libyan state. With this report, Libya received its formal independence on December 24, 1951; it became a federal kingdom comprising the three provinces of Tripolitania, Cyrenaica and Fezzan under the name of the United Kingdom of Libya; Idris al-Sanusi was chosen as its king. Thus Libya became the first country to achieve independence through the UN and the first European colony in Africa to gain independence. After the discovery of oil in 1957, it was obliged to reconsider its political composition in order to maintain its unity and to be able to repel the colonial powers which were trying to control the Libyan's new wealth. The Constitution was amended in 1963 and became that of a consolidated state with a central governmental system under the name of the Kingdom of Libya, making Tripoli became the state capital. Thus, Libya became the only country in history to have changed from a federal to a central ruling system (Frank, 2013).

On 1st September 1969, Colonel Muammar Gaddafi led a military coup against King Idris and announced that Libya would be a sovereign state under the name of the Libyan Arab Republic. Gaddafi dominated as a rule by excluding from power the rival officers who had taken part in the revolution. In 1977 Gaddafi adopted an autocratic system (of individual judgment) and declared the so-called Third Universal Theory, with a new name for the state, the Libyan Arab Jamahiriya. His rule continued for 42 years (Taylor and Francis Group, 2004; BBC News Africa, 2014). On February 17, 2011, massive popular demonstrations broke out against his rule. More details are supplied about the period of Gaddafi's rule and the 2011 revolution in the following section. The so-called Transitional Council was established as a temporary authority to rule the country during the revolutionary period (Cherif, 2013). From the above it can be seen that Libya has been subjected to many waves of colonisation waves, begun by the Phoenicians then the Greeks and the Romans down to the Ottoman Empire, the Italian occupation and finally the division into French and British areas. In all of them, the Libyan people were struggling for freedom. Eventually, Libya received its independence on 24 December 1951 and

accepted an independent Royal government, following which Libya witnessed a semblance of stability. But Gaddafi's coup of 1969 overthrew the king, Idris al-Sanusi. Gaddafi established what he called the Revolutionary Command Council (RCC) with himself as president. The government system changed from a kingdom to a republic, called the Libyan Arab Republic (LAR) (Frank, 2013).

In 1977, Gaddafi issued a Green Book, through which he instituted a new system of governance, named the Third Universal Theory. This theory adopts a policy of what is called people power, that is, that the people govern themselves. Thus all previous laws and legal frameworks of the country were cancelled (Horace, 2012). This was the tipping point in the history of modern Libya when it was transformed from an independent regal system to an undeclared dictatorship or what is known as the rule of an individual. The leader, as he liked to call himself, realised from the beginning that controlling the oil sector was the only way to achieve his goals, so all oil companies were nationalised. He suspended the work of the Revolutionary Command Council to confirm his own power. After this, Gaddafi became the sole ruler of Libya. Then he appointed himself the Supreme Commander of Libyan armed forces. This position gave him full power to rule the country as the army was the strongest power in the state (Kimberly, 2009; Toyin et al., 2012).

In line with Gaddafi's theories, the Parliament changed to the General People's Congress and the Council of Ministers was named the General People's Committee. Theoretically, the people rule in Libya, exercising power through the so-called Basic People's Congresses (BPCs), through which their demands are determined. The heads of these Congresses are members of the General People's Congress who hold legislative functions. The people's demands are taken to the Supreme Planning Council, which is an independent body. The Supreme Planning Council reformulates these demands as decisions and laws. In contrast, what are called local people's committees (LPCs) were also established. These committees are responsible for the implementation of these laws and decisions. The trustees of the local committees received orders from the General People's Committee, which in turn implements the decisions of the General People's Congress (Toyin et al., 2012; Joseph, 2012).

Realistically, Gaddafi was the sole governor of Libya through what was known as the Liaison Office of the Revolutionary Committees. He founded this group to be his right arm with which to strike.

Members of this organisation received orders directly from Gaddafi and implemented them without any conditions or restrictions. The Revolutionary Committees used the General People's Congress and the General People's Committee as tools to implement the orders of Gaddafi (Brian, 1999). Figure 3.3 illustrates the extent of centralisation in Gaddafi's state and the difference between actual and theoretical rule as drawn by the author.

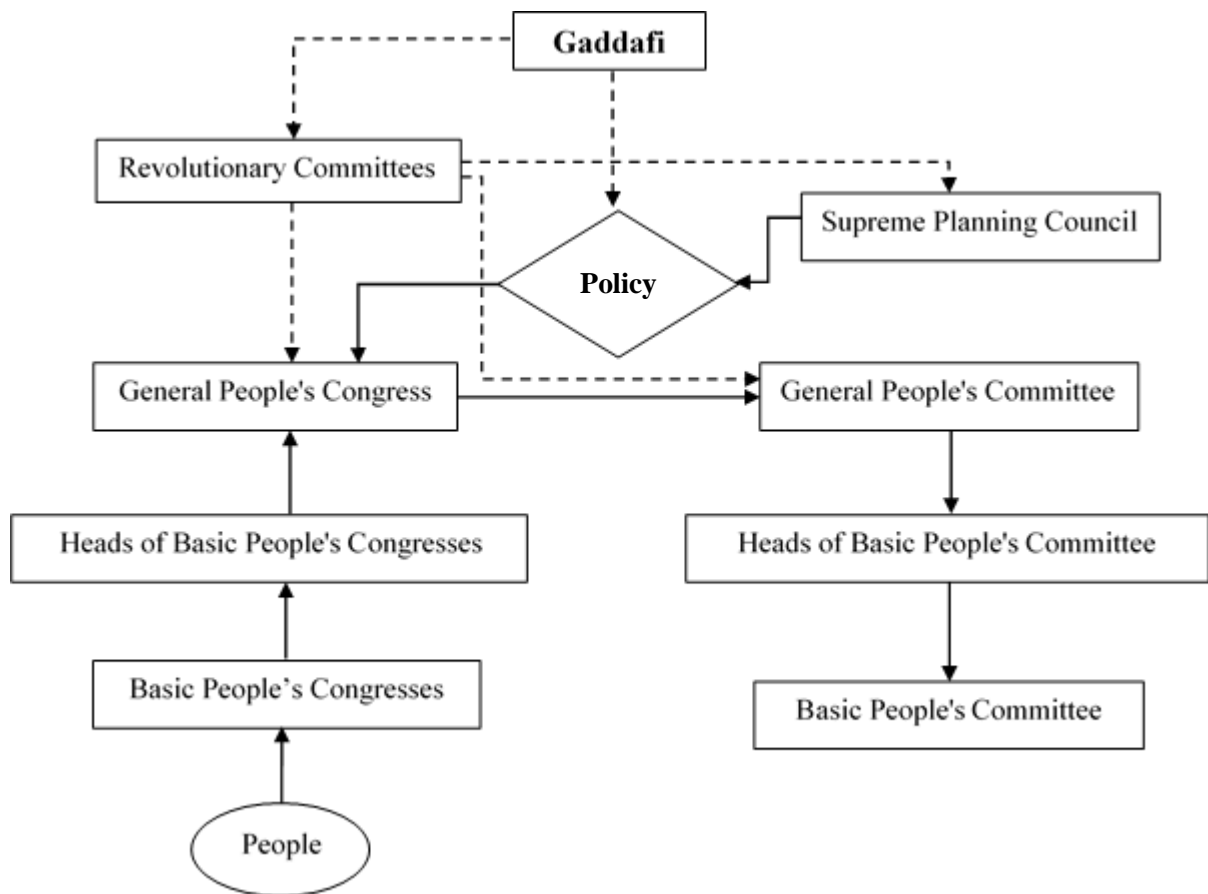


Figure 3.3: The Libyan Government structure from 1969 to 2010 (Source: author).

The members of the Revolutionary Committees performed many acts of terrorism and sabotage inside and outside the country. This led to widespread discontentment and to the deterioration of relations with most other countries, the neighbouring countries and those of the West in particular.

One of the clearest testimonies to the dictatorship of Gaddafi was the 1988 bombing of the U.S. Pan Am 103 over Lockerbie Village, Scotland which killed 270 people. This issue led to further isolation for Libya and the freezing of the country assets in the U.S. and a number of other Western countries. In 1992 the UN Security Council imposed an economic blockade and an air embargo on Libya. This

isolation forced the Libyan government to hand over the suspected bombers for trial in 2001. In 2003, with the continuation of the pressure, Gaddafi accepted Libya's responsibility for the bomb attack on Pan Am 103 and paid significant compensation to the victims' families (Raymond & Anoushiravan, 2002).

As a result of these concessions, the air embargo and the international trade sanctions were suspended. In 2004 as a gesture of goodwill, Gaddafi gave up his nuclear programs and handed over the devices and equipment that might have been used to produce banned weapons, as well as signing up to a treaty banning chemical weapons. As a result, the trade embargo was lifted and the European Union lifted the ban on arms exports to Libya. Western countries, including the U.S. and Britain, restored diplomatic relations with Libya. In 2006 Libya was removed from the list of international terrorist countries (Ibpus.com & International Business Publications, 2013; Jacques, 2012). Thus, Libya returned to the international community to end more than 30 years of isolation. In contrast, the country's internal situation saw no important change. The anger of the people started to increase, which showed the extent of the people's frustration over their country's economic, social and political state.

The Abu Salim prison massacre of 1996 in Tripoli is another witness to the terror that was perpetrated by Gaddafi. In this massacre, more than 1200 prisoners were shot dead without trial after years of unlawful imprisonment and even without the knowledge of their families. Gaddafi's government refused to recognise the crime when it took place. International human rights organisations and some Western countries such as the UK exerted considerable pressure on the Libyan government. These pressures led to some confessions on the part of the government. The head of internal security at the time alleged that prisoners had detained some prison guards and stolen weapons from the prison stores. The security forces intervened to restore order, and shots were exchanged between prisoners and the security personnel. This led to the killing of all the prisoners and their guards. Eventually, the government was forced to open an investigation. Financial compensation was offered to the victims' families, in return for giving up their legal rights in both the Libyan and international courts. The families of the victims declined the offer and insisted upon knowing the truth and bringing the offenders to trial (HRW News, 2006; Amnesty International, 2010; Jeffrey 2013). Despite their desperate attempts to gain their rights

and their many protests, they were subjected to harassment and arrest. This only increased the anger of the Libyan population.

On February 17, 2011, the families of the victims and a group of lawyers demonstrated in front of the Benghazi Court. They demanded the amendment of the Libyan judiciary and the trial of some members of the regime who had killed their relatives. The regime's forces killed some protesters and arrested others, but by this time popular anger had escalated and quickly turned into a major rebellion involving the whole country (U.S. State Department, 2011). Government forces tried to take control of the situation but the intensity of the protests was too strong. Some government security headquarters were stormed and destroyed and some arms depots were seized. Thereupon the so-called revolutionary detachments were set up dominating some regions of the country. The National Transitional Council (NTC) was established to give political support to the revolutionaries. This government persuaded many countries to recognise the new Libyan state, Western countries in particular, such as the UK and France, in addition to Qatar and the United Arab Emirates. In March 2011, and with some foreign assistance, the representatives of the new Libyan government in the UN were able to persuade the UN Security Council to adopt a resolution allowing military strikes against Gaddafi's forces. This support increased the power of the rebel forces which then took control of most parts of Libya (Fawaz, 2014).

On September 20, 2011, Gaddafi was captured and shot dead in his hometown of Sirte. After three days the liberation of all the regions was announced, thus ending the war (HRW, 2012). On October 23, 2012, an interim government for the first year was installed. During that period, a meeting of the General National Congress (Parliament) was prepared, convening 200 members from various Libyan regions (Peter and Anson, 2012). On July 7, 2012, the members of the General National Congress were elected, who in their turn elected the President of this Congress. Thereby, Libya entered a new era, moving on from autocratic rule to a multi-party democratic system. The Parliament elected a prime minister and endorsed whatever ministers he appointed (BBC News Africa (2012).

As a result of the politics left by the Gaddafi regime and the proliferation of weapons, Libya entered a new phase of political pressure, this time one imposed by the political parties. These parties had been trying to control Libya using armed militias. Abductions and killings are increased, and as part of the

force with which policy was imposed, some armed militias resorted to closing oil ports, which resulted in the collapse of many state utilities, such as the electricity supply, which depends on fuel. In addition, the state was sometimes unable to fulfil such obligations as the payment of its employees' salaries in some government departments. On February 20, 2014, the Libyans elected the members of the sixtieth committee, which will write the new Libyan constitution. This is considered the first effective step since the liberation in building the new state (HRW, 2013).

From the above, it can be said that Libya has not seen political stability since Greek times. Other powers have occupied Libya down to the reign of Gaddafi, who built the state's policy on his temperament, and finally to the confusion which Libya faced after the revolution of February 17, 2011. It was then under the control of armed groups and political parties, who took charge of the key oil installations which are the only source of the national income. The laws issued by in the Libyan Parliament had an added influence on decision making in the country. One of the most important issues raised in this section is the Gaddafi's application of socialist principles, supporting the public sector. This section discussed the impact of the international economic sanctions on Libya from 1992 to 2003. This evidence shows clearly how political factors have affected other aspects of life, notably social and economic life, in Libya.

3.4 The Social System

According to the International Labour Organisation (ILO) (2003) "The challenge every country faces is how to become a learning society and to ensure that its citizens are equipped with the knowledge, skills and qualifications they will need in the next century. Economies and societies are increasingly knowledge-based. Education and skills are indispensable to achieving economic success, civic responsibility and social cohesion." This is a clear indication of how important it is to focus on the training of citizens which enhances their capacity to help develop the nation (International Labour Organisation, 2003).

In 1950 the Libyan population was 1.113 million, of whom 537,000 were female and 576,000 males. In 1960, the population was estimated at about 1.428 million, of whom 735,000 were male. This figure rose to 2.076 million in 1970, the number of males and females being about equal. In 1980 the

population had risen to 3.078 million and in the next decade, it grew by more than a million to 4.260 million, of whom 2.249 million were male. In 2000 the number of males was 2.689 million and of females 2.488 million. By 2010, according to the latest official statistics, Libya's population stood at 6.041 million, of whom 2,964 were females (Population Division, United Nations, (2012).

The trend of these figures suggests that the Libyan population's growth rate is weak, only 1.96% between 1950 and 1955, according to the UN statistics. In the period between 1960 and 1965, the rate was 3.62% and there followed an increase to 3.98 % in the period 1970 to 1975. From 1980 to 1985 the rate of population growth did not change much, but slipped to s 3.89%. Indeed, this percentage saw a remarkable decline to 2.17% in the period 1990-1995. The rate continued this decline, dropping to 1.55 % between 2000 and 2005. The period 2005-2010 saw no significant change but a further drop to 1.54%. It is expected that the population growth rate will decline to 0.9% in the next five years because of the social aftermath of the 2011 Libyan war (Population Division, United Nations, 2012). Figure 3.4 shows the rate of population decline between 2000 and 2012.

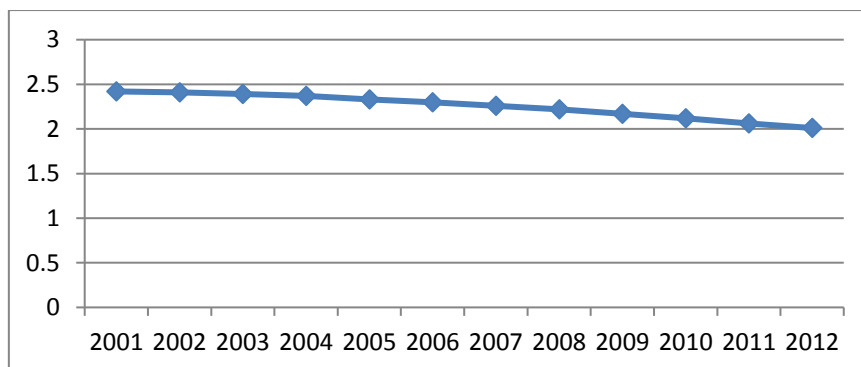


Figure 3.4: The rate of population decline in Libya between 2000 and 2012 (Source: Index Mundi, 2013)

Moreover, the median age saw no great change; for example, it was 21.0 years in 1950 and had fallen to 17.0 years by 1970. This number increased to 18.7 in 1990, reached 22.2 in 2000 and continued to increase, becoming 25.0 in 2010 (Population Division, United Nations,2012). The age structure of the population, equally, did not see any significant change after 1950. The table 3.1 below shows the age structure of the Libyan population from 1950 to 2010.

Table 3.1: The age structure of the Libyan population from 1950 to 2010(Source: Population Division, United Nations, 2012).

Year	1950	1955	1950	1965	1970	1975	1980	1985	1990	1995	2000	2005	2010
Age													
0-4	15.5	16.9	17.5	18.8	19.1	18.7	18.3	16.8	14.1	12.1	10.6	10.6	10.7
5-14	23.2	23.7	24.0	24.8	26.4	27.6	27.8	27.5	25.8	25.7	27.7	20.0	18.8
15-24	18.4	17.9	17.9	17.1	16.7	17.1	18.1	19.3	20.1	21.6	22.8	21.7	19.3
15-64	56.0	45.8	54.6	53.0	51.5	50.7	51.0	52.8	54.9	58.6	62.8	65.1	66.0
65+	5.2	4.5	3.9	3.4	3.1	3.0	2.9	2.9	3.2	3.6	3.9	4.3	4.6

This table shows that, for example, the proportion of people aged between 0-4 was 15% of the total population in 1950. This percentage rose to 18.3% in 1980 and then declined to 10.6% in 2000; even ten years later, the ratio was still more or less the same, 10.07%. The age group 5-14 years occupied 23.2% of the total population in 1950 and had increased to 27.6% by 1980. This percentage fell to 22.7% in 2000 and even lower, 18.8%, by 2010. The age group of 15-24 had an 18.4% share of the population in 1950. This percentage has not changed much by 1980 when it was 18.1%. In 2000 the proportion rose to 22.8% and by 2010 had fallen by 0.11%. As regards the elderly, for example, people of 65 years and older, the percentage in 1950 was 5.2% in 1950, fell in the next thirty years to 2.9% in 1980 and then rose to 3.9% in 2000 and again to 4.6% in 2010.

From the above, it is clear that the population of Libya is small and so is the trend of population decline; to sum up, Libya has limited human resources and this has led to an increase of in the numbers of non-national residents. For example, in 1984 the population of non-Libyans was 2,631,000, mostly from neighbouring countries such as Tunisia, Egypt and other African countries and including some from southern Asian countries. In 1992 the number of foreigners in Libya was about 2 million. This figure may reflect an increasing level of illegal immigration (Encyclopedia.com, 2007).

Despite the lack of official statistics in Libya, the estimate in 2004, for example, indicated that the number of foreigners in Libya was made up of 600,000 officials and from 750,000 to 1.2 million unofficial inhabitants (Migration Policy Centre, 2013).

This appears to be following a contrasting trend to the figures for nationals, according to the latest statistics released by the International Organisation for Migration (IOM). In 2011, the number of non-nationals living in Libya was 2.5 million (IOM, 2011). This number is very high in relation to the

number of nationals and reflects the lack of indigenous human resources in the country compared to the amount of work available.

According to the 'Central Intelligence Agency' (2010), 33% of the total population was younger than 15 years old and the proportion of urban dwellers higher more than 78%. Moreover, most of the population live in the coastal areas where the weather is usually moderate and the basic needs of life, such as natural water, are more readily available and it is easier to travel to other en regions. However, Libya is characterised by a propitious geographic location overlooking the Mediterranean Sea to the north linking it to Europe, in addition to a southern border shared with African countries. This gives Libya the position of a gate linking Africa with Europe and it would have plenty of opportunities to build a strong economy if it properly exploits its location.

Most Libyans can read and write – the literacy rate is about 82%. Arabs and Berbers comprise 97 % of the population and the rest represent other ethnicities such as Greeks and Turks. More than 97 % of the population are Muslims, holding the Sunni Maliki doctrines (one of the ways of following Islam). As a result, the Arabic language is the country's official language, the basis of both the population and the country, and is spoken by everyone, as well as the language is spoken by the Berbers who come from the mountainous western regions (Central Intelligence Agency, 2010, p.371). Although Gaddafi's government did not encourage the use of languages other than Arabic, English is common among the educated classes, postgraduates in particular. In addition, Italian is also spoken, in particular by the elderly who lived through the period of Italian occupation (Library of Congress, Federal Research Division, 2005).

Health care is free to all Libyans and foreigners inhabiting Libya, at private hospitals and treatment centres. According to the latest statistics for 2011, the proportion of health expenditure amounted to 4.4% of the total GDP (World Factbook, 2014).

Although health services are everywhere available, many citizens travel to Tunisia or to European countries for more sophisticated treatment (Library of Congress, Federal Research Division, 2005).

Demographically speaking, Libya extends over a wide area and has a small population, most of whom live in towns. A large proportion of Libyan society consists of young people, which offers many

opportunities to use their potential for developing the country's industrial sector. This could be done through specialised training programmes accompanying scientific developments. Furthermore, the foreign workforce which makes up a good percentage of the population could be considered as a positive factor for improving the performance of the industrial sector in Libya. The productivity of industrial organisations is usually linked to a number of factors, whether economic, geographic or social, which have a significant impact on their level of performance. For example, Hedert (1981, p.3) cited in Grifa (2006, p.80) says: "The construction industry usually reflects a true picture of the demographic and economic situation of a country or region". Here it can infer that there is a close relationship between the overall performance of an industrial organisation and the social environment. The social structure of Libyan society is based on a hierarchy starting from the individual and extending through the family, the clan and finally the tribe, with some amendments to these arrangements in urban areas (Sheban, 1986, p.134).

Mahmoud (1991) and Pack (2013) find that Libyan society is organised through kinship and tribe, the most important social unit in Libya. In other words, loyalty to the tribe or clan is sometimes more important than loyalty to one's career or even to the national laws. The tribal groupings are as a rule confederations composed of several tribes, clans and families. Each of these components has its local leaders and tribal alliances usually adopt a single political orientation (Jackson, 2003). Therefore, tribal relations are very important in everyday life, for example, in getting a job or enhancing one's position at work, regardless of the required qualifications or experience (Aгнаia, 1997). In other words, Libya has many cases of a prominent position in an organisation being held by someone lacking in qualifications or experience. This inevitably affects overall organisation industrial performance adversely and contributes little to the satisfaction of workers. Islam is another factor which plays a major part in Libya's social life. Islam requires all activities to be conducted in compliance with the principles enshrined in the Islamic Constitution (Sharia) accordance to the Qur'an (the revealed words of God), in addition to the Sunnah (the sayings of the Prophet Muhammad) (Hamid et al., 1993). Thus, Muslim people's actions are governed by laws derived from Islam. But when most Libyans are committed to following Islamic laws in addition to the habits that they have inherited over many

centuries, it creates an obvious problem that, as in many other Muslim countries, a misconception of Islamic laws guides so large a proportion of the Libyan community or the laws themselves are not properly applied. This is one of the main reasons for the Libyans' inability to build a strong state.

Yousef et al. (2012) in their study of Arab culture conclude that the direct transfer of Western economic and political theories to developing countries such as Libya without studying the cultural differences between these communities is a major challenge which could have a negative impact on the regulatory and administrative practices in these countries. Moreover, the social structure of the Libyan society is affected by many factors such as religion, political instability and customs and traditions imported from foreign occupiers of various kinds. In addition, the natural and geographical difficulties have influenced people's outlook. But there is still a chance to surmount such barriers to national development by taking advantage of the experiences of other communities and developing the positive aspects of the country's social structure.

It can be summarised that Libya has a very big land with a small population, which mean that the human resources are limited compared with the area. This may hinder industrial development, which mostly relies heavily on the availability of human resources. In addition, it has not been helpful for growth that the social structure depends on the tribal system, with too high a rate of urbanisation. Often this structure does not recognise the laws and regulations, perhaps one of the most important factors in the failure of the management system of any industrial enterprise. In contrast, the high proportion of young people and the availability of many non-national workers are encouraging signs. These positive factors could promote the development of the industrial sector in Libya.

3.5 The Economic system

Industry can only exist in certain conditions of the economic, political, social and commercial environment. Its continued success depends on its ability to coexist with this environment. It can be affected by or affect these elements in good or bad ways, because it requires many basic supplies of labour, for example, capital and raw materials, while conversely, members of the community can benefit from the goods and services provided by the industry (Fewing, 2013).

In the literature on Libya's economic history since the gaining of independence in 1951, it seems to fall into four periods, as follows:

The first period continued until 1962. At this time Libya was classified among the poorest countries in the world, according to the UN classification. Experts predicted that Libya would live on international aid for a long time. The per capita income was less than \$30 per year in 1951 and the illiteracy rate was about 90% in 1952 (IBPUS.com, 2007, p.159 and Obeidi & Obeidi, 2013, p13). Although the state depended upon agricultural income, production was very primitive, with a lack of actual and potential water sources. The huge area of land suffering harsh climatic conditions was one of the reasons for Libya's widespread poverty (Johin, 2002, p.15). No sources ways were found of contributing to raise the state's income level. Table 3.2 shows the contributions made by various sectors to GDP in 1958. It can be seen that the public services such as education, health and transport must have been at their lowest level, due to limited state revenues.

Table 3.2: Industrial Origin of Gross Domestic Product at Factor Cost in 1958 (Source: The International Bank of Reconstruction and Development, 1960, p.371).

Economic Activity	£ Millions	Percent
1 Agriculture, forestry and fishing	13.6	26.1
2 Petroleum prospecting and quarrying	3.6	6.9
3 Manufacturing and repairing	6.0	11.5
4 Construction	1.8	3.4
5 Electricity and gas	0.8	1.5
6 Transportation, storage and communication	2.9	5.6
7 Wholesale and retail trade	7.3	14.0
8 Banking, insurance, ownership of dwellings	9.5	18.2
9 Public administrations and defence	6.7	12.8
Gross domestic product at factor cost	52.2	100.0

In 1953 Libya signed an agreement for 20 years with the UK to establish a number of military bases in Libya, under which the UK undertook to grant Libya £1m annually, covering the economic deficit. In 1954 a similar agreement was signed with the USA in return for economic support of US\$2m per year. This period saw the discovery of oil in 1955 but it took some time to be exploited (Lea & Rowe, 2001, p.241-242).

The second period began with the start of oil exports in 1963. This moved Libya to the forefront of the world's economies. Oil revenues enabled the Libyan population to shift from an agricultural society to

a hydrocarbon society. Libya was able to save large reserves of gold and foreign exchange amounting to \$4 billion. Furthermore, the annual oil revenues were estimated at more than \$6 billion (Mongabay.com.2013). In addition, the economy moved from a budget deficit to a surplus in capital. By now a capitalist system was in place. Private ownership was established, with the minimum of government intervention. The government was encouraging competition between companies in its support for the private sector

The third period began with the military coup in 1969. In this period Libya was re-shaped from a capitalist country with the western orientation to a socialist national state which was anti-capitalist. However, the Libyan economy saw significant growth between 1970 and 1983, due to the increase in oil prices. GDP rose and the state's income significantly improved (IBPUS.com, 2007, p.159).

Despite these changes, there was no significant alteration of the economic structure. Consumer spending rose from 159 million LYD in 1964 to 3,833 million LYD in 1981. (General People's Committee for Industry, Economy and Trade, 2011 cited in Aldrugi, 2013).

The reason for this was the application of socialist principles from the beginning of the 1970s. This allowed the government to control the economy through its expansion of the public sector and diminishing of the private sector. Table 3.3 shows the public sector proportion of investment in the economy compared with that of the private sector over the 1970s and until 1997.

Table 3.3: Comparison of public and private sector investment, Libya, the 1970s to 1997, (in percentages) (Source: Dar al-Jamahiriyah lil-Nashr, 1999, p.255 cited in Niblockm, 2002, P.63).

Years	Public	Private
1970-1972	69.1	30.9
1973-1975	79.1	20.9
1976-1980	87.2	12.8
1981-1985	91.7	8.3
1986-1990	90.2	9.8
1991-1997	75.4	24.6

The nationalisation of private enterprises had a negative impact on the country's economy. Productivity declined and the rate of unemployment increased. Money was wasted on wages and salaries and income for companies was greatly limited. The companies produced merely what the government decreed

(IMF, 2013, p.12 and Cordesman, 2004, p.245). To give one example, the unemployment rate rose from 19.8% in 1990 to 29.9% in 2000 (Navarra & Tubiana, 2013, p.306).

The Libyan economy entered the fourth period at the beginning of the 1980s when oil prices faced a sharp decline. For example, in 1988 it decreased from \$37 per barrel in 1980 to £12.03 (Shojai, & Katz, 1992, p.18-19). But because the country depended very heavily on oil revenues with over 80% of its income derived from oil, this decline had a disastrous effect on the economy as a whole. Libya's real GDP fell by over 14% between 1980 and 1981 and this fall was not halted until late 1986 (Mongabay.com, 2013).

Such a decline gave clear evidence of the government's inability to cope with crises of this kind. The reason for this was the poor planning which underpinned the socialist system established there. With the beginning of the 1990s, the Libyan economy became even more vulnerable, because of the economic and trade sanctions imposed by the UN. This led to the emergence of the so-called Libyan economic crisis. The loss in turnover reached a total of US\$33 billion (Mwaura, 2005, p.18 and IBPUS.com, 2008, p.57-58).

When the socialist system had first been brought in, the public sector had seemed successful and the system was expected to contribute to raising the level of economic performance. However, experience has shown the contrary. In his study, Aldrugi (2013), cites the statistics on 20 plants including cement plants issued in 1988 by the General People's Committee for Industry. This reveals that these factories operated at between 4% and 61% of their production capacity and more than 50% of them had a level of production below one-third of the total production targeted for them. The same author obtained another study of 30 Libyan factories which was presented by the Libyan National Authority for Scientific Research. It shows that even in the best factories the rate of production did not exceed 29% of capacity. This low rate led to a significant shortfall in supply because the industrial sector was unable to meet the needs of the Libyan market.

Furthermore, the continuation of the embargo imposed on Libya increased the economic problems. Industries, oil in particular, began to suffer from a lack of basic materials such as spare parts. Foreign trade slowed dramatically. Most basic goods were imported through intermediaries or what is known

as the black market. This increased prices to more than double. The contribution of the non-oil industries to the GDP virtually ceased to exist (Matar, & Thabit, 2003, p.30 and Volpi, 2013, p.18). Table 3.4 shows the contribution of some industries to the Libyan GDP from 1981 to 1996. The extent of the failure of these industries to contribute to the Libyan economy is clear.

Table 3.4: GDP Contribution from Various Libyan Industries from 1962 to 1996 (Source: the Secretary of Planning, 1997, pp. 42-48 cited in Mashat, 2005, p.37-38).

Year / Sector	62	64	66	68	70	72	74	76	78	80	82	84	86	88	90	92	94	96
Agriculture, Forestry and Fishing	6.9	6.4	4.3	3.1	2.6	2.5	3.1	1.7	2.1	2.2	3.2	4.1	5.7	6.5	5.1	5.5	6.1	6.6
Oil and Natural Gas	24.4	53.7	56.1	60.05	63.1	52.5	62.9	57.7	51.1	61.8	47.4	41.1	35.6	24.7	35.4	28.3	25.8	24.0
Mining and Quarrying	0.4	0.2	0.2	0.1	0.1	0.5	0.4	0.5	0.6	0.5	0.7	0.7	0.9	1.4	1.4	1.4	1.7	1.8
Manufacturing Industry	5.8	3.2	2.3	1.9	1.7	1.8	1.5	1.9	2.7	2.0	3.0	4.6	5.3	7.3	7.1	7.8	8.8	9.4
Electricity and Water	0.6	0.4	0.4	0.5	0.5	0.5	0.3	0.5	0.6	0.5	0.8	1.2	1.7	2.0	2.0	1.9	1.9	2.0
Construction	6.6	5.9	7.1	8.3	6.8	10.4	9.9	10.8	12.4	10.4	13.2	11.1	7.3	6.2	5.9	5.2	6.1	6.8
Trade, Restaurants and Hotels	9.1	5.5	5.2	4.2	3.7	5.5	4.9	5.5	6.2	4.9	6.6	5.5	9.4	11.7	5.9	10.6	11.1	11.4
Transport and Communication	5.5	4.1	3.9	3.7	3.4	5.7	4.1	4.1	4.6	4.0	5.2	5.9	7.2	9.5	9.1	8.5	8.5	8.7
Banks and Insurance	1.1	0.7	0.7	0.6	1.0	2.1	1.9	2.5	3.2	2.3	2.9	3.6	6.1	4.4	8.3	2.7	2.7	2.7
Housing	18.9	9.2	6.9	5.5	4.6	4.4	2.9	3.0	3.1	2.0	2.5	3.1	3.7	4.6	3.7	3.8	3.8	3.6
Public Services (Except Education and Health)	10.0	7.1	7.8	7.2	7.6	8.5	5.5	6.2	7.5	5.7	8.4	10.5	6.7	7.8	3.9	12.9	12.3	11.4
Education Services	3.2	2.6	2.6	2.4	3.1	3.5	2.5	3.1	3.4	2.2	3.9	5.4	6.3	8.3	7.0	6.2	5.9	5.5
Health Services	1.4	0.9	1.0	1.0	1.2	1.5	1.5	1.4	1.7	1.1	1.5	2.2	2.7	3.3	5.5	2.5	2.4	2.2
Other Services	3.4	1.9	1.6	1.1	0.6	0.5	0.5	0.7	0.7	0.4	0.7	1.0	1.5	2.2	2.2	2.6	2.9	3.9
	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

In the 2000s, however, the Libyan economy seemed to recover once more. The reason for this was the lifting of economic sanctions, in addition to the dramatic increase in oil prices, up to \$134 per barrel in 2008 (Global Risk Insights, 2013).

However, the experience with the failed application of a socialist system, and the adverse consequences of the economic blockade convinced the Libyan government that; there it had to support the economy by finding alternative sources to oil. Accordingly, the government started to redraw its economic policies, approving the privatisation of the public sector, including oil, banking and some other industries. Local authorities announced plans to privatise more than 360 government-owned companies. Most of these companies had been working at less than their production capacity or parked for

production (European Commission DG Trade, 2009, p.16, 40), as well as allowing foreign companies to invest in Libya in many fields such as oil and tourism. For example, in 2009 foreign banks were allowed to invest in projects in Libyan by up to 49% (UK Trade & Investment, 2013).

Despite these attempts to change the direction of the economic path to a multi-source economy, it still depends heavily on oil revenues. The reason for this is government centralisation, which controls enactment of laws and decision making without referring to any experienced and competent people. According to the World Fact Book (2014), oil production represents about 80% of Libya’s GDP, 95% of its exports earnings and 99% of government income. Table 3.5 illustrates this economic structure.

Table 3.5: Structure of the Libyan economy as % of GDP 1970-2009 (Source: The General Planning Council cited in Assume et al, 2013, p. 529).

Year / Sector	1970	1975	1980	1985	1990	1995	2000	2005	2009
Agriculture	2.6	2.3	2.2	4.4	6.2	9.5	8.1	2.2	2.8
Manufacturing	2.2	1.8	2.0	5.4	7.1	8.2	5	4.7	6.3
Oil and gas	63	53.4	61.8	44.6	35.0	24.9	39.8	66.1	54.6

Therefore, the factor that determines the country’s overall performance is the amount of oil produced and the prices that can be charged, which are subject to much disruption. However, in the two decades from the beginning of the 1970s, the Libyan economic system was based on socialist principles, which adopt the concept of public support. This approach has proved its fail in Libya. After the lifting of the embargo specifically in the 2000's the country moved to an adoption of the free market rules espoused by the Western capitalist system. The government began to build a diversified economy based on the exploitation of non-oil resources. But at the same time, many problems have arisen, such as the global economic recession and rising prices. Moreover, the people’s exasperation with the government increased as a result of the injustices to which they were exposed. These and other issues contributed to the failure of the Libyan economic programme to develop as expected. Thus it would be fair to say that the Libyan economy has not seen stability since its independence in 1951. For example, the growth rate of GDP increased from 1.9% in 1973 to 22.2% in 1974. This percentage decreased to 4% in 1975 and again reached 22.6% in 1976. In 1981, however, the GDP growth rate saw a sharp decline to -19.8%. This was due to the decline in oil prices. The percentage improved slightly, to -14.7%, in 1987. The year 1999 experienced a slight increase to 0.7%. Due to the lifting of the UN embargo in 2003, the rate

of GDP recorded a noticeable jump to 13%. But this percentage again decreased to –0.7% in 2009. However, the Libyan conflict in 2011 had a big impact on the growth rate of GDP, which declines to -61.2%. After the end of the Libyan war in 2012, oil production increased dramatically. This has had a direct effect on the growth rate of GDP which reached 104.3% (UN, 2013). Table 3.6 and figure 3.5 show the fluctuation of the GDP growth rate in Libya of the period 1970 to 2012.

Table 3.6: Libyan GDP, Annual Rate of Growth % (Source: UN, 2013).

Year	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
GDP growth rate%	-3.5	9.1	1.9	22.2	4.0	22.9	9.8	3.3	9.8	0.7	-19.2	2.8	-2.3	-5.0
Year	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
GDP growth rate%	8.3	-11.4	-14.7	7.6	7.2	3.7	15.7	-2.7	-3.8	1.9	-2.2	2.1	5.2	-3.6
Year	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
GDP growth rate%	0.7	2.3	0.5	-1.3	13	4.4	10.3	6.7	5.1	14.6	-0.7	4.3	-61.3	104.5



Figure 3.5: Libyan GDP, Annual Rate of Growth – Percentages, 1971-2012, constant prices (Source: Kushnir, 2013).

At the same time, however, the number of employed people recorded in the state was 1.51 million in 2003, a figure which rose to 1.64 million in 2008, 2013 (World Fact Book, 2004, 2009, 2014). It should be noted that more than 70% of the labour force in Libya are registered in the public sector, and receive salaries without making any contribution to production (International Labour Organisation, 2012). The unemployment rate is another indicator of the weakness of the Libyan economy; this reached 30% in

2004, according to the latest statistics issued by the World Fact Book (2014) and the International Labour Organisation (2012). This percentage supports the view that the available workforce is not properly made use of.

Moreover, the average per capita income is very low. The following table (Table 3.7) shows the economic indicators between 1971 and 2012. This demonstrates that the total income increased from \$1.917 billion to \$12.4051 billion in the period 1970 to 1980 and then dropped in the 1980s to the lowest point of \$5.715 in 1987. The biggest total annual income in the 1990s was \$7.893 billion in 1991, but it dropped again to \$5.968 billion in 1998. Most of the first decade this century saw an increase of total income, from \$6.605 billion in 2000 to \$16.221 billion in 200, but this number declined in 2011 to \$6.650 billion due to the Libyan conflict which had an obvious negative impact on oil exports. However, in general, the Libyan per capita income was low and fluctuating due to the low government spending (UN, 2013).

Table 3.7: Libyan GDP, Per Capita GDP in US Dollars in the period 1970 to 2012 (Source: UN, 2013).

Year	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
GDP growth \$US	1.92	2.26	2.60	3.42	5.76	5.39	6.73	7.60	7.22	9.85	12.40	10.42	9.82	9.13	8.81
Year	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
GDP growth \$US	7.99	6.30	5.71	6.29	6.50	7.29	7.89	8.17	7.23	6.61	5.95	6.46	6.74	5.96	6.60
Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
GDP growth \$US	7.43	6.47	4.10	4.83	6.04	8.12	9.68	10.83	16.22	11.54	13.40	6.65	15.5		

However, and despite its huge oil revenues and small population, the economic infrastructure is still very weak, almost non-existent. Over the past few decades, Libya has faced many problems, such as an increasing unemployment rate, inferior health care, a lack of healthy housing and poor standards of education. These issues usually have an impact on the nature of Libyan public spending (African Economic Outlook, 2012, p.205). In other words, the state-owned industries, such as banks and service industries have dominated the Libyan economy. These enterprises are inequitable and inefficiently run. The failure of the public sector to manage the country's economy is attributable to several factors, including the lack of incentives for company managers to achieve maximum efficiency, low salaries for

both managers and workers which are not linked to performance and lack of trained manpower. Furthermore, the proportion of the private firms is small. The highly taxed private institutions did not perform efficiently because of low standards of quality (Porter & Chairman, 2006).

The American Federal Research Division (2005, p.7) followed up the reports issued by the U.S. government and concluded that over several decades the Libyan government has wasted a great proportion of the state's income on development programmes of weapons of mass destruction and conventional arms purchases, as well as the very big monetary donations granted to some developing countries. These policies were a part of Gaddafi's plans to control the region. In his report, Al-Ghwell (2013) confirms what has already indicated: "Libya needs to put together a vision and a plan for what Libya wants to be in 10 or 20 years from now. The first and easiest part of this should be an economic vision and strategy that will re-start the economy and offer real concrete hope and jobs for the large numbers of unemployed youth." Other statistics released by the United Nations Development Program (UNDP) are that the growth rate in Libya ranked 53rd out of 169 countries in 2010, before the Libyan war. In 2012 it ranked 64th out of 187 countries. This position is considered is very low in relation to the annual state income (UNDP, 2010, p.177 and 2013, p. 145).

As previously noted, after this recognition of the failure of many publicly owned enterprises, including those in the productive industries sector, the Libyan government started to encouraging the private sector through privatisation campaigns and eased the regulations, for example, exempting these institutions from taxes on income, allowing exports for five years without interest and allowing the importation of constituent equipment and materials for production without extra payments to the government (Ellabbar, 2007).

Despite the ongoing attempts to build an economy on a sound basis, the Libyan conflict which began early in 2011 had a negative impact on the Libyan economy, already faltering mainly due to the political climate during the Gaddafi regime. For example, the rate of oil production dropped from 1.7 million barrels per day (mbd) in 2010 to less than 0.5 mbd in 2011, and the rate of real GDP fell to about 62% of its previous total at the end of 2011. The real GDP from non-oil production fell by 50% because of the dependence of the economy on the oil sector. Nevertheless, the year 2012 has seen a remarkable

recovery from the civil war with an increase in oil production that reached to about 1.4 million barrels per day. This led to the underpinned growth of 100% of real GDP and the budget rose by 20.8% to a record level.

In 2013 the resulting optimism was unfortunately dashed due to the security turmoil in the country. Some militias and labour groups targeted oil facilities as a way of obtaining their political and economic demands. They managed to control a number of key oil sources. As a result, oil production dropped dramatically to 110,000 barrels per day and the value of revenue did not exceed \$13 billion throughout the second half of 2013. This led to the government's inability to cover expenses, forcing it to withdraw some of its international reserves to cover the deficit in the state budget. This lost \$7 billion a month of the foreign exchange reserves in the Central Bank of Libya in 2013 (The International Relations and Security Network, 2014). The arms proliferation has led to insecurity and hence most of the projects contracted under Gaddafi have been suspended, in addition to the problems that have accumulated since the previous era. For instance, many major projects such as railways projects have been damaged by financial and administrative corruption. The new government has been trying hard to re-establish security in which to exploit the oil wealth through the completion of stalled projects and to set up contracts to initiate new projects. For example, after the end of the war, the government has been monitoring a budget of 50 billion LYD (£25 billion) to develop the infrastructure of the country (Jabil, 2011 cited in Salem, 2013).

Through the above outline of Libya's economic issues since independence, it is clear that: the socialist transformation in the previous era accumulated a great many economic problems which together brought the country's economic activity to a state of paralysis. Heavy dependence on oil revenues led to the decline in productivity in the non-oil sector, such as other industries and agriculture. The contribution of non-oil industries to the GDP has never exceeded 20%. This percentage is considered very low in relation to the oil sector. The nationalisation of most of the industrial sector has had a significant impact on many areas. For example, the living standards of most Libyan people have declined, due to the low wages. In addition, a concentration on productivity became unnecessary because the government was responsible for paying the wages of so many employees. As a result, most

of the population have become a burden on the state because their source of livelihood was the low salary paid by the government. These and other factors have led to an absence of competition between private companies and thus their failure. But the advantage of its oil revenues has been the great earning power of the country. This has given it the chance to build a strong economy in a short time.

To sum up, it can be said that, over more than four decades, the Libyan industrial sector has been subjected to political, economic and social vagaries, which have precluded the building of organisational and management structures that could be relied upon in developing the state in general and the industrial sector in particular.

However, to clarify the connection between these issues and their direct and indirect effect on the Libyan industrial sector, the next chapter examines the industrial sector in Libya in general and the cement industry in particular as the setting of the case study.

Chapter Summary

This chapter provided a diagnosis of the current Libyan context. This is in order to get in-depth understanding and knowledge of the environment where the study took place. The chapter provides information about current geographical elements, historical and political background, social system and economic history in Libya which could affect the practices of maintenance and any improvement plans in the Libyan cement industry. The next chapter will discuss the maintenance practices and related issues in the Libyan cement industry.

CHAPTER 4: Maintenance practices in the Libyan cement industry

4.1 Introduction

According to Cambridge Dictionaries Online (2014), industry is “the companies involved in the process of producing goods for sale, especially in a factory or special area.” Gruneberg & Ive (2000. p.90) see industry as “a set of firms using the same specific types of resources of labour, equipment and technology: the supply side of a market is then a set of firms producing a product.” Through these definitions, it can be said that an industry is a way of in organising resources, production and business. Industry plays an important role in supporting the economy of any state. It can, for example, provide employment opportunities and thereby reduce unemployment, a resource for the investment of money and goods and services. The national income of a state increases through its industry and thus provides a better standard of living for its citizens. Indeed, a country which has no industry cannot develop economically and socially (Shridhar, 2009). Ferreira & Ferreira (2006) conclude that the importance of industry continues to increase because of its significant effects on the development of nations by improving living standards through providing jobs and increasing per capita income. This is confirmed by Jefferies (1969) who explains that industry is a key element in the development of a country’s standard of living. Business Case Studies LLP (2014) reports that the importance of the industry goes further than its contribution in building the economy. It supports many other activities, such as agriculture; for example, in the UK; industry represents about two-thirds of total exports.

4.2 Cement industry

Cement is a soft connector material. It changes to adhesive “glue” when mixed with water, giving it the power to hold the parts of a building together. Cement is used to make mortar and concrete, which are used for many purposes, such as holding together blocks and other building materials, and making surfaces and walls concrete. The ancient Egyptians, about 2,600 years ago, used a mixture of natural materials – lime, clay, sand and water – to make buildings. 600 years later, the Romans developed this industry by adding volcanic soil to make the mixture more cohesive (Klieger & Hooton, 1990 & Lafarge, 2014). In 1842 the English stonecutter, Joseph Aspdin, developed cement in his small

workshop, where he burned ground limestone and clay together and ground the mixture into a powder. Aspdin created a material which hardens when the water added to it dries. This invention was named “Portland cement” in reference to the English island of Portland. Aspdin’s invention was the basis of today’s Portland cement industry (Lesley, 1924; Ghosh, 1991 and Lafarge Building better cites, 2014). The work of this cement industry nowadays goes through three basic stages: crushing the raw materials, a thermo-chemical process and the final grinding of the cement (Tourki, T., 2010). In the first stage the raw ingredients of Calcium, Silica, Iron and other things are crushed. These materials are mixed and burned in a special oven called a rotating cement kiln. The output of the burning process is a number of small granules, called clinker. These granules are ground and mixed with other materials, such as gypsum and limestone, to obtain the final product (Lafarge, 2014 and Portland Cement Association Directory, 2014).

The cement industry is one of the oldest industries in the world. The demand for cement has been increasing over the past few decades and it has become the second material after water that is most consumed (World Business Council for Sustainable Development, 2002 and Tourki, 2010). The main reason for this, as reported by Portland Cement Association (2008), is that cement is the fundamental material for all types of construction, including housing, roads, schools, hospitals, dams and ports, which are the indispensable basics of life. The evidence for this is that the cement industry and /or its products are available in more than 150 countries worldwide, directly employing more than 850,000 workers (World Business Council for Sustainable Development, 2002). The importance of the cement industry continues to increase, as evidenced by the growing demand for this material. In 2000 the cement plants around the world produced overall around about 1.6 billion metric tonne (bmt) of cement. This number rose to 4 bmt in 2013. Table 4.1 and figure 4.1 shows the amounts of global cement production from 2000 to 2013 (USGS, 2013). The increasing demand for cement faces the cement industry with the major challenge of meeting it. For example, British cement plants produce only about 90% of the UK’s needs (Environment Agency, 2005).

Table 4.1: Global cement production from 2000 to 2013 (Source: USGS, 2013).

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Production amount(bmt)	1.60	1.70	1.80	1.95	2.13	2.31	2.55	2.77	2.84	3.06	3.31	3.6	3.8	4.0

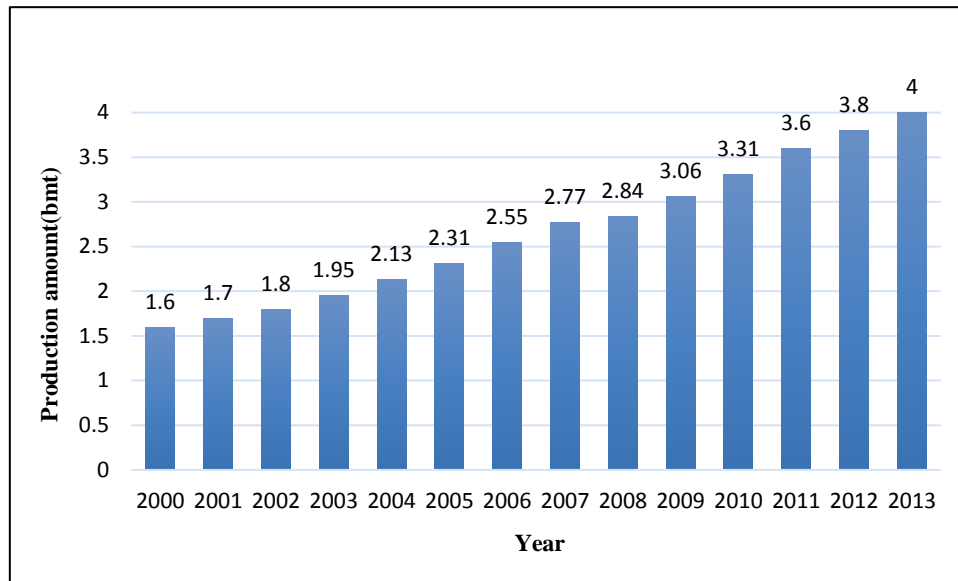


Figure 4.1: Global cement production from 2000 to 2013 (Source: USGS, 2013).

Despite the importance gained by the cement industry, it is capital-intensive, meaning that the costs of building a new cement factory can exceed 3 years of its total revenue following the start of production. Moreover, to produce one tonne of cement needs about 110 (KWh) kilowatts of electricity and about 60 to 130(kg) of oil fuel (World Business Council for Sustainable Development, 2002). Benzer et al. (2001) state that the cement industry is one of the biggest energy consumers in the world. It consumes about 2% of the electricity produced globally and approximately 1.5% of the total global fuel production. Nevertheless, the cement industry has a high level of competitiveness due to its strong indirect influence on the growth of the gross domestic production of many nations. For example, in the UK the cement industry represents less than 1% of UK economic activities in terms of the number of sites, employment used and trade, but it is the main supporter of the construction industry, which contributes about 10% of UK GDP (Environment Agency, 2005).

The cement industry has thrived and grown dramatically in Western countries because it developed there earlier than it did in other regions; however, the world map of cement has significantly changed over the past six decades. Its centre of gravity has moved from the West to the East or to the developing

economies. Production in Europe and the U.S. fell from 80% of world production in 1950 to 20% in the current decade. This is due to the continuous development plans in developing countries, including infrastructure and construction projects in addition to the availability of cheaper labour than can be found in the developed countries (Global Investment House, 2009).

In contrast, as reported by the same reference, the demand for cement in Jordan rose from 2.7 million metric tonne (Mt) in 2002 to 3.8Mt in 2005. Iran's demand for cement was about 31.5 Mt in 2005 and in 2008 reached 36.5Mt. In 2005 the Egyptian demand for cement was 23.6Mt, a figure which increased to 33.9 in 2008. Such increases require more attention to be paid to this industry.

4.3 The Libyan Industry

Studying the industrial sector in Libya allows us to identify the problems and barriers that hamper the development of the sector and thus enable us to find solutions to overcome these problems (Hokoma et al., 2006). Through the previous review of the Libyan economic context (see 3.5), it is clear that the Libyan economy is based on revenues from the oil industry. The non-oil industries are represented by agriculture and a few other industries such as iron and steel and cement. These industries contribute around 20% of Libya's GDP. Figure 4.2 shows the contribution of non-oil activities to the country's GDP. Researchers and economic experts believe that the weakness of the non-oil sector in Libya can be accounted for in several ways. Hokoma et al. (2010) see that the lack of planning strategies at all levels is one of the big barriers to the development of the industrial sector in Libya. A report issued by the Monitor Group (2006) states that Libya suffers from a lack of data systems in all sectors hence, reliable data either do not exist or are hard to access. The main reason for this, as seen by Otman & Karlberg (2007) is that the state has relied on socialist principles in building the economy and accordingly believes that production need cover only domestic needs to support the public sector. Formerly, as Gzema (1999) points out, state support for the private sector declined significantly after 1969 and dropped to zero in 1977, leading to the complete elimination of the private sector. This shift was the main reason for the collapse of the Libyan industrial sector.

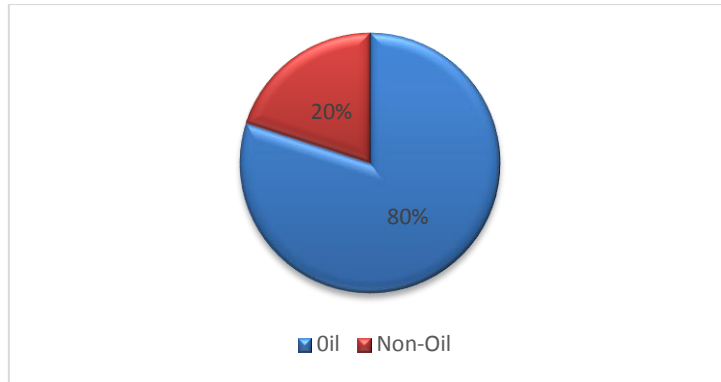


Figure 4.2: The contribution of non-oil activities to the country's GDP % (Source: World Fact Book, 2014).

Despite this, Libya has many advantages which if properly exploited would enable it to reconstruct its industrial sector. The availability of the capital represented in oil incomes is one of the most important of these advantages. It has a favourable geographical location, which connects Africa to Europe and in addition gives Libya the opportunity to be the commercial gateway between Europe and Africa. It enjoys the possibility of being global competitive due to the availability of the raw materials needed for many industries, such as cement and iron, together with the proximity of cheap sources of labour, such as Egypt and other African countries. The Monitor Group (2006) reports that if the available resources were properly exploited to invest in industrial infrastructure, rebuild skills and technically qualified personnel and open the door to competition with the world, Libya would have a very good chance of becoming industrially advanced. It seems now that the new Libyan government has become aware of the importance of exploiting these resources to build the Libyan economy. The Libyan Industry Minister emphasises that the non-oil industrial sector must play an important role in supporting the state's income and transforming it from an oil-based country to one with multiple sources of income. He maintains that the state must export finished goods rather than raw materials because the exporting of raw materials also exports opportunities such as job creation (Zaptia, 2013).

4.4 The importance of the cement industry in Libya

Although the direct contribution to Libya's GDP of the cement sector does not exceed 0.2%, it has a very heavy impact on the development of the country's natural and social environment. The main reason is that cement is considered one of the essential components for the construction industry, which matters

a great deal to both government and the people. It supports basic development plans through the government's investment in its construction and infrastructure projects and helps to build houses and small private projects at the individual level (Pillet et al., 2005). In Libya, more than 97% of the construction industry depends on cement or cement-based materials such as blocks (Ngab, 2005). This means that this industry continues to grow as long as the construction industry itself develops. Taib (2007) adds that the importance of the cement industry in Libya in addition to its cheap labour lies in the availability of raw materials of high quality. However, the actual production of cement in Libya started in 1969 with only about 0.33Mt/yr. In 2010, the production was close to 8Mt/yr. Figure 4.3 shows the quantities produce in the period 1990 to 2010.

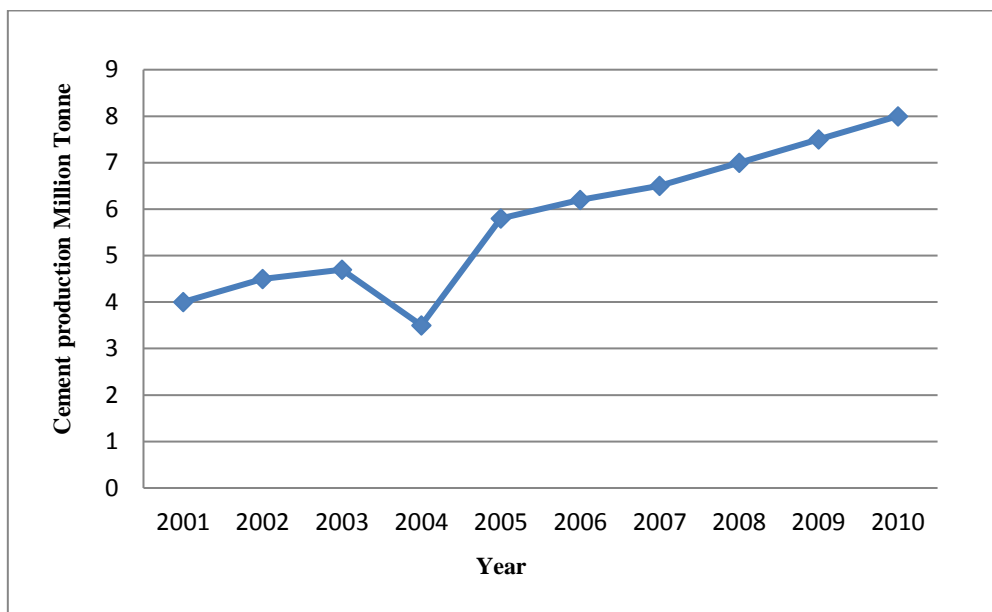


Figure 4.3: Cement production quantities in Libya from 1990 to 2010 (Source: Industrial Research Centre (IRC), Libya, 2010, cited in Shibani, 2012).

The important issue that should be mentioned here is that it is difficult to obtain actual statistics of the amounts produced, due to the lack of systems for collecting data on either government or industrial organisations. Edwards (2013) estimates that Libya's cement production reached more than 7Mt in 2010 and dropped to 3.5Mt in 2011, a decline of about 50% due to the Libyan war against Gaddafi. This decline indicates the damage to which some components of the production systems were exposed, due either to the destruction during the war or to the halts in production for a time. An effective

maintenance programme was needed to restore these systems to work as required. Graisa and Al-habibeh (2010) in their studies of the Libyan cement industry, expect that by 2012 the Libyan market will need about 15Mt of cement. Other estimates issued by Edwards (2013) are that cement consumption has reached 9.6Mt/yr due to the reconstruction of the country after the war. Although the above estimates are different, they are both considered valid to some extent. The reason is that Graisa and Al-habibeh build their estimates on pre-war conditions. Edwards' estimates are, however, closer to the situation at present, in which the security conditions which Libya has had to enforce have led to the failure of most foreign companies to return in order to complete projects contracted before the war.

The previous government had contracted a number of construction and infrastructure companies to complete projects. For example, in 2007, \$30 billion was allocated (£17.8b currently) to infrastructure and \$25 billion (£14.8 currently) to building about 500,000 residential units (Ngab, 2005). These projects were supposed to be implemented during the ten years after 2007. In 2013 the new government allocated other amounts, including \$13 billion (£7.7b currently) for the construction of 420,000 houses and \$14 billion (£8.3b current) to be spent on infrastructure (CemNet.com, 2014).

These huge investments have increased the importance of the cement industry in Libya, because it will be primarily responsible for providing the cement which is the fundamental material for carrying these projects out. Therefore, the cement sector should work as efficiently as possible so that it can meet these requirements (Ngab, 2005).

This was confirmed by Hokoma et al. (2006), who recommended that Libya should provide the technical and scientific support needed by the industrial sector, in particular, the cement industry to keep up with developments in the construction projects around the country.

4.5 The cement industry in Libya

Libya has eight factories spread over three companies (see figure 4.4), as follows:



Figure 4.4: Libyan cement factories locations (Source: Edwards, 2013).

The Libyan Cement Company (LCC) is located in the city of Benghazi in the north-eastern region and is designed to have a total capacity of about 2.8 million metric tonne per year (Mt/yr). The company has three factories, the Hawari plant, with a production capacity of one million tonne annually; the Benghazi Cement Factory, which is designed for a production capacity of 0.8Mt/yr; and the Fattaih Factory which was designed to produce 1Mt/yr (Arab Union Contracting Company, 2011; Libyan Ministry of Industry, 2013& Libyan Cement Company, 2014).

The Alahlia Cement Company (ACC) is located in the north-western region near the capital Tripoli. The company has four factories, the Zliten Cement Factory (ZCF) and the Lebda Cement Factory (LCF) designed to produce 1Mt/yr each. It also has the Souk Al-khamis Cement Factory (SCF) which was designed to produce 0.1Mt/yr. Almargab Cement Factory (MCF) with designed capacity of 0.33Mt/yr. The company also has some other facilities, such as its gypsum factory with a production capacity of 1Mt/yr. (The Alahlia Cement Company will be described in more detail below and in its own case study) (Arab Union Contracting Company, 2011; Libyan Ministry of Industry, 2013 & Alahlia Cement Company, 2013).

The Arab Union Contracting Company (AUCC), located in the Zliten region east of Tripoli has one plant designed with a capacity of 1.4Mt/yr. The company has ready-mixed concrete production line

which contains a series of mixers. Each mixer produces about 45m³/hr (Arab Union Contracting Company, 2011; Libyan Ministry of Industry, 2013).

4.6 Factories of Alahlia Cement Company (ACC)

The ACC is one of the largest cement companies in Libya, and the largest cement producer in North Africa. The company produces Portland cement, gypsum, lime, marble and cement bags in addition to prepared concrete mixtures. The company is designed to produce 3,33Mt/yr of cement included 1Mt/yr of gypsum. It is located in the north-west, near to the Libyan capital. It has four cement factories. The first factory was created in 1968, near Alkhumes city, 80 miles east of the capital. It is called the Margeb Cement Factory (MCF). It is designed to have a production capacity of 0.33Mt/yr. The second factory, named the Souk Al-khamis Cement Factory (SCF), lies 25 miles south of Tripoli. This factory was founded in 1977 with a production capacity about 1Mt/yr. The third plant was built in 1979 near Alkhumes city 90 miles west of Tripoli with a 1Mt/yr production capacity. It is named the Lebda Cement Factory (LCF). The Zliten Cement Factory (ZCF) is the fourth factory, with a production capacity of 1Mt/yr. It located in Zliten city about 103 miles east of the capital and was founded in 1984 (Graisa, 2011 & Alahlia Cement Company, 2013).

All these factories adopt the so-called dry process in the manufacture of cement. Figures 4.5 and 4.6 give a simplified picture of the production process in LCF; all factories have the same method of production. The process begins by collecting the raw materials from their sources and transporting them to a special place for assembly. The mixed materials are then broken into small pieces using a crusher. The next step is storage and additions. The raw materials in their final form are milled in a special grinder. The ground materials are next transported to a convection oven for thermal treatment to obtain the primary product. This product is ground with other materials, such as gypsum. The product in its final shape is transported to the packing station to be distributed to consumers.

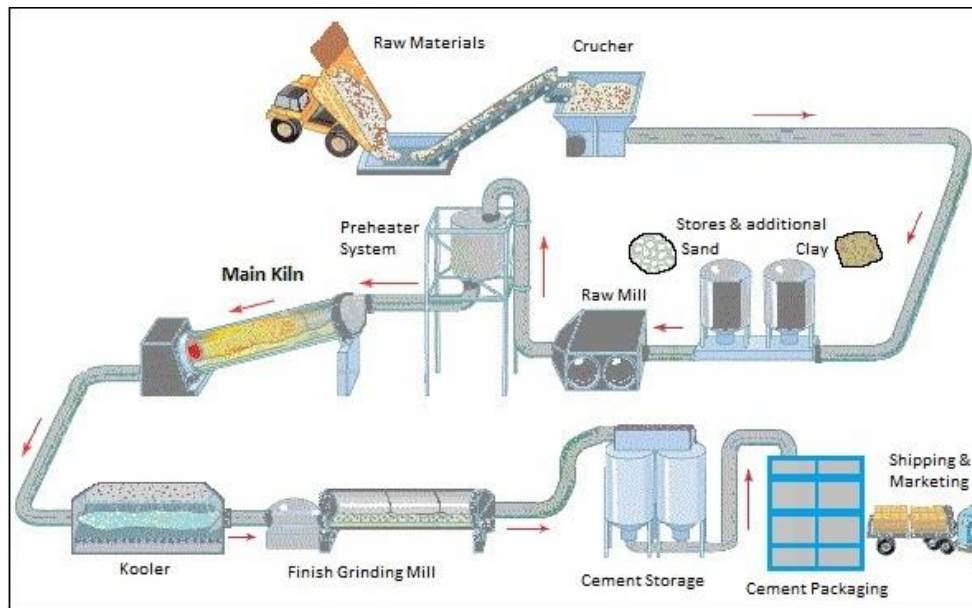


Figure 4.5: Cement production Process (Source: Author based on Graisa, 2011).

4.7 Management issues for the factories of Alahlia Cement Company

Competitiveness is an indicator of the strength of organisation performance, therefore the successful management of any industrial organisation looks for ways to increase the efficiency of the company and tries to avoid or deal with any obstacles (Essmui et al., 2013). This says in other words what Azizul Baten et al. (2006) mean; they state that the efficiency of the organisation reflects the success of the management in leading the institution. Although the cement industry has a promising future because of the availability of its requirements such as raw materials and cheap energy sources, its progress faces some problems and obstacles.

One of these obstacles is its centralised management which completely controls all the company's factories. In other words, orders come directly from senior management, without reference to the relevant sections of authority in each plant (see Graisa, 2011). Figure 4.6 shows the management structure of the Lebda Cement Factory as an example (since all factories have the same management structure). The figure gives a clear idea of the degree of centralisation. For example, the production management and maintenance management are directly linked to the top management, and there is no link to coordinate the interests of production and maintenance. This leads to low reliability in the production lines and therefore an inability to fulfil even the demands of the local market.

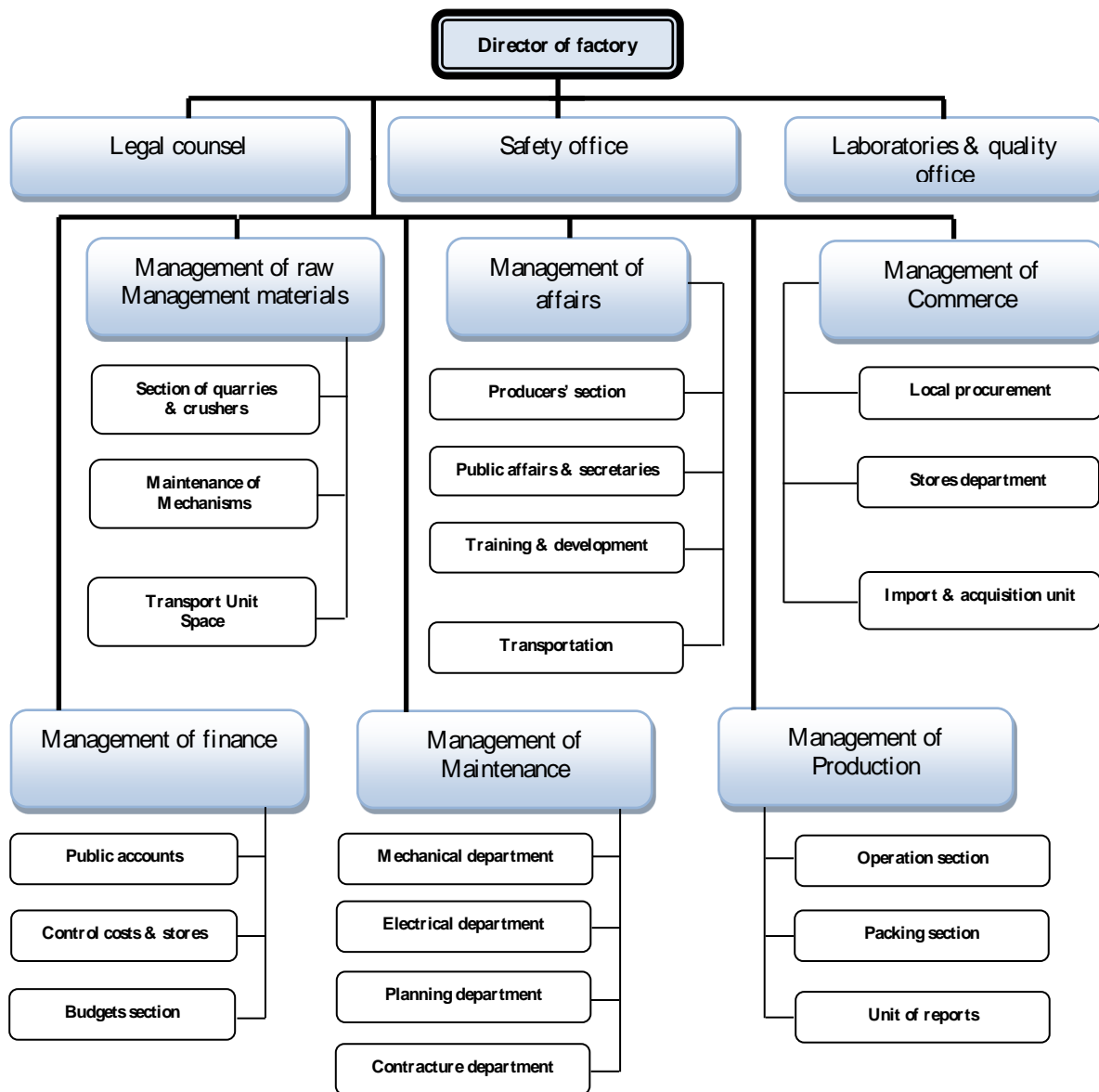


Figure 4.6: The organisational structure of the Lebda Cement Factory (LCF) (Source: RPA, 2006 cited in Graisa, 2011).

Elmagri (2013) explains that the main reason behind this is the centralised government in Libya. This has led to the weakening of the performance of the company's factories and in turn to poor production. Hokoma et al. (2008) see that the Libyan cement industry lacks technical expertise and trained personnel. This is due to management weakness in terms of fulfilling the conditions of running production systems. Furthermore, Essmui et al. (2013) confirm that when 207 Libyan companies were examined it was found that more than 83% of them suffer from a weakness of managerial performance. Socio-cultural factors, as discussed in 3.4, further undermine the industry. The social structure in Libya

is based on tribal traditions which play a major role in Libyan life. Most Libyans believe that affiliation to the most important tribe affiliates them to their jobs, because it is through the authority of the tribe that a job or high position can be obtained. In addition, it guarantees that they will keep their job despite their inefficiency. The report issued by IMF in 2006 finds that the greatest challenge facing the industry is the Libyan bureaucracy, in which tribalism is embedded. This has been entrenched in Libyan minds for more than 30 years. Agnaia (1997) finds that family ties and personal relationships play a bigger role in the selection of managers and workers than qualifications and experience do. Such features have a negative impact on the country's development. Graisa & Al-Habaibeh (2010), in their field visits to cement plants in Libya and the United Kingdom, noted a great difference between the two countries as regards their cement industry. For example, workers in Libyan factories have little environmental awareness and sense of industrial cleanliness. They also lack a competitive spirit and the ambition to develop their individual skills. Behind this lies a lack of effective training programmes and of incentives and encouragement.

This can be re-expressed as follows: the failure to apply specific criteria for choosing managers and employing workers led to the employment of incompetent managers and workers. As a result, management performance and that of ordinary employees have clearly shown weakness. Moreover, the tender proportion of staff, managers and workers is usually at the lowest level due to the dependence on the tribe's support. This is confirmed by Agnaia (1997) most employees, he says, spend a good part of their working time on interviewing their visitors or finishing other jobs such as shopping, which is considered a form of social activity. This means that there is no compliance with official working time which causes much delay in business implementation. Elmagri (2013) adds that some factors affect the performance of the cement industry in Libya, such as the unfair treatment of employees, tribal fanaticism and mismanagement as a result of choosing incompetent managers, in addition to the contradiction between the organisation's policy and the laws of the state.

Tourki (2010) noted that executive directors in top management are not keen to participate in the adoption of new projects. This is due to the lack of education and skills and also to the lack of incentives. These issues have had a damaging impact on the Libyan cement industry. Essmui et al. (2013) believe

that today's competitive environment imposes the obligation on industries to achieve full productivity while minimising spending. From the perspective of maintenance, this means increasing the reliability of production equipment by extending its life while maintaining the required level of performance. Extending the life of a machine means that it must constantly undergo maintenance. Cassady et al. (2001) agree, believing that successful industrial organisations are the ones which recognise that the presence of effective maintenance programs is essential to the success of maintenance. These programmes usually depend on the application of predict and prevent failure strategy rather than fixing. Lack of attention to maintenance is usually costly, for large facilities in particular. States and organisations which do not give enough attention to the maintenance usually incur significant losses. For example, maintenance costs about 40% of the total operating costs in the Nigerian industrial sector. The reason for this is the lack of sufficient understanding of the importance maintenance on both levels, managerial and workers (Ogajl & Probert, 2006). In the cement industry, the estimates indicate that approximately 20%-25% of the total production costs are spent on maintenance activities (Al-Muhaisen & Santarisi, 2002). Ogajl & Probert, (2006) see that the determination of appropriate maintenance systems can play a big role in the success of maintenance and thus raise the efficiency of the production system. Identifying these systems mean planned maintenance instead of reactive maintenance which is often ineffective. Planned maintenance takes the trouble to consider the internal and external factors of the organisation. Today's challenge is to change cement production systems from simple traditional mass production to the more effective systems in order to improve overall system performance and thus increase productivity, in addition to maximising the use of the available capacity, human and material, to meet the growing demand for cement (Tourki, 2010).

The factories of Alahlia Cement Company, like many other Libyan companies, suffers many problems in its production systems, due to the missing or poor maintenance. This can be seen in the performance weakness of the company's factories. Hokoma et al (2008), in their study of Alahlia's cement factories, found that no maintenance strategies at all were applied. This was confirmed by Graisa (2011), who writes that in the four company plants, the only approach used at factory level was "if there is a problem, fix it".

Hayes & Pisano (1996) claim that one of the reasons for maintenance failure is the lack of harmony between employees and senior management, which derives from the culture of Libya, in which is considered unacceptable to implement the orders of other people. According to the company's official website, the maximum amount of output achieved in 2008 was 2.5Mt. This number is less than 70% of the capacity for which the plants were designed. This amount includes ready-mixed concrete and gypsum (Alahlia Cement Company, 2013). The Executive Director of the Libyan Cement Company, in an interview, said that the company's factories could not produce more than 50% of the design capacity. Many production lines either needed to be renewed or to have some of their components replaced. He added that the reason for this was poor maintenance or the application of ineffective maintenance strategies, such as running to failure (World Report, 2004). In the same context, the executive director of one of Alahlia Cement factories mentioned that many of the of production systems components have become dilapidated and need to be changed because of poor or missing maintenance in the past decades. Managers are inexperienced and workers need to be trained, otherwise the application of maintenance inevitably fails (Alsellani, 2011). This is evident from the low levels of production. According to the company's website production declined to 1.3Mt in 2012 (Alahlia Cement Company, 2013).

From the above, it is clear that the firms of Alahlia Cement Company have no clear maintenance strategy, which means that it has no clear maintenance goals. The decline in productivity levels clearly indicates this. Running to failure is the only approach adopted and even this approach is not well thought out. It is only when production systems stop that the company is forced to do maintenance work. The issue here is not the lack of maintenance strategies in itself, but the reason why there are none.

Graisa & Al-Habaibeh (2010) believe that the barrier to the proper application of maintenance is the lack of effective training programmes in maintenance techniques, which would aim to make workers more aware of the importance of maintenance and the strategies for carrying it out, apart from the failure to record for future use data on the maintenance currently being applied. A study by Shibani (2012) clarifies that the policy of keeping production just ahead of domestic demand led to a lack of competition between cement companies, both nationally and internationally which led to a decline in

production rates. Elmagri (2013) states that the poor performance of the cement industry results from poor maintenance. This is due in turn to poor management, the unfair treatment of employees and tribal fanaticism. These points can be designated cultural factors. The author's experience for more than 10 years as an engineer in the Libyan industrial sector confirms the lack of maintenance strategies which could be relied on in undertaking maintenance. The main reason for this is that most employees (workers and managers alike) misunderstand what the term 'maintenance' and how it can be applied. This basically results from recruiting most managers and workers on the basis of nepotism without at all considering either their qualifications or how far the organisation needs them.

However, as part of an attempt to overcome the maintenance problems in the Alahlia Cement Company, Graisa (2011) tried to implement the Total Productive Maintenance (TPM) strategy in the company's factories, but with limited success for several reasons, including the lack of senior management support and the failure to provide sufficient funding for maintenance. Moreover, the tasks are haphazardly distributed and the administration takes an irresponsible attitude to dealing with maintenance as an important element in ensuring continuity of production. Graisa applied TPM, counting on its success in Japan without studying the factors that can affect the success of TPM in Libya. As well as not identifying the maintenance requirements and the lack of resources, the Libyan culture, for instance, considers that the participation of managers in maintenance is unacceptable. In this regard, it can be found also that the application of TPM failed in the U.S. because of the prevailing belief that maintenance was the responsibility of maintenance workers alone and that operators and managers had nothing to do with it. This approach is quite different from that taken in Japan, where the culture favours teamwork (Dowlatshahi, 2008 and Maggard & Rhyne, 1992). This is confirmed by Williamson (2000) and by Baluch et al (2012) who state that the rate of failure in U.S organisations which have tried to apply TPM and not taken account of elements in the maintenance environment such as the community culture is more than 50%. The foregoing shows clearly that the application of maintenance without a planned strategy will inevitably lead to failure. Production systems in cement plants in Libya need to be at a high level of reliability. This is in order to ensure the continuation of production so that they can cover domestic demand and thus access foreign markets. In other words, the components of the

production systems, in particular, those which have a direct impact on production, must be highly reliable. In this context, Tourki (2010) emphasises that cement plants which seek to compete with others must give more attention to the components of their production lines to avoid unplanned failure during the production process. On this basis, Blanchard (1997) and Ireland & Dale (2001) believe that identifying the consequences of failure is very important for increasing the reliability of the system. This means that a focus on raising the profile of the consequences of failure in the components of the production system will help to ensure the success of maintenance at less cost. In order to keep the cement industry capable of competing, the efficiency of the plants should be maximised and their operating costs reduced. In this case, the production systems must be highly reliable so as to ensure continued operation (Environment Agency, 2005). Shafeek (2012) agrees with this; he believes that the continuity of productivity in modern cement plants depends on the reliability of the components of their production systems, which can be achieved through planned maintenance.

The above discussions imply that the cement industry in Libya has a promising future owing to the availability of raw materials, its excellent geographical location and its capacity to provide manpower, either national or foreign, trained with state support in the form of training programmes. Furthermore, Libya's massive oil income can be exploited to support the industry through the development of existing plants and the establishment of new factories. The industry could then consider the possibility of entering an open competitive market whether local or global. These and other factors give Libya's cement industry a great chance to be successful.

Nonetheless, the cement industry still continues to lag behind and faces many obstacles to its progress, for example, the failure to train current employees and accustom them to up-to-date methods so that they could perform their work of operating production systems as efficiently as required. In addition, poor maintenance in itself is one of the biggest barriers facing the development of the cement industry, which reveals a lack of understanding of maintenance in terms of its types, strategies and requirements. This has led to the widespread inability to properly deal with maintenance.

As a result, some of the company's factories operate at less than 50% of their designed production capacity. This is a great loss to the economy, given the high costs of setting them up. The failure to

implement maintenance properly has also led to reduced levels of reliability in production systems and in turn to the fluctuations of output. This study seeks to investigate the barriers and problems which hinder the success of the maintenance strategies applied in the factories of the Alahlia Cement Company in Libya through suggestion of RCM strategy as one of the solutions that could ensure the operating continuity of production systems at high efficiency and thus continued productivity while maintaining the quality of the output.

Chapter Summary

This chapter has provided an insight into the related managerial issues in the four Libyan cement plants. The intention being to discover top management interest in respect of maintenance practices and how the managerial performance could affect maintenance activities in these factories. This chapter explores management power in driving these firms and discussed the management structure of LCF given that all the four factories adopted nearly the same managerial structure. Also, it discovered the impact of the state's laws on the managerial performance and thus on maintenance practices in the Libyan cement plants under investigating by exploring the difficulties associated with maintenance improvement from maintenance management perspective. The following chapter presents the methodology that was employed to achieve the aim and objectives of this research.

CHAPTER 5: Research Methodology

Introduction

The main aim of this chapter is to describe and discuss in detail the research methodology used in the present study. This chapter states the philosophy of the research and then moves to the reasoning behind it. Next, it discusses the research approach and strategy of the research. The choice of single case or multiple case studies is also examined. This chapter deals also with the design of the research and the pilot study. Evaluating the credibility of the research and its methods of data analysis are discussed at the end of the chapter.

5.1 Research philosophy

According to Bajpai (2011), the philosophy of a research study is its method of dealing with its sources, its nature and the development of knowledge. Easterby-Smith et al. (2002); Crossan (2003 and Saunders et al. (2009) state that articulating the philosophy of the research can help in several ways. For example, the research method to be used will be clarified by understanding the research philosophy. Consequently, the easiest permissible ways of gathering sufficient evidence are used to answer the research question(s). Moreover, it helps researchers to deal with different types of methodology and to avoid unrelated or inappropriate work. Finally, researchers can be more creative and exploratory in their methods if they have a wide understanding of research philosophy. Collis and Hussey (2013), Yin (2009) and Saunders et al. (2012) argue that there is no general rule for selecting a research philosophy. It all depends on the scope and nature of the study, the research aim and objectives, the research hypotheses and/or questions, the data sources and the research limitations. In the literature of research, according to Saunders et al., (2009) and Collis and Hussey (2013), positivism and interpretivism are the two main types of research philosophy.

Positivism holds that reality is stable and can be observed and described from the standpoint of objectivity. Therefore, the knowledge gained through precise empirical observation is trustworthy. In this philosophy, the researcher's role is limited to data collection and interpretation and the research results are usually observable and quantifiable (Levin, 1988; Hallbone & Priest, 2009; Saunders et al., 2009 and Collins, 2013). Interpretivism, in contrast, holds that reality can be fully understood only

through the subjective interpretation of and intervention in the various different elements of research (Myers, 2009). Therefore, the researcher should have a full understanding of and ability to address the phenomena, the influencing factors and the differences between people in their natural environment (Saunders et al., 2009). The literature suggested that pragmatism represents the best philosophy to adopt for the present study. Hence, more details and discussion of this philosophy are presented in the following chapter.

5.1.1 Pragmatism as a Research Philosophy

Pragmatism, according to James (1909) is a philosophy of research; it is a responsible and logical way to deal with the problems that exist in a particular situation instead of relying on ideas and theories. Peirce (1905) explains that the focus of pragmatic philosophy is not on practical results but on logical method. It tends to promote a realist rather than nominalist acceptance of the world of everyday, common-sense experience. James (1909) and Gutek (2013) mention that pragmatism rejects the idea that the function of thought is to represent, describe or mirror reality. Saunders et al. (2009) emphasise the existence of many different approaches to understanding and interpreting the world and undertaking research. These authors believe that no single viewpoint can ever give a complete image and that there may be more than one reality. Although positivism and interpretivism are the two basic paradigms and the most widely adopted in research, seasoned researchers need to revise assumptions of their philosophical stance and, over time, move to a new position on the continuum (Collis and Hussey, 2013). Pragmatic researchers, at least, those who are seen as experienced researchers, have modified the philosophical hypothesises (Lodico et al., 2010).

The philosophy of research, according to the pragmatic research philosophy, is mostly determined by the research question. In the pragmatics paradigm, both positions, positivist and interpretivism, can be combined within the scope of a single research study, according to the nature of the research question (Saunders et al., 2009).

As shown in Table 5.1, pragmatism, unlike the interpretivist and positivist research philosophies, can combine more than one approach and strategy of research within the same study.

Table 5.1: Positivism, interpretivism and pragmatism (Source: Wilson, 2014).

	Research approach	Ontology	Axiology	Research strategy
Positivism	Deductive	Objective	Value-free	Quantitative
Interpretivism	Inductive	Subjective	Biased	Qualitative
Pragmatism	Deductive/Inductive	Objective and subjective	Value-free/biased	Qualitative and/or quantitative

Pragmatism as a philosophy is concerned about identifying what works rather than focusing on whether the research is describing an objective or a socially constructed world. What is, works. This means that knowledge and understanding can arise from investigating problems and clearly determining what works in a particular situation. The existence of one or more reality does not matter as long as the answers that can help what should be done to be done are discovered (Powell, 2001; Lodico et al., 2010 and Bacon, 2014). Pragmatism usually adopted more than one approach to collect the data that need to be studied, which are collected by mixed methods (Creswell & Plano Clark, 2007). According to the above discussion, the present study is capable of a mixed methods approach, and pragmatism has been described as the appropriate philosophical dimension for it.

5.2 Research Approach

In the social sciences, while interpretivism and positivism are represented by two research approaches, qualitative and quantitative, respectively (Easterby-Smith et al., 2002; Yin, 2009; Hussey and Hussey, 1997), Johnson and Onwuegbuzie (204) have described mixed methods research as appropriate to pragmatism. The next section presents the both methods, quantitative and qualitative.

5.2.1 Quantitative and Qualitative Approaches

According to Rees (2011, p44), the qualitative approach is “a systematic, subjective approach used to describe life experiences and give them significance. It is a way to gain insights through discovering meaning.” The qualitative research adopts methods of generating data which are sensitive to the social context. It usually emphasises words rather than numbers in the collection and analysis of data (Phillips & Pugh, 2005). This approach is used when the intention is to extract the opinions of experts and specialists in the field of research. It uses inductive reasoning to generate ideas or to derive them from the data (Thomas, 2003). In contrast, the quantitative approach usually assumes the existence of

objective reality. This kind usually focuses on accurate measurement and the use of numbers to explain a particular phenomenon; it asks particular questions which seem immediately suited to being answered (Thomas, 2003). Quantitative research relies on deductive reasoning, which uses the theory of the study to develop a hypothesis and then collects and analyses the data through which the hypotheses can be tested (Guindon, 2011). These two approaches could be combined in a mixed method to provide a better understanding of the research problem and tackle the research question from many angles. The present research has been carefully designed in order to meet the time-scale of a PhD thesis; hence, a mixture of methods is seen as the most suitable approach to collecting its data. Through such an approach, according to Bryman (2015), more in-depth information can be gained to explore or investigate the factors that affect the case under scrutiny. In addition, it can help in extracting more accurate insights, findings and recommendations (Amaratunga et al., 2002; Easterby-Smith et al., 2002 and Jankowicz, 1993). Moreover, as Creswell & Clark (2007) state, a mixed methods approach can be used to triangulate the data, by combining the quantitative and the qualitative methods to address or study the same phenomenon.

5.2.2 Mixed Methods Research

According to Johnson & Onwuegbuzie, 2004 and Lodico et al., 2010), the mixed methods approach is mostly used by pragmatic researchers because it allows both quantitative and qualitative attempts to answer the research questions. Therefore, both techniques can be combined in creative ways to more fully respond to the research questions. These authors add that mixed methods is an eclectic, innovative and unrestrained form of research, which attempts to give proper answers to the research questions through legitimising the use of multiple approaches in a single study. Johnson and Onwuegbuzie (2004) also state that, in its recent history the behavioural and social sciences began to use mixed methods because researchers believed that the viewpoints and methods of both the quantitative and qualitative approaches could answer the research questions correctly and appropriately.

Subarna (2015), in her study of engineering education for sustainable development, concluded that the mixed methods approach, in contrast to the employment of either research approach on its own, would

more inclusively represent the field. The combination of quantitative and qualitative approaches would enable the researcher both to depict trends and to understand in depth the participants' perspectives. The multiple pragmatic and practical means of mixed methods research would help more than a unitary approach would to understand the research problem. Moreover, the comparison, validation and converging of the results of the research would be easier if mixed methods were used. By using many quantitative and qualitative sources the needed data for the study could be gathered which would assist in problem-solving. Moreover, Johnson et al. (2007) state that the identity of mixed methods research is distinct and different from the quantitative and qualitative approaches since it combines them both. Given the above, mixed methods was chosen as the research approach with the aim of understanding in depth the studied situation, which in turn would help in problem-solving in the cases under review.

5.2.3 Sequential Explanatory

Looking at the continuum shown in Figure 5.1, mixed research can be seen as including several overlapping groups of mixed methods. In the centre is what is called a pure form of mixed methods where both approaches are employed equally. According to the same figure, qualitative research, mixed research, and quantitative research are the three major homes, and it is logical that, out of these three homes, one primary home can be adopted in a given study. However, visiting other homes could also be logical when such a visit can help the study (Johnson & Onwuegbuzie, 2004). Qualitative- dominant mixed methods research is another type of mixed methods research. In this type, qualitative prevails in the research. Mixed method research can also be quantitative dominant. In this case, the research relies on the quantitative approach, but it still employs qualitative data as another source of information to benefit the research. This is the type used in the present study, given that in-depth information is needed to increase understanding and help solve problems; this can be obtained only from specialists. According to Creswell et al., (2003), this design of research called 'sequential explanatory'. What is proposed is to use the results of a qualitative approach to help explaining and interpret the findings of a quantitative approach. This means that the collection and analysis of quantitative data in the first stage is followed by the gathering and analysis of qualitative data. In this design, a general picture of the

research problem is provided through the quantitative data and results. The qualitative data and results are followed and in the second stage used to refine and explain those statistical results through exploring in more depth the views of the participants regarding the research issues or problems (Tashakkori & Teddlie, 1998 and Creswell et al., 2003).

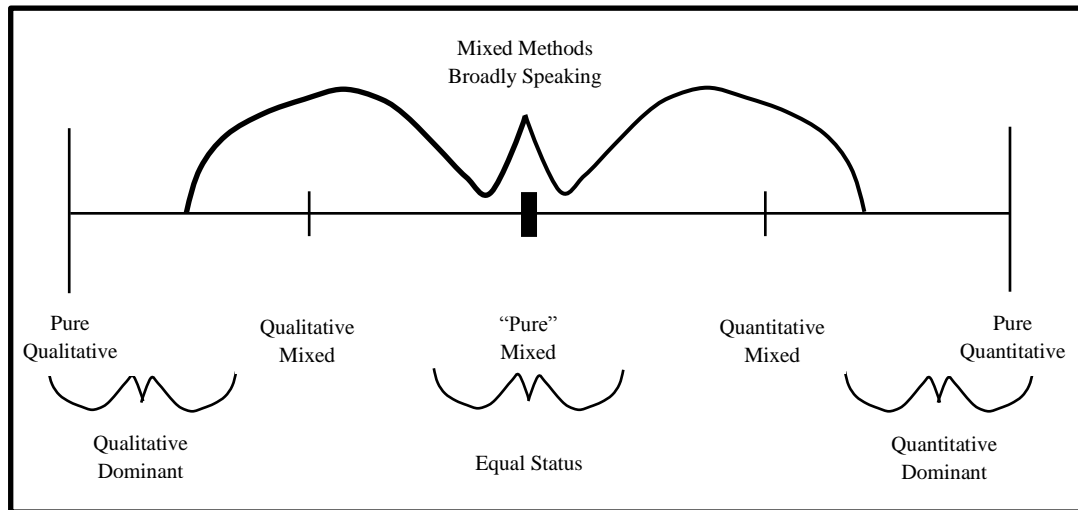


Figure 5.1: Graphic of the Three Major Research Paradigms, including Subtypes of Mixed Methods Research (Source: Johnson et al., 2007).

5.3 Research strategies

The strategy of the research refers to the plan for answering the research questions in order to achieve the objectives of research (Saunders et al., 2009). The research strategy is the systematic process of conducting research. It includes all the procedures adopted to collect, analyse and interpret the needed data (Cavana et al., 2001). Thus it can be said that the strategy of the research is the methodological link between the philosophy adopted for the research and the methods used to collect and analyse the data. Denzin and Lincoln (2011) support this; they say that the methodological link between the research philosophy and the subsequent methods for data collection and analysis could be considered the research strategy. According to Saunders et al. (2009) and Yin (2009), surveys and case studies are the two main research strategies.

5.3.1 Survey Research

Survey research is a method used to extract specific data about a research subject through sampling a representative population in the targeted field of study (Sapsford, 2007). Using surveys allows

researchers to collect data from small or large populations and can be done by means of either questionnaires or interviews (Saunders et al., 2009). Tanur (1983) defines a survey as an established procedure for collecting information about the opinions or characteristics of a determined group of people, referred to as a population. The questionnaire is usually the main tool for collecting data in large-scale surveys (Simon et al., 2012). Many issues can be measured by using surveys, such as beliefs, attitudes and preferences, past experiences, future predictions and levels of knowledge. Strauss & Corbin (1990); Dillman (2000); and Yin (2009) note that much care must be taken when developing and using surveys in order to get useful information.

The survey strategy was used in this research because it was believed that, as discussed above, it allows the characteristics of a large population to be described in one study. It also ensures a more accurate sample from which to gather targeted results, permitting conclusions to be easily drawn and major decisions made in problem solving in the research. The anonymity of surveys gives the targeted respondents more confidence, hence the answers are more candid and valid, which makes the collected data more accurate.

5.3.2 Single Case or Multiple Cases

Hartley (2004) defines a case study as a strategy to undertake research within the natural environment of an organisation and without any external influence on the participants in order to obtain correct and accurate information about the organisation. Oates (2006) and Saunders et al. (2009) state that case study strategy aims to gain an in-depth understanding of the study subject and thus contribute to the existing knowledge. Robson (2002) maintains that appropriate solutions to a research problem can be provided in different disciplines using the case study strategy. According to Yin (2009), a case study can be conducted in one or more than one organisation. Therefore, it can be classified into two types, namely, single case studies and multiple case studies. The single case can be used when the aim is to study and understand a particular phenomenon, an extreme or unique case without conducting any comparison of the studied phenomenon in another institution (Yin, 2009). Although a greater in-depth understanding of the studied situation can be obtained through adopting a single case study, the

possibility of generalising the conclusions drawn is very limited Voss et al., 2002). On this basis, Yin (2009) says that researchers who believe in the superiority of the single case study should provide a strong justification for this choice. This is supported by Lee (1992), who believes that using multiple case studies can replicate the findings and theoretical generalisations can be supported. Multiple case studies involving more than one organisation allow in-depth comparison to provide a wider understanding and thus help to find appropriate solutions to the research problem (Oates, 2006). In view of the above considerations, multiple case studies were seen as the most appropriate strategy for this research. They replicate the same phenomena in different contexts; the targeted problem involves four factories, all of which were studied. To sum up, with the use of these two strategies a very formal judgment could be made since together they provided an in-depth knowledge of the subject.

5.4 Data Types and Data Collection Methods

5.4.1 Secondary Data

According to Saunders et al. (2009) and Jain (2016), secondary data are the data that have already been obtained by another source (someone else). This means that somebody else has collected and analysed these data. Saunders et al. (2009) add that secondary data can be found in many different forms, such as books, journals, magazines, archives, internet sources and social networks, etc.

5.4.2 Primary Data

Primary data are data that did not exist before; they are collected afresh and for the first time and therefore are in their original state (Currie, 2005). According to Blaikie (2009) and Freise (2014), with primary data, more focus can be put on specific subjects related to the research problem which might help to furnish appropriate answers to the research questions. Questionnaires, interviews and direct observation are some of the main sources of primary data (Graham & Cook, 1996; Struwing & Stead, 2001; Shah et al., 2008 and Mooi & Sarstedt, 2011).

5.4.2.1 Questionnaire

The questionnaire survey is one of the most widely used research strategies to collect data. The greatest use of questionnaires is made within surveys in the fields of management and business (Saunders et al.,

2009). Questionnaires are considered an effective way of collecting responses before quantitative analysis. This is because a large number of people can be asked to answer a set of questions and each person (participant) should respond to the same set of these questions (Bernsen and Dybkjær, 2009). Compared to other techniques of collecting primary data, using questionnaires is inexpensive. Moreover, it is easy to get quick responses at the same time using questionnaires (Oppenheim, 2000). However, according to Cummings and Worley (2009), adopting the techniques of the questionnaires can be a risk since some participants do not show a true responses and/or may not return questionnaires on time. In addition, respondents have little opportunity to ask for more clarification if they are in doubt. It can be summarised from Taschereau (1998) that some points need to be focused on if a questionnaire is to be successful. First, the questions in the questionnaire should not contain a double meaning. In addition, the questions should be written simply to make them clear and understandable for everyone. Last but not least, the ethics of research should be followed, and the language of the questions should not be humiliating. Thus, in the present research, the questionnaire has been used as the main approach to gathering the primary information, since these data need a large number of participants to yield trustworthy results. Moreover, in the present research it was necessary to capture the vision and beliefs of the shop floor maintenance staff who are supposed to be familiar with maintenance in the targeted cement factories.

5.4.2.1.1 Questionnaire Types

Saunders et al. (2009) state that designing a questionnaire varies according to the way in which it is to be administered and the amount of contact that can be made with the respondents. Questionnaires can be administered in many ways: electronically, using the internet which is called Internet-Mediated; by post, where the questionnaires are posted to the targeted respondents who return them by post; or by delivery and collection, where a questionnaire is delivered by hand to each respondent and collected later, also by hand. In this research, delivery and collection of the questionnaire was chosen, due to the inability to use the post to deliver the questionnaires and the low reliability of data collection sites on the internet.

5.4.2.1.2 Questionnaire Design

The questionnaire's design and structure can have a direct impact on the response rate and validity and reliability of the received data (Saunders et al., 2009). Therefore, it is very hard to create a good questionnaire, as researchers discover. The collected data need to be precise if they are to answer the research questions and achieve their objectives (Oppenheim, 2000 and Bell & Waters, 2014). Gillham (2008, p10) says that " few people are strongly motivated by a questionnaire unless they can see it as having personal relevance, e.g., gathering information and opinions on job organisation, status and salary, or related to a topic of real importance". Saunders et al. (2009) emphasise that the response rate and the reliability and validity of the collected data are affected most by the design of the questionnaire. Therefore, the questionnaire should be carefully designed in every individual question; have a clear layout; lucidly exploit its purpose; be pilot tested and be carefully planned. All the questions of the questionnaire in the present study were originally deduced and designed in light of the literature on maintenance in Chapters 2, 3 and 4.

It was a big challenge in the present study, to construct a valid and reliable questionnaire that would help to answer the research question properly. This was because of the critical situation regarding the cultural, social, political and geographical issues in Libya which have already been discussed in Chapters 3 and 4. One of these issues, for instance, is the structure of Libyan society, which mainly rests on a tribal lifestyle. This lifestyle permeates people's behaviour and their dealings, making loyalty to the tribe the most important aspect of any decision. This makes Libyan people cautious in dealing with others. In addition, there are demanding geographical conditions, such as the wide extremes of temperature, very cold in winter and very hot in summer. Moreover, most of Libya's territory is desert, which makes the movement of people, animals and goods very difficult, especially in the absence of effective transportation such as trains. This generates a certain stubbornness of character; consequently, more effort than usual is needed to thaw communication with Libyans and make it as easy as it should be. Moreover, successive political factors over hundreds of years, such as incompetents usurping senior positions in the State, have destroyed citizens' confidence in each other, especially when they are facing someone in authority. The lack of data in the four factories regarding maintenance practices and

productivity was another obstacle encountered in putting the questionnaire together. The availability of certain data had to be used as a guide in generating the survey questions. These issues made some questions in the questionnaire very sensitive, a problem which was not easy to overcome. Therefore, in choosing and phrasing the questions to align with the research objectives, it was critical to take into account all these factors, rather than simply following a well-known method such as using a Likert scale.

5.4.2.1.3 Questionnaire Structure

In light of the above discussion, and in order to obtain the most useful answers, the respondents had to be able to understand easily the purpose of the questionnaire. Therefore, and in line with the research aim and objectives, the questionnaire was divided into three sections (see Appendix 5) as follows:

Respondent's background: this section focused mainly on the experience, qualifications and official position of the respondents. The intention here was to have a clear view of the positions of the respondents, since it was believed that such statistical data could affect both the maintenance practices in the cement factories of the study and the reliability and validity of the questionnaire.

Maintenance practices: questions about the maintenance activities were included in this section to measure the efficiency level of the respondents regarding the application of maintenance. In addition, the purpose was to check whether the respondents had a clear understanding of maintenance and its practices which would enable them to carry it out properly.

Management issues: this concerned matters that relate to maintenance practices and would help assess the interest of senior management in meeting maintenance needs such as training, rewards and help in creating maintenance plans, etc.

5.4.2.1.4 Response Rate

According to Collis and Hussey (2013), carefully choosing the desirable respondents can play a significant role in the research and helps to save time which gives the research more credibility. In this research, the mixed methods approach involved gathering quantitative and qualitative data. The former

was gathered via a questionnaire survey. This study concentrated on four cement factories and targeted the maintenance staff who work on the shop floor. The number of maintenance staff in total, according to the factories' statistical data, was about 200 employees, "around 50 in each factory". The sample size was chosen according to the table by Krejcie & Morgan (1970), who say that a questionnaire sample for a population of 200 would have a confidence level of 95% and thus an error margin of 5%, making 132. Hence, a total of 132 questionnaires was distributed to the four cement factories, 33 to each factory. The total number of replies was 112. Thus, a rate of response of 84.85% was achieved. Table 5.2 shows the response rate in total and in each plant. This high percentage gives a strong indication of the desire of most members of maintenance staff in the four targeted firms to take part in such studies. They believe that their engagement would contribute to improving the work environment and enhance the efficiency of the factories. It was believed that this high percentage should increase the reliability of the survey.

Table 5.2: Response Rate in Total and in Each Factory.

Name of Factory	A	B	C	D	Total
Total number of maintenance employees	50	50	50	50	200
Number of respondents	30	31	27	24	112
Percentage of respondents	60	62	54	48	56

5.4.2.1.5 Questionnaire Translation

The first version of the questionnaire was written in English and validated for the first time through feedback from the research supervisor. However, it was an essential to translate this English vision into Arabic, the main language of the vast majority of the participants. Because this sensitive task needed great care to maintain the quality of the questions and to ensure that the meaning of the English version was retained in the Arabic translation, the translation process was made by experts in the fields of both languages and industry.

5.4.2.1.6 Questionnaire Pilot Test

The importance of a pilot study in research studies has been mentioned by many authors. For example, Yin (2009) and other authors have referred to the possibility that refining the plans for collecting data

with the necessary content and the processes that should be followed can be ascertained only through piloting the questionnaire. Oppenheim (2000) states that the function of a pilot study is to test out the questions and procedures. Gill and Johnson (1991) affirm that good feedback for clearer and more accurate questions can be obtained if a pilot study is conducted. These authors add that piloting the questionnaire allows the researchers to overcome many problems, since problems can be identified and corrected before the main survey begins. A pilot study makes it possible to verify the capacity of a question to generate the required information. The emphasis here is on ensuring that the questions of the survey make sense to the respondents. In addition, more questions related to the research problem can be generated from a pilot study. Furthermore, a pilot study enhances the validity of the questionnaire because the questions can be reworded and reconstructed. Therefore, a total of six experts, three from academic fields and three from industry were individually asked to test the questionnaire and give feedback on whether the purpose of the questions would be met if the same wording was chosen throughout. The clarity of meaning of both the questions and the possible answers for the targeted respondents and the degree of consistency in the structure of the questions was intended to avoid puzzling the respondents. The questionnaire was later modified according to the experts' feedback.

5.4.2.1.7 Questionnaire Validity

Validity is a term generally used to describe the accuracy or precision of results. In other words, the validity refers to the ability of a questionnaire to measure what a study is intended to measure (Saunders et al., 2009). According to Flynn et al. (1990) and Nunnally (1978), there is no specific way to determine the validity of a questionnaire. Therefore, the ability of a questionnaire to convey current conditions became a critical issue. Saunders et al. (2009) point out that such an issue imposes on researchers the need to look for evidence which will support the answers obtained from the questionnaire.

Many researchers refer to what is called content validity when discussing the issues related to a questionnaire's validity (Cooper and Schindler, 2008). Content validity refers to what appears to be in need of measuring. In the literature, this is the theme that is most often addressed. This led to the belief that content validity was the most appropriate for validating the questionnaire since the development of

measurement tools was based mainly on an extensive literature review and the detailed evaluations achieved by experts in this field.

5.4.2.1.8 Questionnaire Reliability

According to Patel and Joseph (2016), the reliability of a method is shown in the extent to which it can produce the same results under the same conditions at different times. This means that any group of respondents should be tested twice. A reliable questionnaire would produce the same answer from each respondent at both points in time (Field and Hole, 2002 and Davey et al., 2014). However, it is not a good idea to test the same people twice with the same questions because the respondents would very probably remember their previous response and give the same answer. Saunders et al. (2009) state that reliability refers to the consistency of the questions with their purpose. This emphasises that sufficient attention should be paid to preventing potential respondents from interpreting a question in a way not intended by its writer (from inability to catch the question's purpose).

To overcome this critical difficulty, it has been suggested by Saunders et al. (2009) that reliability can be tested by using the same questionnaire for another organisation that operates in the same conditions; if reliable the questionnaire should produce the same or similar answers. With the above discussion in mind, and due to time limitations and the concurrent political crisis in the same place, another factory was chosen to test the reliability of the questionnaire. This factory had the same conditions, produced similar products and was in the same area as the four cement factories under investigation. However, only about ten questionnaires were distributed and collected. As part of the testing of reliability, the respondents were given the opportunity to answer the questions without any intervention by the researcher, but with a comprehensive explanation of the questions, their nature and purpose. The respondents were also informed that they could withdraw from participating in any part or all of the survey at any time if they did not wish to give answers. The results of these questionnaires were discussed with some experts from the factory, as recommended by Subarna (2015), to assess the reliability of the questionnaire. All this evidence confirms the high reliability of the questionnaire.

5.4.2.2 Semi-Structured Interview

An interview can be defined as a purposeful and meaningful discussion between two or more interlocutors (Kahn and Cannell, 1957). Interviewing is a method of gathering reliable and valid data (Saunders et al., 2009). Hussey and Hussey (1997) add that the opinions and views of a group of people (selected participants) are extracted by asking them a set of questions relevant to the research subject. Therefore, according to Saunders et al. (2009), it can be said that conducting interviews aims to provide information about the research objectives and to give proper and logical answers to a research question. Collis and Hussey (2013) state that interviews can be conducted with individuals or with a group of persons, either voice-to-voice, screen-to-screen or face-to-face. Easterby-Smith et al. (2002) define three types of interview, namely; structured, unstructured, and semi-structured.

Myers (2013, p. 122) defines semi-structured interviews as “involving the use of some pre-formulated questions but no strict adherence to them”. This author adds that new questions may emerge during a conversation. In this type of interview, although it may vary from interview to interview, the list of themes and key questions that need to be covered during the interview process should be prepared in advance (Saunders et al. 2009).

According to Bryman (2015) and Marshall and Rossman (2014), researchers adopt face-to-face interviews for more than one reason. For instance, although the interview questions need to be covered, it is possible to talk generally about issues related to the research subject instead. In addition, using semi-structured-interviews give researchers a chance to obtain a large amount of in-depth information from multiple organisations in a relatively short period. This was seen as essential for the present study which had limited resources of time and cost. Moreover, through face-to-face semi-structured-interviews, the respondents’ environment can be directly observed by the researcher. This type of interview enhances trust between interviewee and interviewer, promoting the validity of the research findings in consequence.

According to the above, face-to-face semi-structured-interviews with open-ended questions were chosen as the main approach of qualitative data collection in this research. Saunders et al. (2009) state that the participants can better define and describe a situation or event if the researcher adopts the

strategy of open-ended questions. Robson (2002) mentions that researchers should not ask long and leading questions because they lead the respondent's answers in a particular direction. However, the As discussed earlier in this chapter, the questionnaire was adopted as the main source of the primary data, followed by face-to-face semi-structured interviews to supplement the questionnaire survey and to explore in depth the research issues under investigation which no questionnaire could fully cover. Therefore, it can be said that the purpose of the conducted interviews was to explore the perspectives and beliefs of the maintenance and production departmental managers on the level of maintenance practices and related issues, such as the employees' output and the senior management interest in maintenance. In other words, the conducted interviews sought to uncover specific information from the interviewees who already knew of and had legal access to the information being investigated in this research. The interviews can be used as a way of validating the questionnaire, since the interview findings can be compared with those from the questionnaire by addressing the extent of the similarities and differences between them. Because the interviews involved middle managers from the four Libyan cement factories, more in-depth information about managerial views on maintenance could be obtained. Such information would not have been elicited from the shop floor staff. The face-to-face semi-structured-interviews explored the managers' opinions on the level of maintenance practised and their ability to identify the barriers in their factories to carrying out maintenance. Moreover, they allowed the interviewees to envision the actions that should be taken to overcome these problems.

5.4.2.2.1 Interview preparation

Interviews, to be successful and achieve their goals, should be organised and administered properly (Subarna, 2015). It was believed that the proper preparation for interviews would ensure that the interviews would proceed with minimal disturbance. Therefore, it was essential for the present study to take account of the preparation for interviews recommended by Bryman (2015). These measures can be summarised as follows: the questions included in the interviews were formulated in a logical, definite and specific, but not too rigid order, remembering that the order of questions can be changed when required. The interview questions were formulated in line with the level of the targeted participants. All the interviews locations and settings were determined before the interviews and were all at the work

sites of the respondents. Herbert and Irene (2005) emphasised that a few minutes of casual chat between the interviewer and interviewee should be the first action by the interviewer. Almost anything can be in this conversation such as sports events, shopping or food. Sometimes, a mild joke might have a significant impact to relax the interviewer. Those authors believed that such this start could lead to more successful and more fruitful interviews. Since the confidence level of some interviewees is low and they might feel nervous when talking about their jobs to strangers. Furthermore, in this crucial part of the interview, the interviewer can express his respect to the interviewee, his position and his company. The interviewees who agreed to be involved must be informed on the privacy and the importance of the information they provide (Herbert and Irene, 2005, and Leslie, 1988). The interviewees were given an overview of the research and the main reasons behind conducting this study. This approach gives the participants more sense of the importance of the research so they would give more responsible answers to the interview questions which would increase the reliability of the interviews. Many authors such as Margaret & Harry, (1997); Leslie, (1988) and Herbert & Irene, (2005) have given strong support to the idea that the aim of research must be described firstly by the interviewer to the targeted interviewees as this could lead to a more productive interview.

The interviewer introduced himself by starting with informal discussion and jokes, to relax the interviewee before the formal part of the interview. A recording device was used to tape all the interviews instead of writing notes, so as to not miss any information while the interview lasted. All the interviews ended by asking the interviewees if they wished to add any information to the interview.

As suggested above, the questions in the interviews were developed to cover some aspects which had already been explored in other areas of the research (see Appendix 6). The first point was to assess the current level of maintenance in the four firms. The evaluation of the managers was focused on here; the interview focused critically on their comments about the efficiency level of the shop floor staff regarding maintenance tasks and their own understanding and awareness of maintenance and related issues. The extent to which senior management provides the maintenance staff with the needed facilities, such as sufficient salaries and rewards, and the attention given to the production systems were

essential topics in the interviews. The factors that may have hindered the successful implementation of maintenance and maintenance improvement requirements were also addressed.

5.4.2.2.2 Size of Sample Interviewed and Selection of the Interviewees

In qualitative research, although the research population is used to identify the sample size, many authors such as Creswell & Clark (2007) and Saunders et al. (2009) state that there are no clear regulations or standards for determining a suitable number of interviews even if the purpose of the research is clear and enough time and resources are available. Dean (2007) contends that most qualitative research seeks to conduct enough interviews to confirm the richness and variety of the situation under study. Despite this, no one has defined how many participants are enough. Creswell & Clark (2007) mention that, in mixed methods research, the sample in the qualitative part is usually smaller than in the quantitative part. However, according to Creswell, 2012 and Saunders et al., 2009, replication logic plays a major role in determining how many interviews are enough rather than using sampling logic. Therefore, researchers who take the qualitative approach should continue interviewing participants until they reach the data replication stage or what is called saturation point. That is to say, the researcher should stop holding interviews only when new information ceases to emerge and the data begin to be repetitive. In this research, most of the data came first from a total of 12 middle managers working in the four targeted Libyan cement factories. Three from each factory were chosen in order to avoid any participant bias. This again promotes the reliability and validity of the research. This number was considered high enough to ensure in-depth information since the saturation point was reached at this stage. The interviewees were maintenance managers, production managers, general supervisors of maintenance and general supervisors of production. The rational basis behind this choice was that these managers were supposed to be aware enough of maintenance-related issues and at the same time familiar with managerial aspects. In addition to avoiding bias towards one factory of another, they worked in from different departments and levels, which will enhance their representativeness and, in turn, the reliability and validity of the study.

5.4.2.3 Direct observation

A good definition of observation comes from Robson (2002) when he said that the observation is a method which observes a person or a device and what they do or how they operate. O'Hara et al. (2011) claim that rich data and insights into the nature of the phenomena observed can be gained from observation. Direct non-participant observation, according to Zikmund et al. (2013), is a procedure to record what people do during an event without the observer's having any effect on the people's behaviour or the event; the observer merely records what is happening. Direct observation can involve writing notes about what has been observed or by taking photos of a situation, object or event, such as a place or a machine. In this research, the direct observation method was adopted, aiming to observe the work environment of the factories during the maintenance processes as one way of collecting the primary data. Using this method enhanced the understanding of the conditions in which maintenance is practised on the shop floor. Pelosi et al. (2001) believe that the data obtained from observation is more reliable and free from respondents' bias. However, permission had to be obtained from one of the four Libyan cement factories under review for the researcher to be on the shop floor during one of the maintenance processes. Unfortunately, taking photos was not allowed, for reasons of privacy. Instead, notes regarding maintenance activities and maintenance staff behaviour were written during the period of observation using a checklist (see Appendix 7).

For the present study, it was believed that adopting direct observations would enhance the data validation by linking the results of the questionnaire and interviews with the observation data. In this way, in line with Robson's conclusions (2002), it would be easy to recognise any discrepancies between what the participants said and what actually took place in the factory's maintenance practices.

5.4.2.4 Data collection stages

The data collection and analysis stages should be distinct as far as possible, to avoid confusion for both the researcher and the reader. In the study, the data were collected in the period from July 20014 to June 2014. The collection and analysis of the data were structured as follows: the first stage was gathering data from the participating factories through a questionnaire survey. In the second stage, the answers obtained from the questionnaire sheets were collected and organised. These answers yielded findings,

which were organised and prepared for analysis under their main factors. The third stage was gathering more data from face-to-face semi-structured interviews and direct observations from the four targeted cement factories. The interview data were translated from Arabic into English and then transcribed, and the direct observation notes were arranged.

The material from the transcribed interviews was coded as determined by the research aim, objectives and questions. Based on these codes, main and sub-themes were developed for analysis at a later stage. The results of both approaches, quantitative and qualitative, were merged to draw the final conclusions of the research, in order to provide a comprehensive insight into the current barriers to the optimum implementation of maintenance. Figure 5.2 shows the stages of data collection and analysis in this study.

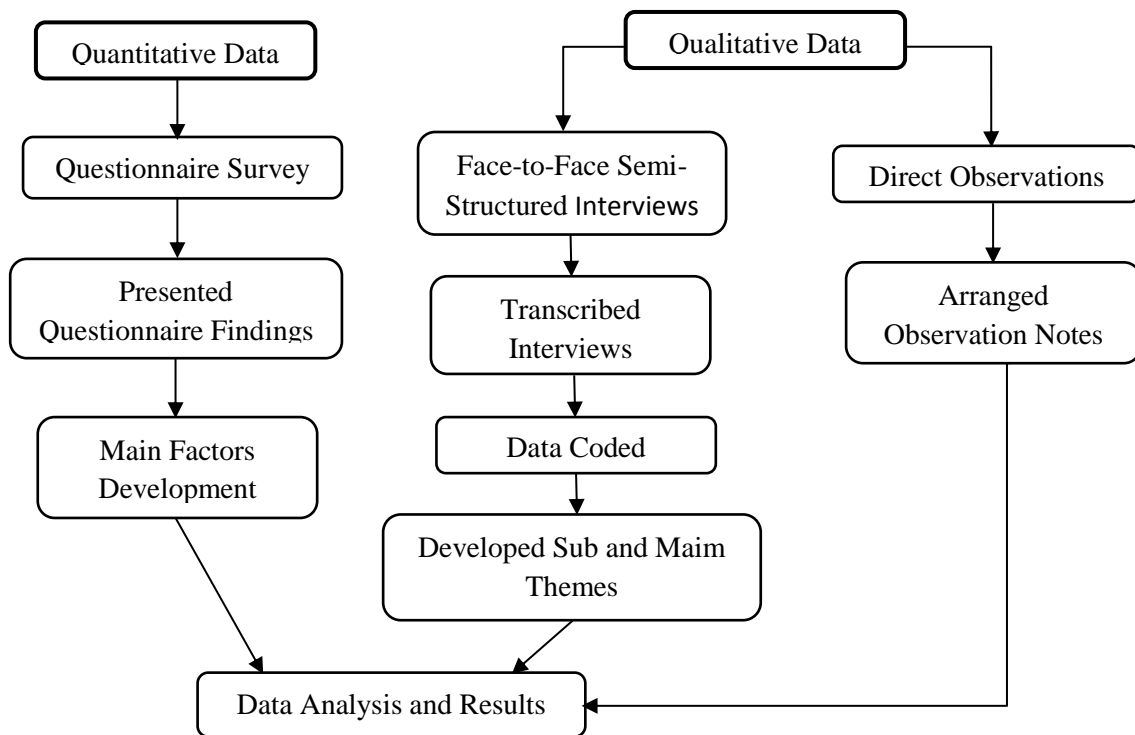


Figure 5.2: Data Collection and Analysis and processes (Source: Author).

5.5 Data Analysis

The analysis of data is one of the most important stages of research. This is because a good analysis of the data increases the chance of generating more reliable and valid results, which aid the researchers in addressing the research problems and finding the best solutions (Gast and Ledford, 2010; Collis and Hussey, 2013). Despite this, every research study has its unique problems, preventing any specific method from being generalised in the analysis of research data Silverman (2010). Taylor and Bogdan

(2015) state that researchers can develop their own methods for analysing research data. As the present study used mixed methods, two directions were followed in analysing the collected data.

5.5.1 Quantitative Data Analysis

Quantitative data need to be carefully analysed because they convey little meaning to most people before they are processed and analysed. In other words, it is very important to make these data useful by turning them, through analysis, into information that can be dealt with. This process lets the relationships within the collected data be explored, examined and presented to help in answering the research questions. In this regard, it was essential to use quantitative analysis techniques (Saunders et al., 2009).

In quantitative analysis, as stated by Oppenheim (2000), different statistical tools are adopted for different purposes mainly depending on the nature of the collected data. Statistics allows the data to be gathered, organised, summarised, presented, and analysed so as to extract applicable conclusions (Triola, 1998).

Aft (1997), Scott and Mazhindu (2014) and Holcomb (2016) discuss descriptive statistics as methods of analysing data that can describe and summarise them in meaningful ways. Weinberg and Abramowitz (2002) say that “descriptive statistics are used when the purpose of an investigation is to describe the data that have been (or will be) collected”.

This technique uses a variety of tables, graphs and charts to show the occurrence frequency of the data and enable comparisons to be made (Argyrous, 2011 and Lynch, 2010).

In this research, the data gathered from the survey questionnaire were statistically analysed. Frequencies and percentages were included to present the main characteristics of the data as recommended by (Park, 2008). All the collected questionnaires were carefully reviewed to ensure the completeness, accuracy and quality of the responses; Excel spreadsheets were then used to present and analyse these data. LeCompte and Schensul (2013) and Fleisher and Bensoussan (2015) warn that, although software such as SPSS can help with the process of data labelling and coding, it does not perform the analysis. The use of Microsoft Excel software allowed simple and clear tables, charts and graphs to be created which

help to describe events clearly in numerical forms, such as percentages. The analysis was carried out in accordance with the research aim and objectives. This means that factors which would contribute to answering the research questions could be identified as shown in Chapter 7.

5.5.2 Qualitative Data Coding and Analysis

According to Collis and Hussey (2013) and Saunders et al. (2009), there are no specific methods for analysing qualitative data. Taylor and Bogdan (2015) add that the analysing of qualitative data is derived from the researcher's views. A good justification of this was given by Collis and Hussey (2013) who state that the quality of analysis of qualitative data is directly linked to the quality of the data themselves and the ability of the researcher in interpreting these data without prejudice or bias.

However, Saunders et al. (2009) emphasise that one of the essential steps to a sound analysis of the qualitative data is to reading and re- reading the transcripts or notes of the qualitative interviews or observations. Some authors, such as Boyatzis (1998), Braun and Clarke (2006) and Robson (2002), identify thematic analysis as a general approach to analysing qualitative data. It can be used to examine differences, commonalities and relationships in the data (Gibson and Brown, 2009). Thematic analysis is a method of identifying the main, frequent or most important factors or themes that emerge from a body of evidence (Pope, Mays, and Popay, 2007). Lyons and Coyle (2009) define thematic analysis as “a technique or method for identifying and interpreting patterns of meaning (or themes) in qualitative data”. Collis and Hussey (2013) affirm that the methodical rigour and systematic processes required for analysing qualitative data can be provided by thematic analysis. The thematic analysis gives an opportunity to deal with and better comprehend each issue in a study. This is necessary because so many aspects of the data need to be clearly understood (Myers, 2013). Thomas and Brunton (2008) and Collis and Hussey (2013) suggest a general procedure for analysing qualitative data which can involve thematic analysis, as follows:

- Any raw field notes should be converted into written forms.
- All materials that have been collected should be clearly referenced.
- The collected data should be coded as early as possible.

- The codes should be grouped into smaller categories according to emerging themes, subthemes or patterns.
- Summaries of the analysis results should be made at various stages.
- The extracted summaries should be used to construct generalisations through which existing theories can be controlled, or new theory can be built.
- This process should be continued until the researcher is convinced that the results may be considered strong enough to stand with the analysis of existing philosophies or to build a new theory.

Collis and Hussey (2013) add that under the thematic analysis approach graphs, charts, matrices or networks can be used to display the qualitative data and summaries of its analysis. Yin (2009), Ayres et al. (2003) and Creswell (1994) identify within-case analysis and cross-case analysis as two stages in organising the data analysis process in the strategy for multiple case studies.

With this in mind, thematic analysis is seen as the most suitable for the present study because it gives a chance to focus on interpreting the collected data, in addition to a chance to link the theme frequency to the entire contents, which would enhance the accuracy of the research overall. By using thematic analysis, one can accurately determine the relations between patterns and themes (Corbin and Strauss, 1998). Furthermore, the thematic analysis offers an accessible and flexible path to the analysis of the qualitative data as a whole (Collis and Hussey, 2013). In this research, the analysis and discussion of the qualitative data are organised as follows:

In the first stage, each case was analysed separately using within-case analysis. Then the similarities and differences between the findings of the four cases were discussed and combined in one in an attempt to answer the research questions using cross-case analysis method.

The collected data were analysed manually as recommended by LeCompte and Schensul (2013) and Fleisher and Bensoussan, (2015); here, the researcher's views controlled the analysis and interpretation of the data and charts were presented as a sensory support for the analysed data.

In order to make it easier to deal with the qualitative data and make it less subjective, multiple case studies were used. The general procedures for thematic analysis were set up as follows:

- The aim, objectives and questions of the research were clearly identified and kept in mind at all stages of the analysis process.
- The interviews were audio-recorded which gave an opportunity to concentrate in great depth on what respondents were saying at the time.
- All the material from the interviews and the direct observation were carefully referenced.
- The interviews were transcribed verbatim using Microsoft Word software (see Appendices 8.1 to 12 for a sample of the transcripts). Because Arabic is the only language spoken by almost all the interviewees, it was used in all the interviews. The words, expressions and phrases were transcribed in their original form to preserve the essence of the expression. Then they were carefully translated from Arabic to English to retain their meaning.
- The analysis process started by reading and re-reading the interview transcripts. This process continued until the maximum understanding of these data had been reached, as recommended by Saunders et al. (2009).
- After this, the data were coded according to the research aim, objectives and questions. Coding of the data is a process of fracturing and rearranging them in groups or categories according to the research questions to facilitate the analysis (Corbin and Strauss, 1998).
- The next stage after data coding was grouping the codes into smaller categories (sub-themes), as recommended by Saunders et al. (2009) and Collis and Hussey (2013).
- The generated sub-themes were also categorised into more specific groups, named main themes, aiming to address in more depth the maintenance related issues in the present research.

During the analysis process seven main themes were identified, as follows:

- 1) Employee Output; 2) Production line Improvements; 3) Quality of Maintenance Strategy; 4) Improvement of Maintenance Strategy; 5) Maintenance Selection Procedures; 6) Maintenance Output; 7) Management Performance.

However, to begin with, the four case studies were analysed separately. Then the findings from these four case studies were combined and discussed as a set to find differences or similarities among them regarding maintenance practices.

5.6 Data Triangulation

The credibility of research can be enhanced by triangulating the data (Profetto-McGrath, 2010). In this research, the design of triangulation by mixed methods was employed. Both methods, quantitative and qualitative, were used to collect different data but were complementary in answering the research questions and thus achieving the research aim. The following procedures were adopted to address this aim. The use of a questionnaire survey for the shop floor maintenance staff aimed to evaluate the level of maintenance as well as the staff's efficiency. In addition, face-to-face semi-structured interviews were held with the maintenance and production managers and general supervisors of maintenance in order to obtain additional input to the research. Direct observations on the shop floor were also used to triangulate the findings in the study, as shown in Figure 5.3.

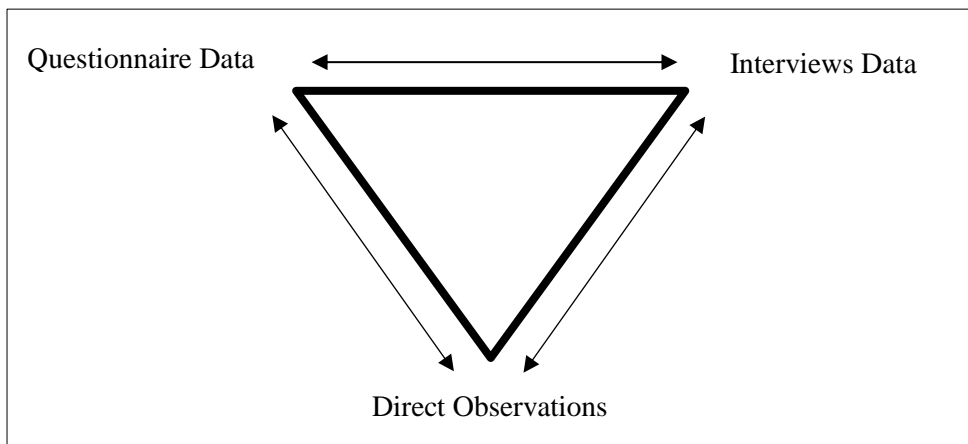


Figure 5.3: Data Triangulation (Source: author).

Many authors, such as Jick (1979), Brewer & Hunter (1989), Greene et al. (1989), and Robson (2002) see triangulation as the best way to obtain different but complementary data in a single study. Triangulation allows researchers to get more in-depth understanding of the research related issues through increasing the level of confidence in the data.

5.7 Ethical Issues

Penslar, (1995, p13) defines ethics as “the philosophical study of normative behaviour, the ‘shoulds’ and ‘oughts’, the ‘rights’ and ‘wrongs’ of our conduct”. Alderson and Morrow (2015, p3) add that research ethics is concerned with respecting the research participants throughout each project, partly by using agreed standards. Ethical standards are also designed to protect researchers and their institutions,

as well as the good name of research. Understanding the ethical requirements in the present study was essential because management involves human participants (Saunders et al., 2009).

For the purpose of this study, permission for ethical clearance was sought from the University of Aston, School of Engineering and Applied Science, before data collection began. The next steps were followed for ethical purposes, in view of the mixed methods used (see appendices 1, 2 and 3). The permission from the four targeted factories was obtained as the first and the essential step before goes forward with the data collection process.

For the quantitative part; the purposes of the study were clearly notified to all participants in the questionnaire survey and the manner in which the research would be conducted was described. Sufficient time was given to the participants to discuss and have explained to them any unclear points regarding the research issues. The questionnaire had a research information cover-sheet so the participants could easily read it before they started to answer the questions of the questionnaire. All the necessary information and details about the research were on the information sheet, including the research title; a summary of the research; the confidentiality of the respondents' identities and the information they might provide; their right to withdraw from participating in the survey at any time and to have their data expunged; and the contact details of the researcher (see Appendix 5).

For the qualitative part; the interviews were conducted in compliance with specific conditions to ensure the complete agreement of the participants. These conditions are listed as follows:

- The purpose of the research was explained to each interviewee before the interview.
- Before each interview took place, all the interviews were verbally asked if they have the desire to participate in the research.
- All interviews were held at convenient times for the interviewees.
- The interviewees had the right to halt the interview at any time they wanted and could withdraw and have their data expunged.
- The anonymity and confidentiality of the interviewees' personal data and responses were guaranteed in advance by encoding these data and were informed of this before the interview took place. Hence, all

the participants were given a participant information leaflet & participant consent form to read and then sign if they agreed to take part in the research (see Appendices 4.1 and 2).

Chapter Summary

The methodology used in this research was discussed in detail in this chapter. The issues discussed included the research philosophy, the research approach, the research strategies, data collection methods and data types, data collection stages, data analysis, data triangulation and the ethical issues arising. The next chapter gives the findings of the data gathered by both quantitative and qualitative methods for the present research.

CHAPTER 6: The Findings from the Collected Data

6.1 Introduction

The previous chapter presented the methodology and methods that used in this research. This chapter presents the results obtained from both the quantitative survey and the qualitative interviews. The questionnaire findings were produced from 112 respondents out of 132 in total. Those participants represent the shop floor staff in the four targeted Libyan cement factories, including engineers, technicians and technicians' assistants. 12 face-to-face semi-structured interviews from the four case studies, three in each case, were also conducted. The targeted interviewees were maintenance managers, production managers and general supervisors of maintenance and production. This chapter intended to lead the reader to the chapter of analysis and discussion, so as to draw a full image of the current situation of maintenance and its practices in the four targeted Libyan cement factories. The primary source of evidence was provided by a survey questionnaire, distributed to shop floor staff in the targeted sites. This survey was followed by interviews with middle managers and some direct observations from the shop floor to get in-depth information to support the survey findings and cover any details that the questionnaire missed. However, in order to identify the factors generated from the semi-structured interviews that mattered in terms of maintenance and its practices, a frequency analysis was made after the findings from each case. Next, a comprehensive frequency analysis was made for the four cement factories together. The aim here was to facilitate the work of analysis and discussion and make it more accurate.

Like the previous one, this chapter comprises three sections; the first presents the findings of the questionnaire survey. This section is divided into three parts, namely,

Characteristics of the Research Population;

Maintenance practices;

Management Related Issues.

These factors were identified by the research questionnaire structure which was originally built upon the review of the literature and the research questions. The results of the semi-structured interviews are

presented in the second section. This part is constructed according to the seven main themes that these interviews generated. To re-arrange these themes according to their importance, a frequency analysis was made for each set of case findings. The last section consists of cross-case findings followed by a comprehensive frequency analysis for the four factories as a set. Here it should be noted that both methods were designed to collect primary data related to maintenance and its practices in the Libyan cement firms in order to suggest solutions for those obstacles that might hinder the success of maintenance in the factories. Tables, charts and graphs were used with the aim of adding validity and giving the reader sensory support.

6.2 Quantitative Findings

6.2.1 Introduction and Characteristics of the Research Population

The main purpose of this section is to illustrate the demographic information about the respondents' gender, age, education level, maintenance qualification, job position and length of experience in working, both in these factories and in the field of maintenance. The assumption underlying these questions was the fact that the participants' background information is a critical factor which could directly affect other people's confidence in them and hence the results of the study. For instance, it has been found by Haniffa and Cooke (2002) and Mackety (2007) that there is a significant relationship between the respondents' confidence level and their academic or training background, in terms of giving truthful answers. In this research, a total of 132 questionnaires were distributed in the four targeted cement factories, 33 in each. 112 usable responses were obtained. 30 from factory A, 31 from factory B, 27 from factory C and only 24 from factory D.

1 Age Distribution of Respondents

Figure 6.1 illustrates that 42.9% (48 of the respondents) were aged between 30 and 39 years. This percentage is followed by 37.5% (42 respondents) whose ages ranged between 40 and 49 years. The total of people aged between 50 and 59 years was 17.9% (20 respondents) and only 2 participants, about 1.8% of the total, were aged between 21 and 29. From Table 6.1 it is evident that the number of people

who were aged between 21 and 29 and between 30 and 39 reached 90 altogether, a percentage of 61%.

From the table, it can be noted that no staff members were under 21 or over 59 years old.

Table 6.1: Age Structure of Respondents (Source: author).

Age / Year	Under21	21 to 29	30 to 39	40 to 49	50 to 59	60 or over	Total
Factory A	0	0	11	17	2	0	30
Factory B	0	1	10	11	9	0	31
Factory C	0	0	13	8	6	0	27
Factory D	0	1	14	6	3	0	24
Total	0	2	48	42	20	0	112
Total %	0	1.8	42.9	37.5	17.9	0	100

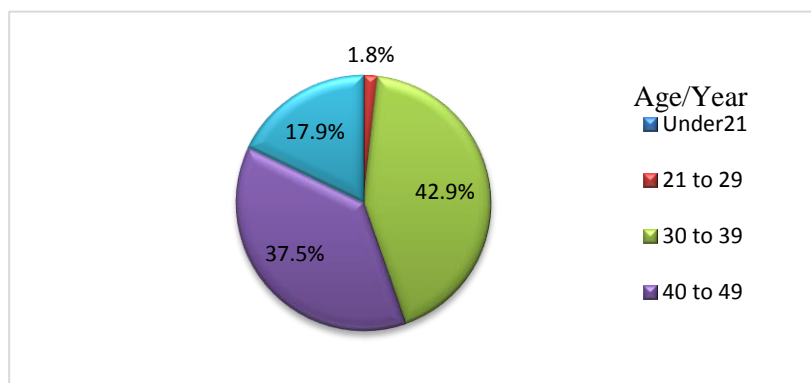


Figure 6.1: Age Structure of Respondents (Source: author).

2 Educational Level

The empirical findings in the sample shown in Table 6.2 and Figure 6.2 provide information about the level of education attained by the respondents. As the table shows, the number of participants whose qualifications were from secondary school or below was 6 (5.4%). This number is followed by 22.3% (25 respondents) had obtained a high school certificate. The table also indicates that a percentage of 42% (47 respondents) held a diploma and 28.6% (32 respondents) had a bachelor's degree. This means that a total of 78 respondents (nearly 70%) had an educational level of diploma, secondary school or below. From the same figure, it may be observed that the highest level of education was a master's degree, but only 1.8% (2 people) had attained it. Two further points can be made from the table. The number of respondents who held a PhD. The degree was zero. In contrast, none of the respondents was illiterate: the percentage of participants whose educational level was below primary school was zero.

Table 6.2: Educational Level of Respondents (Source: author).

Educational Level	Below Primary School	Below Secondary School	Secondary School	Diploma	Bachelor	Master	PhD	Total
Factory A	0	2	6	14	8	0	0	30
Factory B	0	2	5	11	11	2	0	31
Factory C	0	1	7	11	8	0	0	27
Factory D	0	1	7	11	5	0	0	24
Total	0	6	25	47	32	2	0	112
Total %	0	5.4	22.3	42	28.6	1.8	0	100

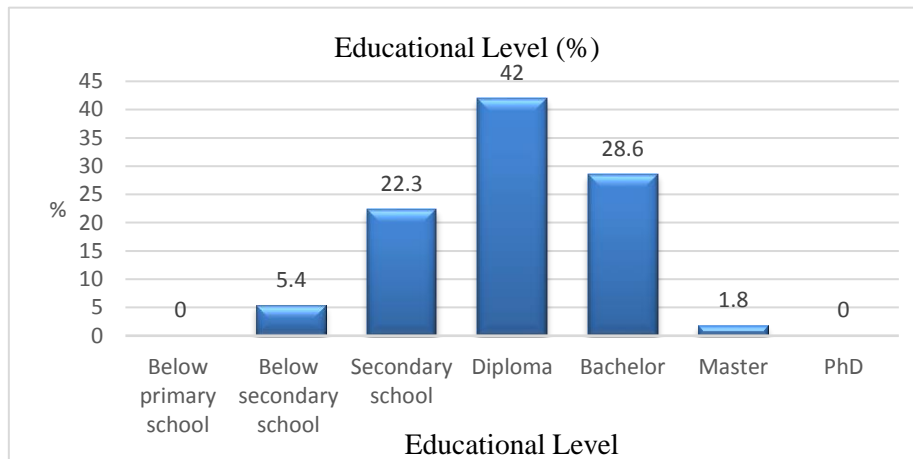


Figure 6.2: Educational Level of Respondents (Source: author).

3 Qualifications in maintenance work

The status of a job may reflect the level of qualification associated with it. Table 6.3 and Figure 6.3 show the maintenance qualifications held by the respondents. The result indicates that a total of 19 respondents (17%) had acquired qualifications from the professional education of the kind offered by institutes specialising in maintenance and related subjects. 24.1% (27 respondents) had received formal vocational education as represented by the medium government institutes (equivalent to high school). From the same table and figure, it can be seen that nearly half the respondents (45.5%) used experience alone in carrying out their duties. Moreover, the certificates of 13.4% (15 respondents) were no longer relevant to the maintenance field. These two last totals added together account for 66 respondents (58.9%).

Table 6.3: Maintenance Qualification of Respondents (Source: author).

Qualification in Maintenance Work	Professional	Technical	Experience	Not Relevant to Maintenance	Total
Factory A	4	7	14	5	30
Factory B	5	9	12	5	31
Factory C	6	5	12	4	27
Factory D	4	6	13	1	24
Total	19	27	51	15	112
Total %	17	24.1	45.5	13.4	100

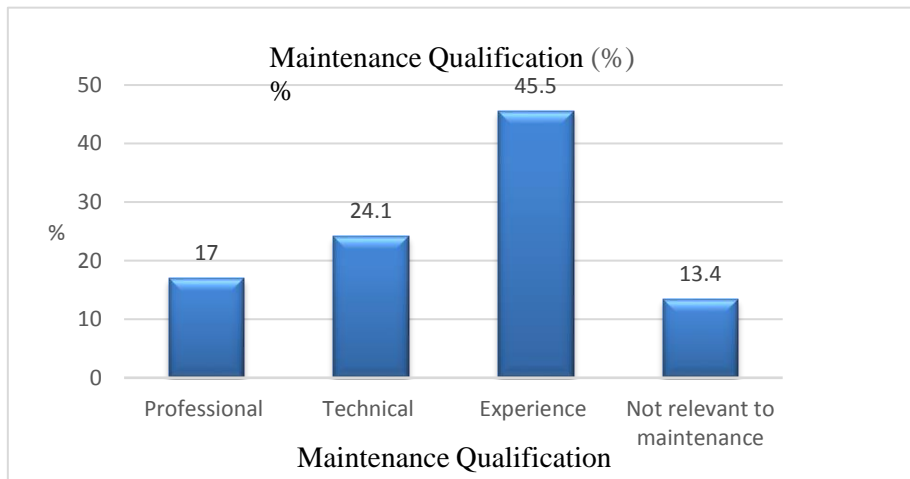


Figure 6.3: Maintenance Qualification of Respondents (Source: author).

4 Job Title

Figure 6.4 and Table 6.4 clarify that about 54.5% (61 respondents) were technicians, while 37 of them (33%) had the rank of engineer. The number of technicians' helpers who responded to this survey was 7 (6.3%). This number was followed by 5.4% (6 respondents) who had the position of manager. The respondents with the lowest levels of qualification who had been working as helpers comprise only 6.3% (7 respondents). This result shows the shortage of this category of staff on the shop floor. Further consideration of the table reveals that most of the participants were engineers and technicians (87.5% in total). This percentage could be a good sign of the success of the survey, since these people should have a broad knowledge of maintenance practices and thus be more efficient on the shop floor, in addition to doing the administrative work associated with maintenance.

Table 6.4: Job Titles of the Respondents (Source: author).

Job Title	Manager	Engineer	Technician	Helper	Other (please specify)	Total
Factory A	2	7	19	1	1	30
Factory B	3	13	12	3	0	31
Factory C	0	11	15	1	0	27
Factory D	1	6	15	2	0	24
Total	6	37	61	7	1	112
Total %	5.4	33	54.5	6.3	0.9	100

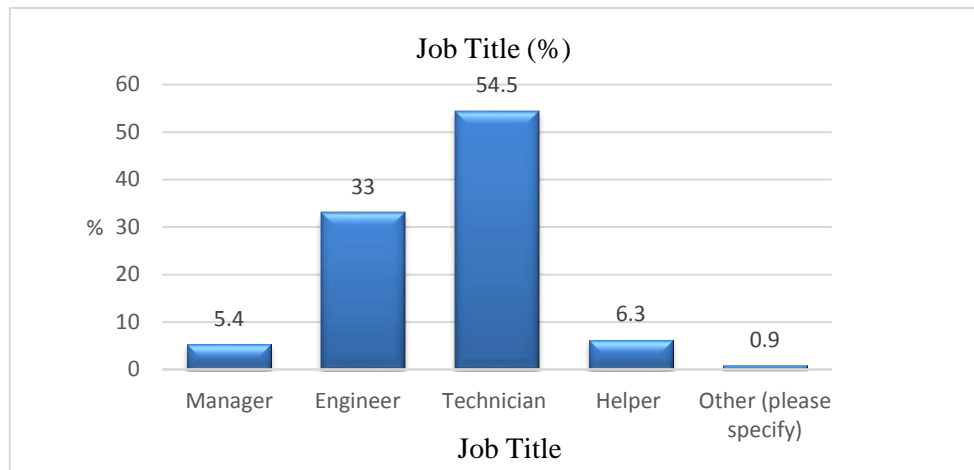


Figure 6.4: Job Titles of Respondents (Source: author).

5 Years of Experience in the factory

This question was designed to identify the length of the respondents' experience and the general stability of their work background. As can be observed from both Figure 6.5 and Table 6.5, only 9% of the participants can be considered new members of the maintenance staff and even they had had up to 5 years' experience with these firms. Approximately 32% (36 respondents) had worked in these factories for between five and ten years. A relatively high percentage, 38.4% of the population, had been working in the targeted cement factories for between 11 and 20 years. The longest period of working in these centres was between 21 and 30 years, achieved by 20.5% of the respondents. Here it can be said that a longer period of continued employment means more experience and more exposure to the same work environment. From table 6.5, it can be seen that most of the staff seem to have a sufficient experience: a total of 66 respondents (58.9%) had had experience in the same factory of between 11 and 30 years.

Table 6.5: Years of Experience in the Factory (Source: author).

Job Age / Years	Less than 5	5 to 10	11 to 20	21 to 30	More than 30	Total
Factory A	7	14	9	0	0	30
Factory B	3	16	10	2	0	31
Factory C	0	2	14	11	0	27
Factory D	0	4	10	10	0	24
Total	10	36	43	23	0	112
Total %	9	32.1	38.4	20.5	0	100

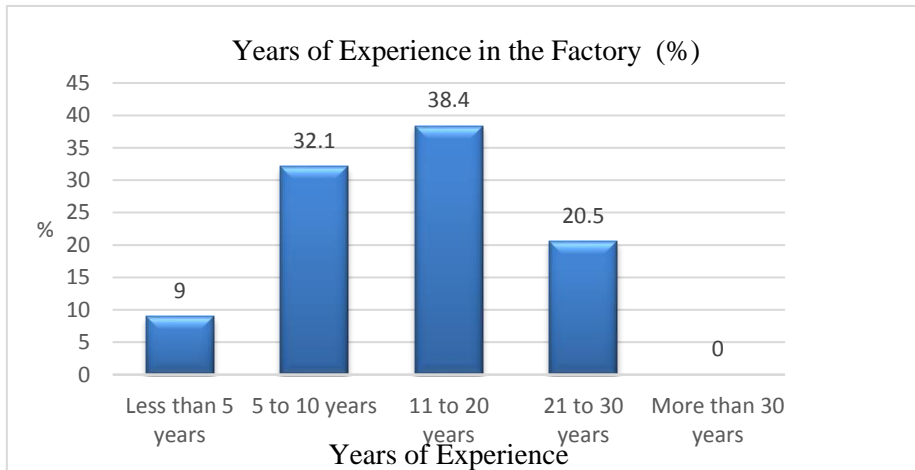


Figure 6.5: Years of Experience in the Factory (Source: author).

6 Years of Experience in the Field of Maintenance

This question was asked to find how far the respondents could depend on their experience of maintenance work. The answers were linked to other factors, such as education level, training courses and the whole working period in the same factory, which would all contribute to a clearer picture of the adoption of maintenance practices. The participants' answers here were very similar to those for the previous question, which reflects the fact that the vast majority of them had spent most of their lives working in maintenance. From Figure 6.6 it can be understood that 4.5% (5 respondents) had less than five years' experience of working in maintenance. The number of participants who had between 5 to 10 years of experience was 39, about 34.8% which was clearly the highest percentage. This number was followed by 32.1% (36 respondents) who had been working in the same field for between 11 and 20 years. 31 respondents (27.7%) had had between 21 and 30 years of experience. The longest period of experience, more than 30 years, applied to the smallest percentage (0.9%), claimed by only two people.

A look at Table 6.6 makes it clear that the vast majority of staff, about 94.6% of the total, had had work experience of between 5 and 30 years.

Table 6.6: Years of Experience in the Field of Maintenance (Source: author).

Maintenance Experience / Years	Less than 5	5-10	11 - 20	21 - 30	More than 30	Total
Factory A	2	14	9	5	0	30
Factory B	2	14	6	8	1	31
Factory C	1	4	13	9	0	27
Factory D	0	7	8	9	0	24
Total	5	39	36	31	1	112
Total %	4.5	34.8	32.1	27.7	0.9	100

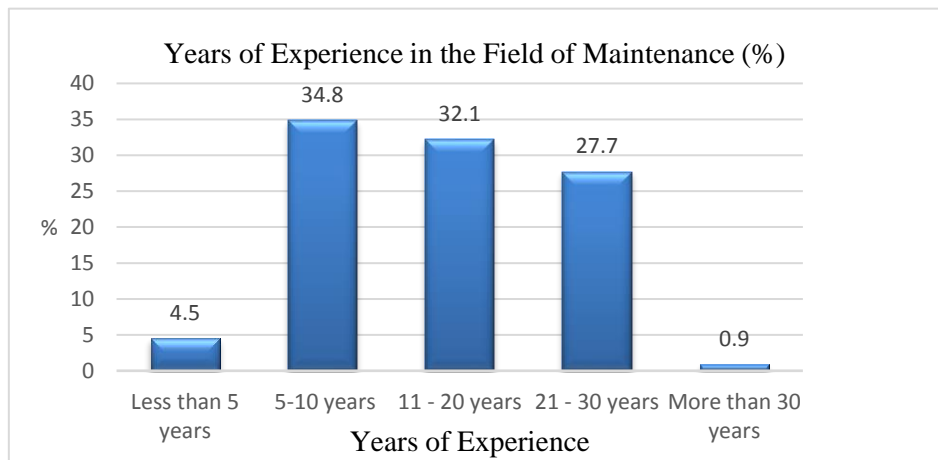


Figure 6.6: Years of Experience in the Field of Maintenance (Source: author).

6.2.2 Maintenance Practices

The main focus of the survey was to identify the level of implementation of maintenance in the four factories. Therefore, this part investigated the state of maintenance practices at the time. The questions included the maintenance strategy in place, the respondents' knowledge of types and strategies of maintenance, and the availability of assistance tools such as manuals; other questions are related to the respondents' awareness in dealing with production systems. Questions listed under the heading of maintenance practices were further divided, as follows.

1 Dealing with equipment

The survey respondents were asked to indicate the type of equipment they were familiar with. Through this, the percentage of the workforce able to operate and maintain the components of the production

lines as required could be determined and thus the barriers affecting staff in their work with these systems could be identified. Hence appropriate solutions could be devised to the maximum benefit of the workforce operating and maintaining these production systems. It can be seen from both Table 6.7 and Figure 6.7 that most of the respondents (93.8%) could deal with the machines in their factory. From the table, it can be noted that 100% of respondents knew how to deal with equipment. The three other plants had roughly the same proportion of respondents who could deal with the components of the production systems.

Table 6.7: Dealing with the equipment of the production lines (Source: author).

Dealing with Equipment	Yes	No	Total
Factory A	28	2	30
Factory B	31	0	31
Factory C	25	2	27
Factory D	21	3	24
Total	105	7	112
Total %	93.8	6.3	100

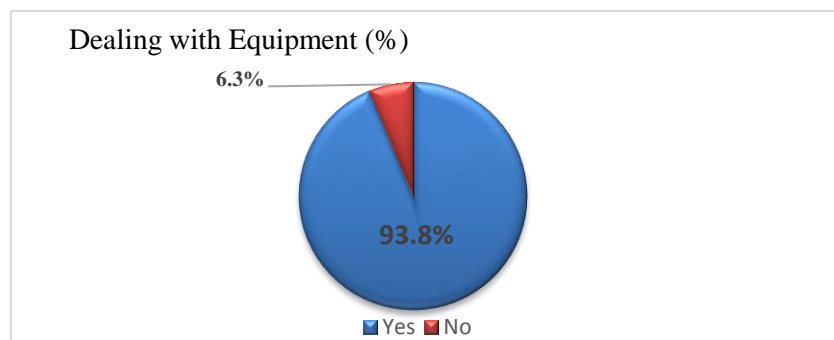


Figure 6.7: Ability to deal with the equipment of the production lines (Source: author).

2 Types of equipment that the respondents can deal with

This question was designed to indicate the ability of the respondents to deal with complex machines that operate with advanced technology, such as computerised systems. The results of this question would be evidence of the reliability of other points that had already been covered in the questionnaire, such as the period of experience in the field of maintenance and the level of training received. Table 6.8 and Figure 6.8 clarify that only 34.8% (39 respondents) knew how to deal with complex equipment. The others, more than 65% (73 respondents), were unable to run or maintain the devices that adopted advanced technology in their factories.

Table 6.8: Type of Equipment that can be dealt with (Source: author).

Equipment Type	Complex	Simple	Total
Factory A	12	18	30
Factory B	12	19	31
Factory C	7	20	27
Factory D	8	16	24
Total	39	73	112
Total %	34.8	65.2	100

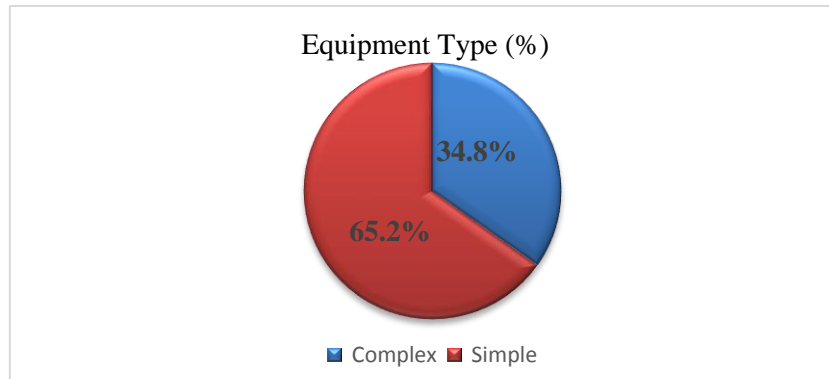


Figure 6.8: Type of Equipment that can be dealt with (Source: author).

3 The availability of Maintenance and Operation Manuals

Regarding the availability of maintenance and operation manuals, the respondents' answers were different, as can be seen from both Table 6.9 and Figure 6.9. They illustrate that the number of staff who confirmed that the manuals are available for all devices and machines was 22 (19%). A percentage of 36.6% (41 respondents) stated that the operation and maintenance manuals were not available at all. This number was followed by 39 (34.8%) staff members who believed that the operation and maintenance manuals were available only for critical equipment where failure could result in serious consequences such as stopping production or causing damage to the surrounding machinery such as the main ventilation fans. Only ten respondents (nearly 9%) believed that there was a shortage of manuals and they were available only for expensive machines, because significant capital is needed to replace these devices. An example is the main kiln which is no easy task for the factory to replace quickly.

Table 6.9: The Availability of Operation and Maintenance Manuals for the Equipment (Source: author).

The availability of manuals	Yes	No	Not all (Only Critical Ones)	Not all (Only Expensive Ones)	Total
Factory A	5	7	15	3	30
Factory B	7	16	8	0	31
Factory C	6	10	8	3	27
Factory D	4	8	8	4	24
Total	22	41	39	10	112
Total %	19.6	36.6	34.8	8.9	100

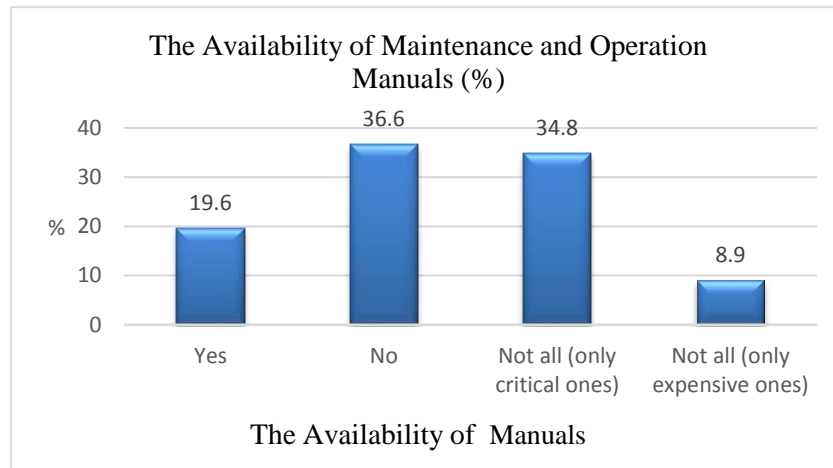


Figure 6.9: The Availability of Maintenance and Operation Manuals (Source: author).

4 The stoppage of production systems due to a technical failure

This question was designed to measure the overall level of efficiency of the production systems, as well as determining the attention paid by staff to the production systems in their firms. From Table 6.10, as was expected, 100% of the respondents admitted that production was sometimes interrupted due to technical problems in a production system.

Table 6.10: The Stoppage of a Production System due to a Technical Failure (Source: author).

Production System Failure	Yes	No	Total
Factory A	30	0	30
Factory B	31	0	31
Factory C	27	0	27
Factory D	24	0	24
Total	112	0	112
Total %	100	0	100

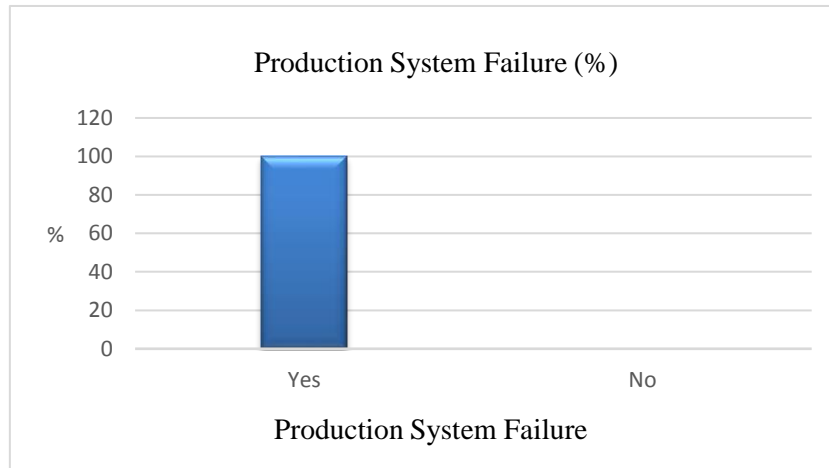


Figure 6.10: The Stoppage of a Production System due to a Technical Failure (Source: author).

5 Stoppages number

It was believed that measuring the efficiency level of the production systems' performance in the targeted factories was very important. The findings would reflect the efficiency level of the employees' performance of maintenance work. I would also help to get a clear idea of the senior management's response to this issue. From Table 6.11 it can be observed that the four factories had two or more stoppages per month, in the view of 62 % (44 respondents). The other respondents (42 in total) confirm that their factories had one or two stoppages each month. Going back to the table, it can be seen that the results obtained for each plant give clear signs that there was no significant difference between the levels of performance in the four factories.

Table 6.11: Number of Breakdowns in the Production Lines in Production Time (Source: author).

Stoppages Number	1 to 2 Stops Per Month	More than Two Stops Per Month	Total
Factory A	11	19	30
Factory B	8	23	31
Factory C	12	15	27
Factory D	11	13	24
Total	42	70	112
Total %	37.5	62.5	100



Figure 6.11: Number of Breakdowns in the Production Lines in Production Time (Source: author).

6 The ability to diagnose the fault in the production systems

The possibility of diagnosing the reason for failure easily may reflect the extent of staff response in performing their work. This question went further, seeking to determine the reliability of the participants over giving accurate answers to the survey questions. This reliability can be checked by linking these results to other factors, such as length of experience and qualifications in maintenance work. As shown in both Table 6.12 and Figure 6.12, only 30.4% (34 responses) said that they could easily determine the fault. In contrast, more than double this number, 69.6% (78 respondents), had difficulty in identifying the reason for the failure of a production system.

Table 6.12: Ability to Diagnose a Fault in a Production System (Source: author).

Failure Identification	Yes	No	Total
Factory A	8	22	30
Factory B	13	18	31
Factory C	10	17	27
Factory D	3	21	24
Total	34	78	112
Total %	30.4	69.6	100

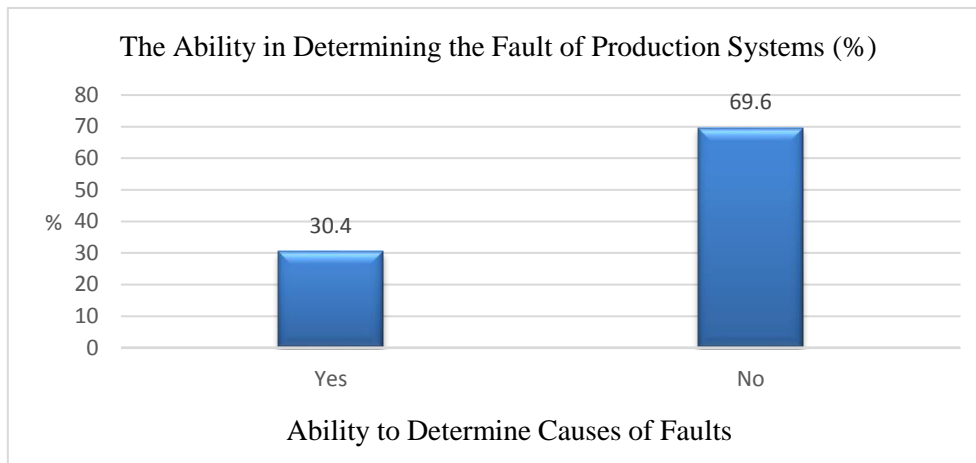


Figure 6.12: Number of Breakdowns in the Production Lines in Production Time (Source: author).

7 The percentage of faults that could be determined

This question might seem similar to the previous question asked. However, it is different, because this question seeks to draw a general picture of staff skills when working as a group. Figure 6.13 shows that more than half the respondents (50.9%) find themselves unable to identify the faults in production system components in their factories in more than 25% of cases. A percentage of 25% to 50% of failures could be determined according to 41 respondents (36.6%). Only 12.5% (14) respondents were confident in their ability to identify 51% to 70% of faults but nobody could claim a percentage of more than 75% when in came to detecting possible faults before they occurred.

Table 6.13: The Percentage of Faults that could be Determined (Source: author).

Percentage of Determined Faults	Less than 25%	25-50%	51-75%	More than 75%	Total
Factory A	10	16	4	0	30
Factory B	20	7	4	0	31
Factory C	16	8	3	0	27
Factory D	11	10	3	0	24
Total	57	41	14	0	112
Total %	50.9	36.6	12.5	0	100

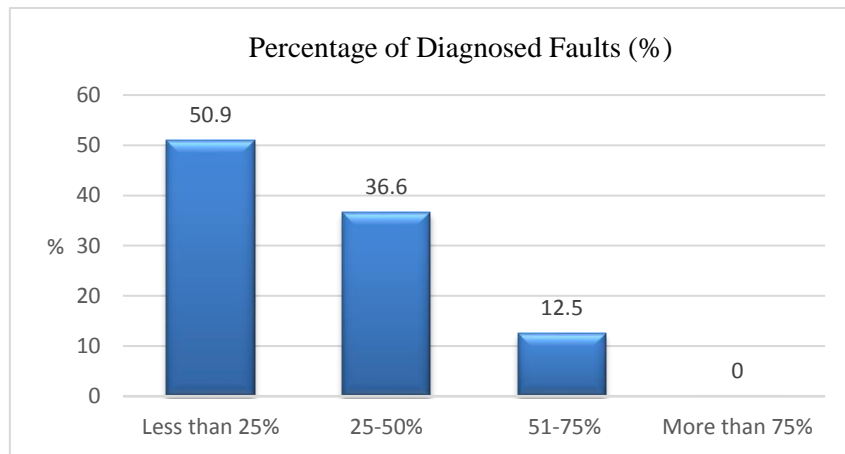


Figure 6.13: The Percentage of Faults that could be Diagnosed (Source: author).

8 Outsourcing maintenance activities

According to Table 6.14, the vast majority of participants, 91.1% (102 respondents) confirmed that their plants outsource their maintenance work. Only ten respondents (8.9%) see the contrary, stating that maintenance activities were undertaken only by the maintenance staff in their factory. This finding illustrates the inability of these factories to rely on their workforce in carrying out such activities. The table shows that the proportion of outsourcing maintenance activities by these factories is very high, almost reaching the level in factory D, where the outsourcing ratio reached 100%.

Table 6.14: Outsourcing in Doing Maintenance Activities (Source: author).

Outsourcing of Maintenance Work	Yes	No	Total
Factory A	27	3	30
Factory B	28	3	31
Factory C	23	4	27
Factory D	24	0	24
Total	102	10	112
Total %	91.1	8.9	100

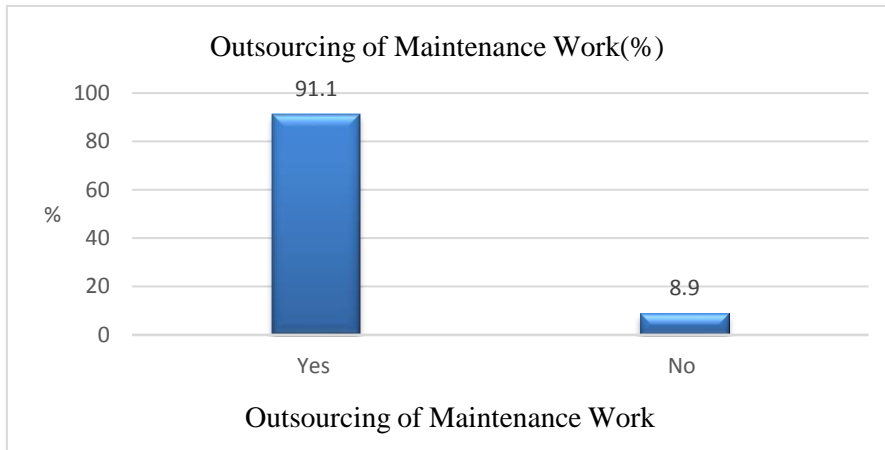


Figure 6.14: Outsourcing in Doing Maintenance Activities (Source: author).

9 Maintenance of equipment according to a specific and known schedule

Table 6.15 reveals that no scheduled maintenance is in place, as stated by 74.1% (83 respondents). Only 29 respondents (25.9% in total) mentioned that the equipment in their factory is maintained according to a specific and published schedule. The table gives detailed information on the four firms' results. From this, it can be said that firm A has the highest percentage of participants, 11 out of 30 altogether, who believe that maintenance is performed in accordance with a specified schedule; in contrast, the vast majority of respondents in firm D, 22 out of 24 in total, believe that maintenance work is done randomly in their factory.

Table 6.15: Maintenance of Equipment according to a Specific and Known Schedule (Source: author).

Scheduled Maintenance	Yes	No	Total
Factory A	11	19	30
Factory B	8	23	31
Factory C	8	19	27
Factory D	2	22	24
Total	29	83	112
Total %	25.9	74.1	100

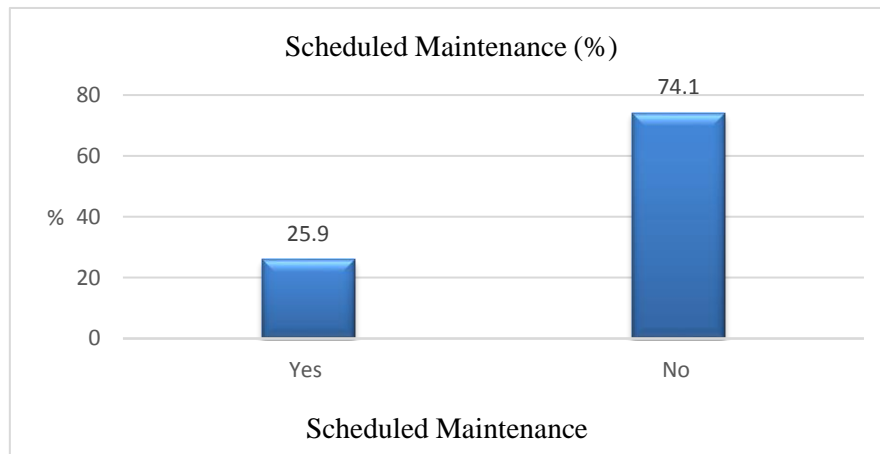


Figure 6.15: Maintenance of Equipment According to a Specific and Known Schedule (Source: author).

10 Staff knowledge of the equipment that they are about to fix

The respondents were asked to indicate the satisfaction level of their knowledge of equipment. Table 6.16 and Figure 6.16 show that more than 56% (63 respondents) had full information about the equipment of the production system in their factories. The rest, 49 respondents, were unsatisfied with their level of awareness about the equipment; they would have liked to know more about the components of the production systems in their factories. From Table 6.16 it can be observed that factories A, C and D have the same percentage of people who answered 'Yes', while the others, nearly two-thirds of the total, answered 'No'.

Table 6.16: Maintenance Staff Knowledge of the Equipment that they are about to Fix (Source: author).

Staff Awareness of Equipment	Yes	No	Total
Factory A	12	18	30
Factory B	21	10	31
Factory C	16	11	27
Factory D	14	10	24
Total	63	49	112
Total %	56.3	43.8	100

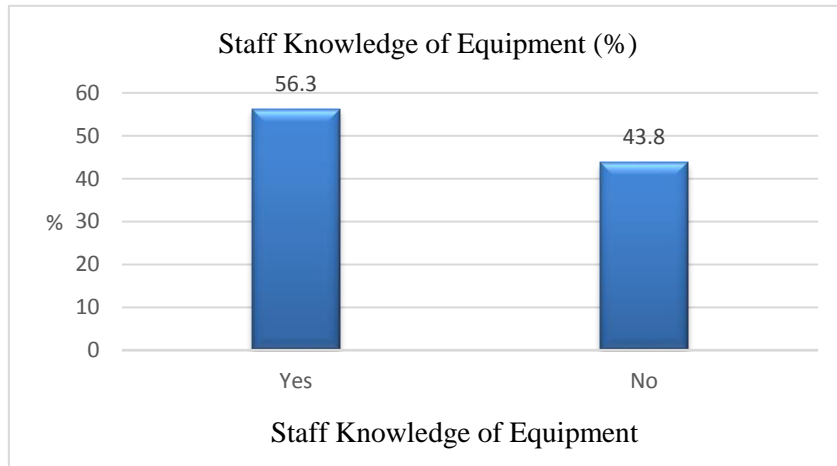


Figure 6.16: Maintenance Staff's Knowledge of the Equipment that they are about to Fix (Source: author).

11 Knowledge of any of the maintenance strategies

In relation to maintenance strategies, 69.6% (78) of the respondents, as shown in Table 6.17, answered that they knew of some maintenance strategies. In contrast, the remaining 30.4 % (34 out of 112 respondents in total) admitted that they did not know any strategies for maintenance.

Table 6.17: Knowledge of Maintenance Strategies (Source: author).

Maintenance Strategies Knowledge	Yes	No	Total
Factory A	21	9	30
Factory B	19	12	31
Factory C	21	6	27
Factory D	17	7	24
Total	78	34	112
Total %	69.6	30.4	100

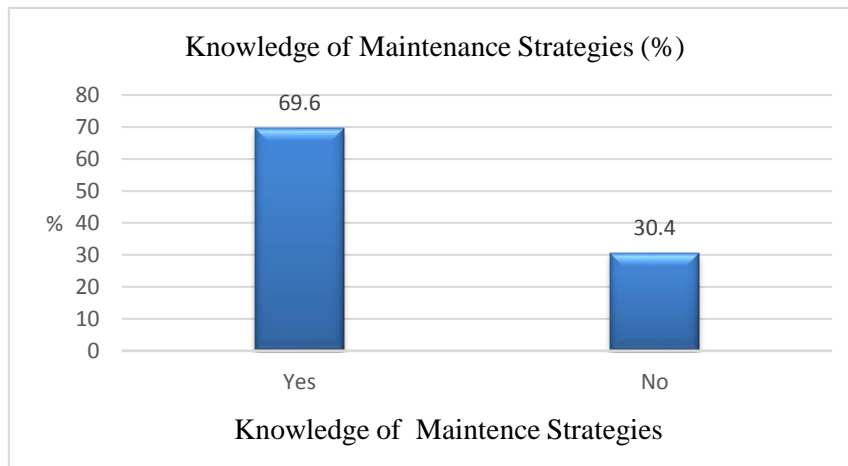


Figure 6.17: Knowledge of Maintenance Strategies (Source: author).

12 The desire to learn about maintenance strategies

Although 69.6% of the respondents (see the above figure) said that they knew of some modern maintenance strategies, it was an important aspect to involve in this question. The purpose of it was to assess the desire of the participants to learn about modern maintenance strategies. Table 6.18 illustrates that there is a significant difference between the participants who answered 'yes' (more than two-thirds) and those who answered 'no'. This contrast can be seen in Figure 6.18, showing that 77.7% (87 of respondents) maintained that they wanted to learn about modern maintenance strategies, whereas only 25 respondents (22.3%) were not interested in doing so. The most important issue that should be mentioned is that more than half the participants, 55.9% (19 out of 34 in total) who did not know any maintenance strategies, had no desire to learn them, as shown in the same figure.

Table 6.18: The Desire to Learn About Maintenance Strategies (Source: author).

Maintenance Strategies Learning	Yes	No	Total
Factory A	23	7	30
Factory B	24	7	31
Factory C	20	7	27
Factory D	20	4	24
Total	87	25	112
Total %	77.7	22.3	100

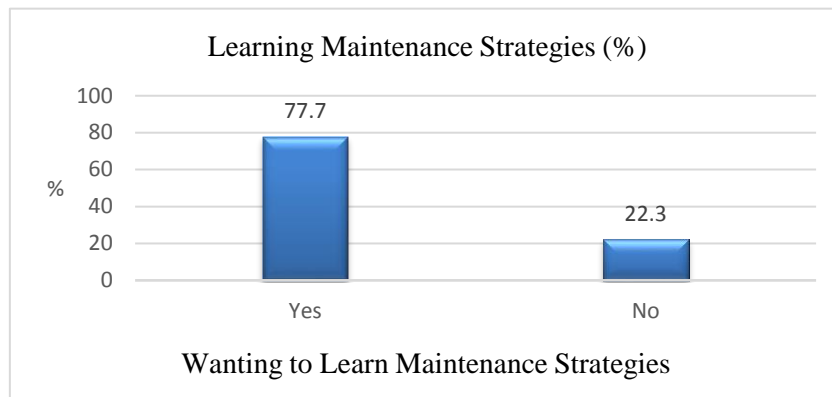


Figure 6.18: The Desire to Learn About Maintenance Strategies (Source: author).

13 known maintenance strategies

A substantial percentage, 69.6% (78 respondents), who had already answered they knew some of the maintenance strategies (see Table 6.19.1) were asked if they could identify any of these strategies. The analysis of this question, as shown in Figure 6.19, reveals that Reactive Strategy is the most widely known strategy among the targeted participants, with 43.6% (34 respondents) claiming that they knew it. This percentage was followed by 28 (35.9%) of the respondents who knew of the Proactive Maintenance Strategy. The percentage of staff who talked about the strategy of Total Productive Maintenance (TPM) reached just over 11.5% (9 respondents). The strategy of Reliability Centred Maintenance (RCM) was known by only 2.6 % (2 members of the maintenance staff) making it the least well-known. The percentage of respondents who claimed to know another strategy of maintenance was 6.4 percent. 39 respondents recognised reactive strategy in maintenance as the only one, while a proactive strategy was categorised as the only one by 28 respondents. The respondents who believed that they could identify more than one strategy of maintenance numbered 30 in total, as shown in Table 6.19.2.

Table 6.19.1: Known Maintenance Strategies (Source: author).

Recognised Maintenance Strategy	Reactive	Proactive (Predictive/Preventive)	Aggressive (Total Productive Maintenance)	Reliability Centred Maintenance	Others	Total
Factory A	8	9	4	0	0	21
Factory B	10	7	0	0	2	19
Factory C	12	6	2	0	1	21
Factory D	4	6	3	2	2	17
Total	34	28	9	2	5	78
Total %	43.6	35.9	11.5	2.6	6.4	100

Table 6.19.2: Knowing more than one Maintenance Strategy (Source: author).

Known Maintenance strategy	Reactive	Proactive	Total Productive Maintenance TPM	Reliability Centred Maintenance RCM
Reactive	39	0	0	0
Proactive	0	28	0	0
TPM	9	9	9	6
RCM	2	2	2	2

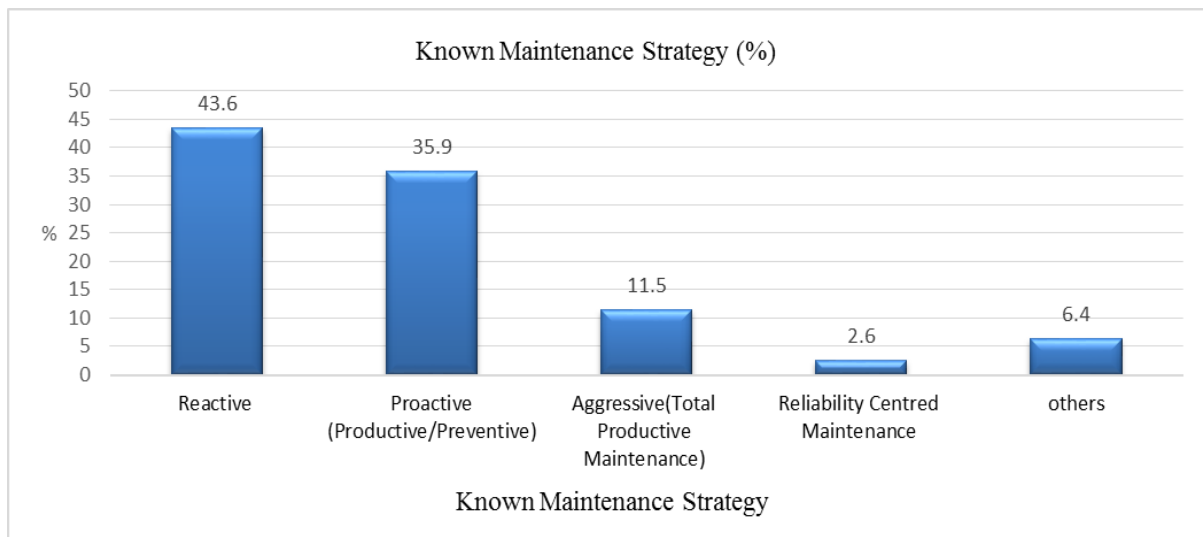


Figure 6.19: Known Maintenance Strategies (Source: author).

14 Maintenance strategy application

All the participants in the survey were asked to indicate whether their firms applied one or more of the identified strategies. This question aimed to measure the level of maintenance currently in place in these four cement factories. As can be seen from both Table 6.20 and Figure 6.20, more than two-thirds of the respondents, 69.9%, confirmed that there was no strategy of maintenance in place in their firms. 32

respondents (28.6%) stated that the maintenance departments in their factories applied one strategy or more when carrying out maintenance. The number of respondents who answered ‘don’t know’ was only four, 3.6%. From the same table, which illustrates the results of the four plants individually, it can be inferred that factory C favours the adoption of one or more of maintenance strategies, as stated by 11 out of 27 respondents in total.

Table 6.20: Application of Any Strategy of Maintenance (Source: author).

Maintenance Strategy Application	Yes	No	Don't know	Total
Factory A	7	20	3	30
Factory B	8	23	0	31
Factory C	11	15	1	27
Factory D	6	18	0	24
Total	32	76	4	112
Total %	28.6	69.9	3.6	100

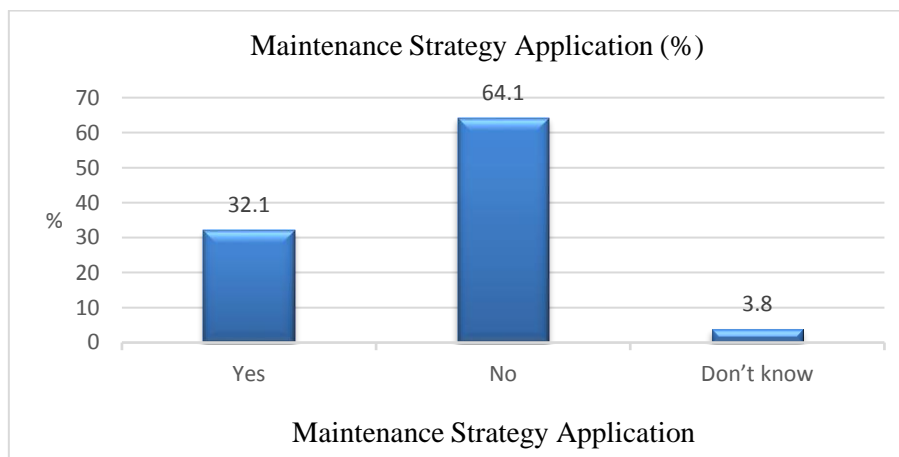


Figure 6.20: Application of Any Strategy of Maintenance (Source: author).

15 Reasons for not applying strategies

Reverting to the analysis of the previous results (Table 6.20), it was clear that the number of participants who saw no maintenance strategy currently in place in their firms was 76 out of 112. All respondents were asked to state what reasons, in their opinion, there were for not using maintenance strategies. This question sought to identify precisely the obstacles which might hinder the implementation of a proper maintenance strategy which would ensure successful maintenance. From Table 6.21, the signs of a significant managerial deficiency are obvious. The evidence of it is that nearly 54% (60 respondents out of 112 in total) believed that a lack of senior management interest was the main reason for not

applying strategies for maintenance. The lack of financial support is another obstacle to adopting any strategy of maintenance, as mentioned by 24.1% of the respondents. The opinion of six respondents about the reasons for non-application of strategies was different: they thought that there was no need for any maintenance strategy. Of the total (112), 19 respondents saw that the lack of staff awareness of the importance of maintenance was the main reason for the failure to think strategically about it.

Table 6.21: Reasons for Non-Application of Strategies (Source: author).

Reasons for not applying strategies	Lack of Financial Support	Lack of Senior Management Interest	No Need for Maintenance Strategies	Employees being Unfamiliar with Maintenance and its Importance	Total
Factory A	7	19	0	4	30
Factory B	6	16	3	6	31
Factory C	9	12	3	3	27
Factory D	5	13	0	6	24
Total	27	60	6	19	112
Total %	24.1	53.6	5.4	17.0	100

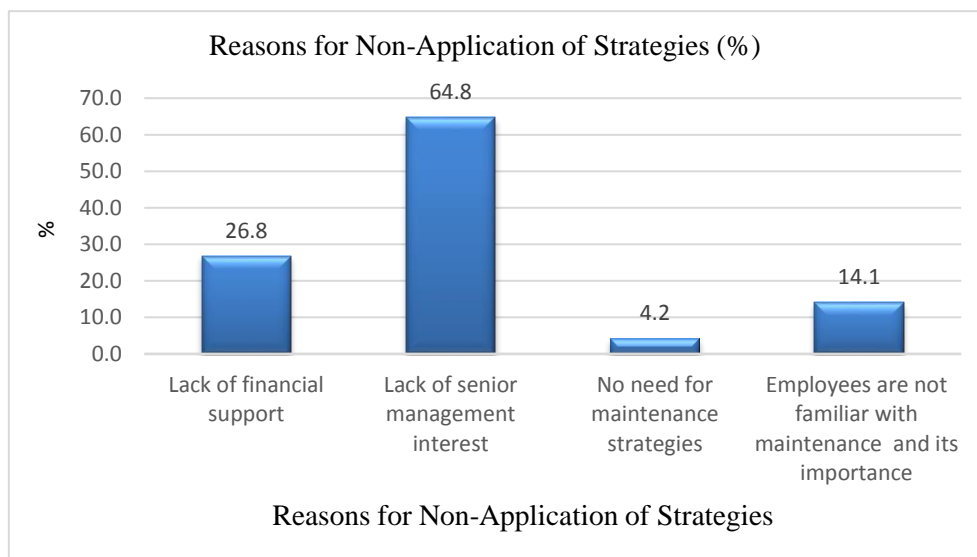


Figure 6.21: Reasons for Not Applying Strategies (Source: author).

16 Maintenance strategy used

Only 32 of the 112 respondents answered that their factories adopted one maintenance strategy or more, as shown in Table 6.20. These participants were asked to identify which strategy was used in their plants. According to Figure 6.22, the results were as follows: 78.1% (25 respondents) saw a reactive strategy as the most used approach in their firm. Only seven of those in the first of these categories

(21.9%) stated that their factories took a proactive approach as a strategy for maintenance. From Table 6.22 it is clear that the strategies of TPM and RCM are no longer implemented; none of the respondents acknowledges the use of such strategies.

Table 6.22: Maintenance Strategy Adopted (Source: author).

Maintenance Strategy Used	Reactive	Proactive (Predictive/Preventive)	Aggressive (Total Productive Maintenance)	Reliability Centred Maintenance	Total
Factory A	4	3	0	0	7
Factory B	6	2	0	0	8
Factory C	11	0	0	0	11
Factory D	4	2	0	0	6
Total	25	7	0	0	32
Total %	78.1	21.9	0	0	100

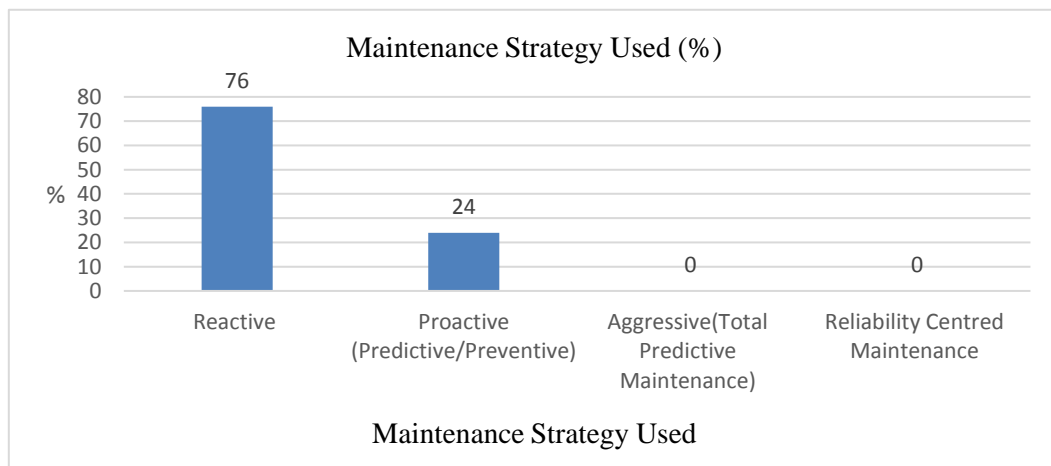


Figure 6.22: Maintenance Strategy Adopted (Source: author).

17 Reasons for choosing the strategy

The same number of participants, 25, who answered that their factories had adopted one maintenance strategy or more, were asked to give their reasons for choosing the strategy in question. From both Table 6.23 and Figure 6.23, it is clear that experience was the main determinant if this choice; it was given by 56% (14 respondents out of 25 in total). The strategies of maintenance were selected according to scientific studies, in the view of eight respondents (32%). Out of this 25, only three respondents (12%) admitted that maintenance strategies were chosen at random in their factory.

Table 6.23: Basis of chosen the Current Strategy (Source: author).

Reasons for Choosing the Strategy	Scientific Study	Experience	Random	Total
Factory A	0	4	1	5
Factory B	3	4	0	7
Factory C	2	5	2	9
Factory D	3	1	0	4
Total	8	14	3	25
Total %	32	56	12	100

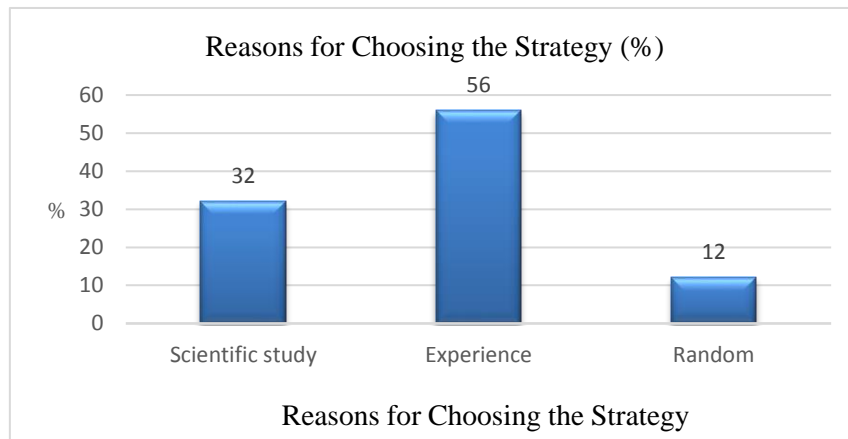


Figure 6.23: Basis for Choosing the Current Strategy (Source: author).

18 The effectiveness of current strategy

The participants in the survey were asked to express their views on the effectiveness of the maintenance strategy or method currently in place. As can be seen from Table 6.24, more than half of the total, 56.3% (63 respondents) agreed that the strategy currently in place was ineffective. 22 respondents (19.6%) saw the opposite, claiming that the strategy used in their factories was efficient. The number of respondents who were not sure if the strategy used in their plants was effective or not was 27 (24.1%).

Table 6.24: The Effectiveness of the Current Strategy (Source: author).

The Effectiveness of Current Strategy	Effective	Not effective	Don't Know	Total
Factory A	8	16	6	30
Factory B	4	18	9	31
Factory C	6	14	7	27
Factory D	4	15	5	24
Total	22	63	27	112
Total %	19.6	56.3	24.1	100

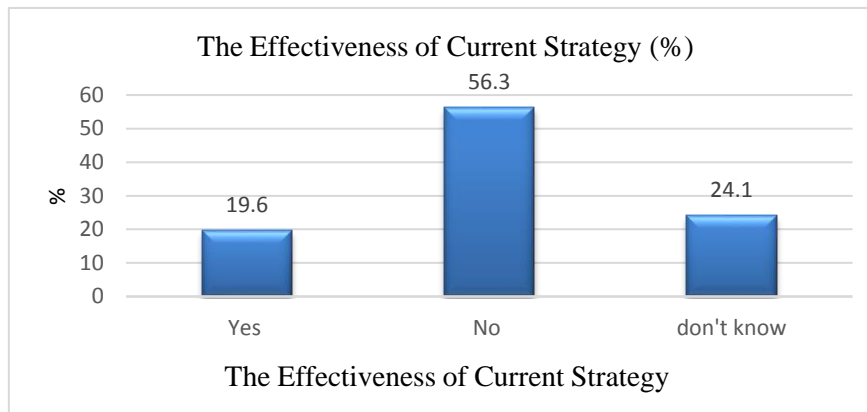


Figure 6.24: The Effectiveness of Current Strategy (Source: author).

19 Encountering problems when carrying out maintenance

It can be observed in both Table 6.25 and Figure 6.25 that administrative issues are among the greatest obstacles faced by the staff when conducting maintenance activities. This finding is mentioned by 59 respondents (52.7%). The number of participants who saw technical problems as the main obstacles to the success of maintenance was 39 (34.8%). From the perspective of 14 respondents (12.5%), financial issues head the hindrances to the success of maintenance. Looking at the table, almost half of the total number in each plant see that managerial issues impede the success of maintenance.

Table 6.25: Problems Encountered in Maintenance Work (Source: author).

Maintenance Problems	Financial	Technical	Managerial	Total
Factory A	4	11	15	30
Factory B	4	12	15	31
Factory C	5	7	15	27
Factory D	1	9	14	24
Total	14	39	59	112
Total %	12.5	34.8	52.7	100

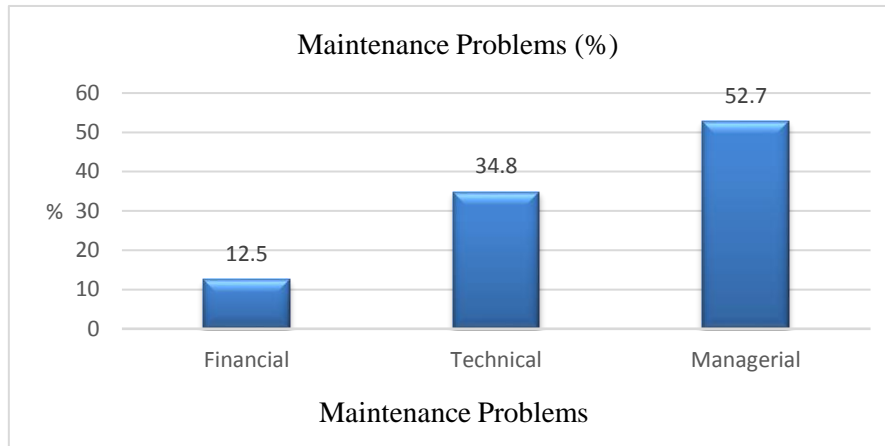


Figure 6.25: Problems Encountered in Maintenance Work (Source: author).

20 Clear understanding of the importance of maintenance

The only conclusion that can be drawn from Figure 6.26 is that the shop floor staff of these firms do seem to have a good level of understanding of the importance of maintenance. This view is expressed by 69.6% (78 respondents), who said that they had sufficient understanding of the importance of maintenance. The remainder, 34 out of the 112 respondents, had no clear understanding of maintenance and its importance. From Table 6.26, it can be noted that, unlike the other three, factory D had an equal number of respondents answering yes and no to this question.

Table 6.26: Clear Understanding of the Importance of Maintenance (Source: author).

Understanding of the Importance of Maintenance	Yes	No	Total
Factory A	22	8	30
Factory B	24	7	31
Factory C	20	7	27
Factory D	12	12	24
Total	78	34	112
Total %	69.6	30.4	100

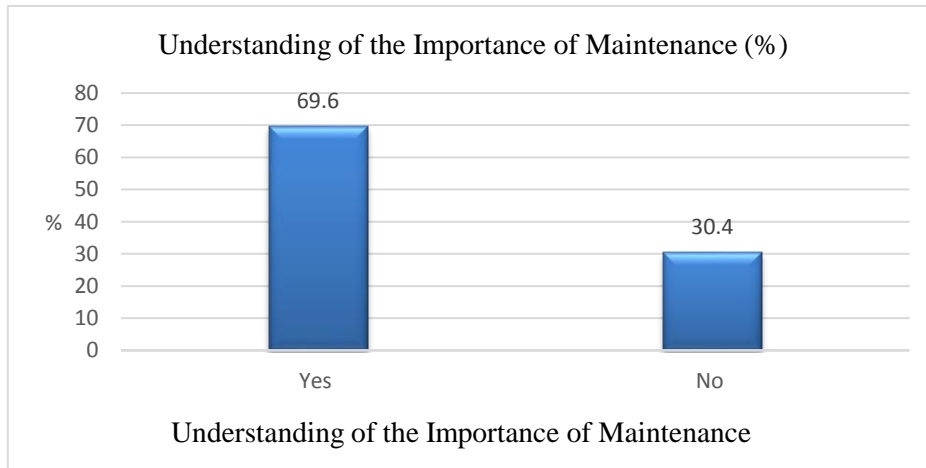


Figure 6.26: Clear Understanding of the Importance of Maintenance (Source: author).

21 Maintenance development plans

The respondents from the shop floor were asked whether there were any plans to develop maintenance in their plants. As can be seen in both Table 6.27 and Figure 6.27, more than 60% (68 respondents) indicated that their factories had no maintenance plans. The remaining 39.3% (44 respondents) stated that there are some plans to improve maintenance under discussion in their factory. From the same table, one can find that factory A has the highest proportion of respondents who answered yes (16, more than half of the 30 respondents). In contrast, this number was about one-third of all participants in firms B, C and D.

Table 6.27: The Availability of Plans to develop Maintenance (Source: author).

Maintenance Development Plans	Yes	No	Total
Factory A	16	14	30
Factory B	11	20	31
Factory C	9	18	27
Factory D	8	16	24
Total	44	68	112
Total %	39.3	60.7	100

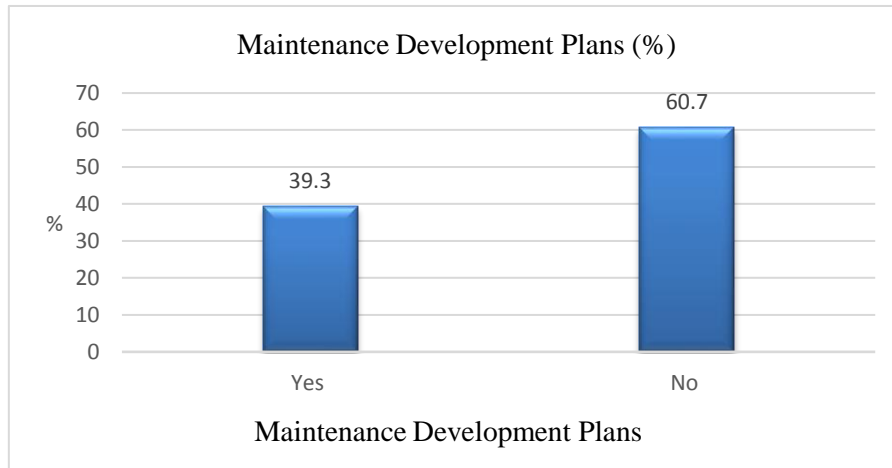


Figure 6.27: The Availability of Plans to Develop Maintenance (Source: author).

22 Belief that improving maintenance could increase the reliability of production systems

Table 6.28 and Figure 6.28 present the staff opinions on increasing the reliability of the production systems through improving maintenance. Of the 112 respondents, 46 (41.1%) claimed to “Strongly agree” and 48 (42.9%) to “Agree” that this would be possible. More than 14.3% (16 respondents) stated that they had no knowledge whether improving maintenance would positively affect the reliability of the production systems in their factories. A relatively very small number of participants (only 2) saw no relationship between maintenance activities and improving system reliability. From the same table, it can be observed that a considerable majority of surveyed staff, about 84%, believed see that reliability of production systems could be improved through giving more attention to maintenance.

Table 6.28: Increasing Production through Ensuring its Reliability by Maintenance (Source: author).

Reliability Increases the Amount of Production	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree	Total
Factory A	8	18	4	0	0	30
Factory B	11	12	6	2	0	31
Factory C	12	13	2	0	0	27
Factory D	15	5	4	0	0	24
Total	46	48	16	2	0	112
Total %	41.1	42.9	14.3	1.8	0	100

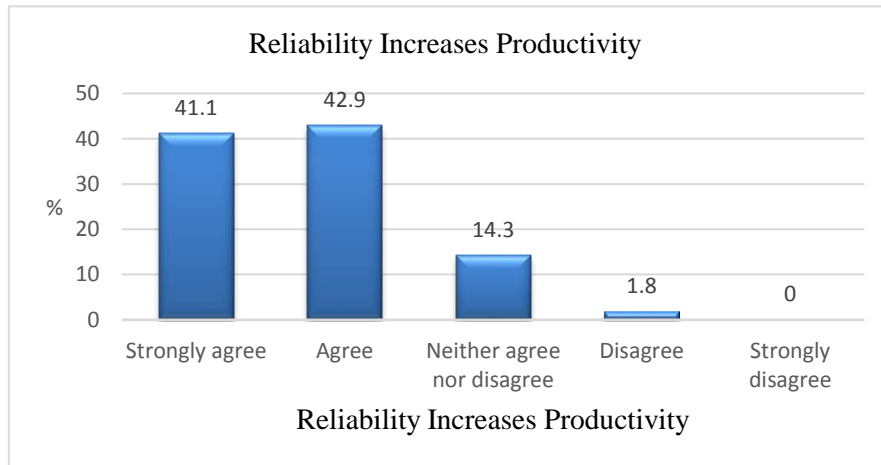


Figure 6.28: Increase the Amount of Production Through Ensuring the Reliability of Production Lines by Maintenance (Source: author).

23 Knowledge of RCM

A simplified definition of the RCM strategy was given with this question to put participants in a good position for answering it. As can be seen in both Table 6.29 and Figure 6.29, among the 112 respondents, only 33 (29.5%) had heard about RCM as a strategy through which the reliability of production systems could be increased. In contrast, more than 70% (79 respondents) had no idea of the meaning of Reliability Centred Maintenance as a strategy. Regarding these results, it is worth mentioning that in question 13 only two people claimed to be aware of or knowledgeable about RCM, but after the 112 respondents had been given the definition of this strategy it became apparent from the answers that more than this number knew about it.

Table 6.29: Knowledge of RCM (Source: author).

Knowledge of Reliability Centred Maintenance	Yes	No	Total
Factory A	8	22	30
Factory B	11	20	31
Factory C	6	21	27
Factory D	8	16	24
Total	33	79	112
Total %	29.5	70.5	100

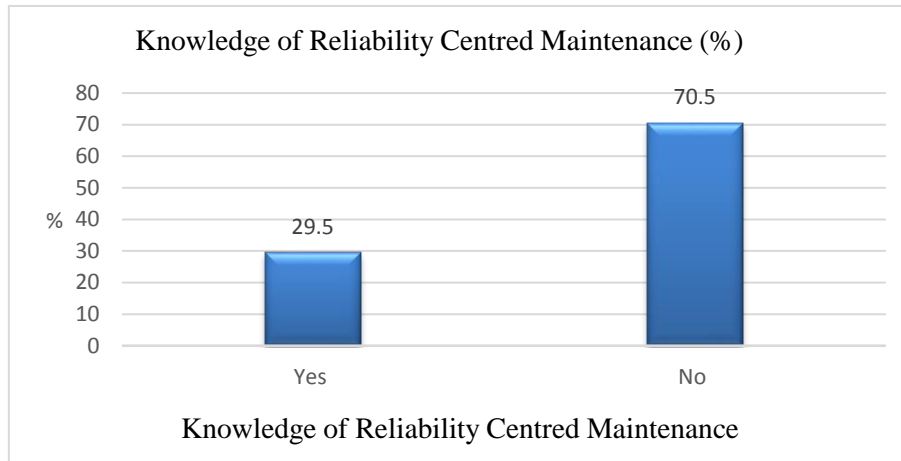


Figure 6.29: Knowledge of RCM (Source: author).

24 Feeling a need to apply a modern strategy such as RCM

The respondents were asked to indicate if there was a need to apply RCM in their firms as part of the maintenance development programme. The analysis reveals that most of the respondents (91 respondents, more than 81%) thought that there was a great need to apply the strategy of RCM to improve the efficiency of maintenance in their firms, which in turn would improve the performance of their production systems. In contrast, only 18.8% (21 respondents) asserted that implementing a strategy such as RCM would make no difference (see Table 6.30 and Figure 6.30, below).

Table 6.30: The Need to Apply a Modern Strategy Such as RCM (Source: author).

Need to Apply RCM	Yes	No	Total
Factory A	22	8	30
Factory B	24	7	31
Factory C	23	4	27
Factory D	22	2	24
Total	91	21	112
Total %	81.3	18.8	100

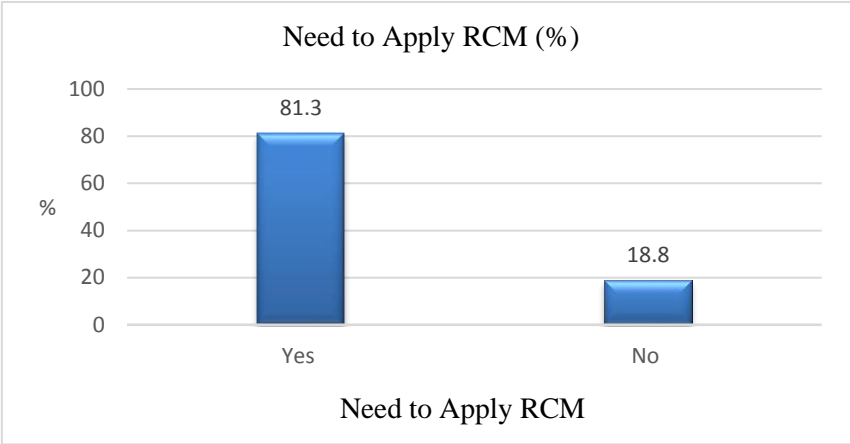


Figure 6.30: The Need to Apply a Modern Strategy such as RCM (Source: author).

25 Previous attempts to use RCM

The results for this question, as shown in Table 6.31, illustrate that the vast majority of the surveyed staff, 93.8% (105 respondents out of 112) could not recall any previous attempt to use a modern strategy such as RCM in their factory, while a small number of participants, only seven, maintained that efforts had been made to implement this new strategy in their factories.

Table 6.31: Previous Attempts to Use a Modern Strategy such as RCM (Source: author).

Previous Attempt to use RCM	Yes	No	Total
Factory A	2	28	30
Factory B	3	28	31
Factory C	2	25	27
Factory D	0	24	24
Total	7	105	112
Total %	6.3	93.8	100

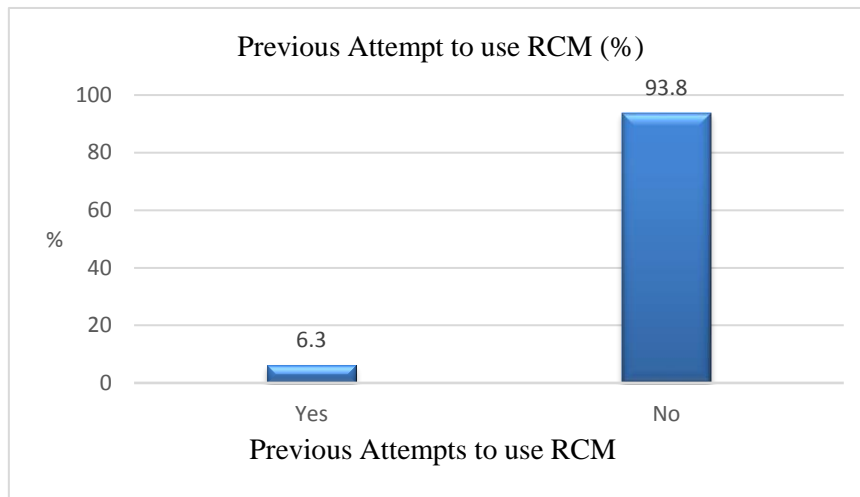


Figure 6.31: Previous Attempts to Use a Modern Strategy such as RCM (Source: author).

26 The availability of monitoring systems

There was significant variance in the respondents' answers about the availability of devices or a system to monitor the components of production systems, such as temperature sensors and cameras. This difference can be seen in Figure 6.32, which indicates that very nearly all the respondents, slightly less than 94%, confirmed the existence of devices to monitor equipment. In contrast, only seven respondents (6.3%) agreed with this point by confirming that no programmes had been set up to monitor equipment.

Table 6.32: The Availability of a Monitoring System (Source: author).

The Availability of a Monitoring System	Yes	No	Total
Factory A	26	4	30
Factory B	29	2	31
Factory C	27	0	27
Factory D	23	1	24
Total	105	7	112
Total %	93.8	6.3	100

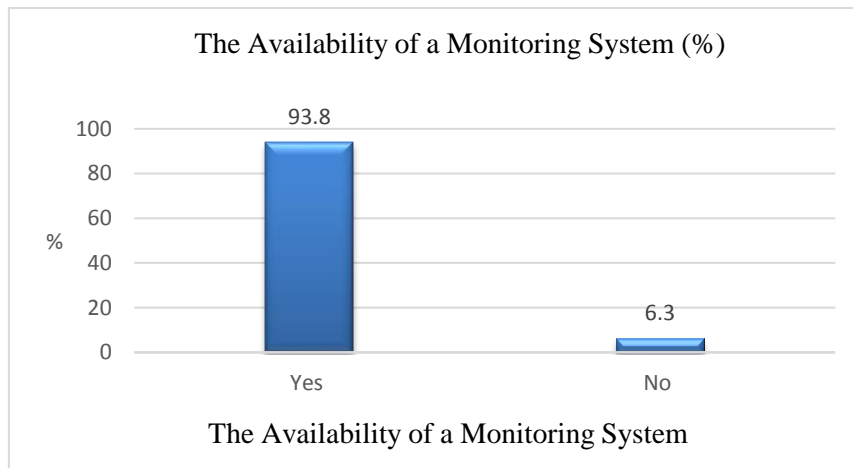


Figure 6.32: The Availability of a Monitoring System

27 Programme to calibrate the monitoring system

The respondents who answered yes to the previous question, 105 out of 112 in total, were asked to indicate whether their monitoring systems had any programmes of calibration. The findings are presented in both Table 6.33 and Figure 6.33. More than 83% (88 respondents) replied that their control system was regularly calibrated. A relatively small proportion (only 16.2%) said that calibration programmes were not available in their firms.

Table 6.33: The Availability of Programmes to Calibrate the Monitoring System (Source: author).

Programme to Calibrate the Monitoring System	Yes	No	Total
Factory A	24	2	26
Factory B	21	8	29
Factory C	23	4	27
Factory D	20	3	23
Total	88	17	105
Total %	83.8	16.2	100

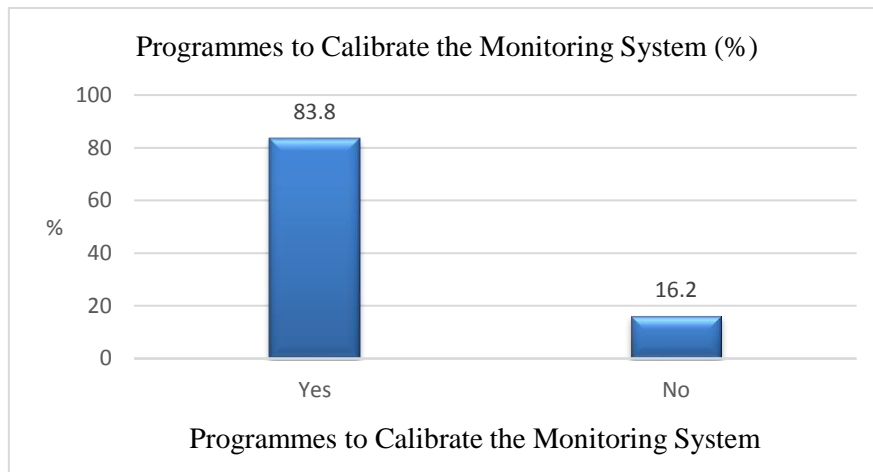


Figure 6.33: The Availability of Programmes to Calibrate the Monitoring System (Source: author).

6.2.3 Management Related Issues

Evaluating the administrative status of the targeted plants is an important matter. Through this assessment, the level of management’s effectiveness and the contribution to the implementation and success of maintenance can be determined. To explore these issues, the respondents were asked a set of questions about their perceptions and their views with respect to the managerial performance in their factories.

1 Receive support from management when carrying out maintenance

To reveal the level of interest among senior management in supporting maintenance activities, the respondents were asked to indicate if they received any support from management to help them do their work better. The findings are presented in both Table 6.34 and Figure 6.34. Only 14 respondents (12.5%) mentioned that they received support from the management when carrying out regular maintenance work, while nearly twice as many (26 respondents, 23.2%) said that they would receive managerial support just when they ask for it. From the same figure, it can be seen that 45.5% (51

respondents) said that they received some help if there was a big problem with the production systems which could lead, for example, to the complete destruction of the components of some of these systems leading to a loss which would exceed the amount of reward demanded by the workers. The number of participants who did not believe in management encouragement under any circumstances was 21 respondents out of 112.

Table 6.34: Receive Support from Management when Carrying out Maintenance (Source: author).

Management Support for Maintenance	Yes	When I ask	If there is a big problem	No	Total
Factory A	4	8	16	2	30
Factory B	4	8	14	5	31
Factory C	6	5	12	4	27
Factory D	0	5	9	10	24
Total	14	26	51	21	112
Total %	12.5	23.2	45.5	18.8	100

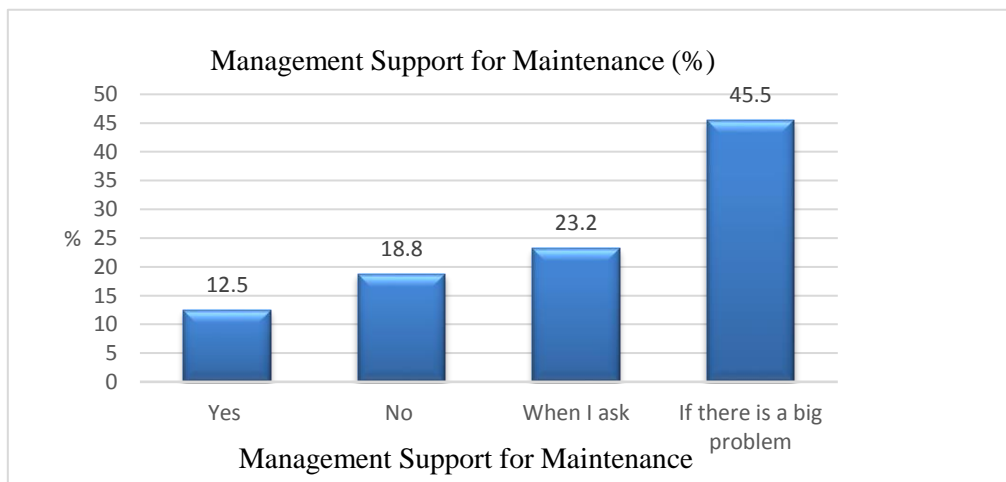


Figure 6.34: Receive Support from Management when Carrying out Maintenance (Source: author).

2 Cooperation between the maintenance and production departments

The respondents were asked to indicate if there was any cooperation between the maintenance and production departments in their factories. In answer, as shown in Table 6.35 and Figure 6.35, 39.3% (44 respondents) stated that there was continuous cooperation between the maintenance and production departments represented in regular meetings and information exchanges between them. More than half the respondents (59 out of 112) found the departments of maintenance and production teamwork sometimes worked as a team. Only nine respondents (8%) pointed to the rarity of cooperation between those two departments, since they may be unable to arrange regular meetings. This is due, for example,

to the lack of communication tools in use, such as the internet. From the same table, it can be noted that no one ever disagrees with this; since none of the respondents answered "Never", there is always some kind of relationship between these departments.

Table 6.35: Cooperation between the Departments of Maintenance and Production (Source: author).

Cooperation Between the Maintenance and Production Departments	Always	Sometimes	Rarely	Never	Total
Factory A	12	16	2	0	30
Factory B	11	14	6	0	31
Factory C	9	17	1	0	27
Factory D	12	12	0	0	24
Factory A	44	59	9	0	112
Total %	39.3	52.7	8	0	100

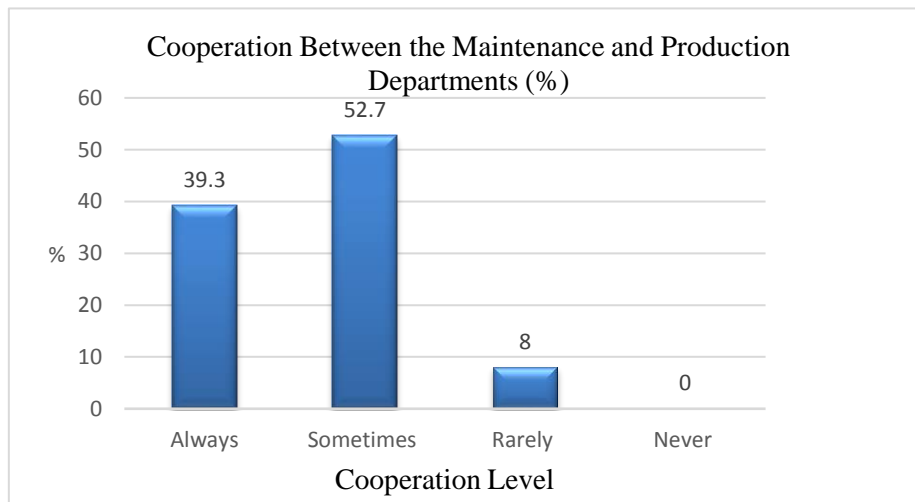


Figure 6.35: Cooperation between the Departments of Maintenance and Production (Source: author).

3 The relationship between the staff categories

It is believed that measuring the level of cooperation between the shop floor staff and management, and between the shop floor members themselves is critical to painting a clear picture of the conditions surrounding maintenance. To reach this, the participants were asked to give their opinions of the relationship between the following three pairs: engineers and technicians, engineers and managers and managers and technicians in the staff of their factories. The results of these questions are described in 3; 1, 3; 2 and 3; 3.

3-1 Relationship between engineers and technicians

The analysis of the answers to this question, as shown in Table 6.36, reveals that 48 of the respondents (just under 43%) see the relations between managers and technicians in their plants as strong one; they always share their views regarding maintenance and help each other as a team in performing maintenance activities. The relations between these two groups are neither strong nor weak, in the view of 60 respondents (53.6%), since engineers are quite often not interested in dealing with technicians. A relatively small proportion (only 3.6%) describes these relations as weak, evidenced by the unwillingness of engineers to do technical jobs. From Figure 6.36 it can be observed that none of the respondents considers the relations between managers and engineers to be inadequate.

Table 6.36: Relationship Between Engineers and Technicians (Source: author).

Relationship Between Engineers and Technicians	Strong	Medium	Weak	No relation	Total
Factory A	13	16	1	0	30
Factory B	13	17	1	0	31
Factory C	11	16	0	0	27
Factory D	11	11	2	0	24
Total	48	60	4	0	112
Total %	42.9	53.6	3.6	0	100

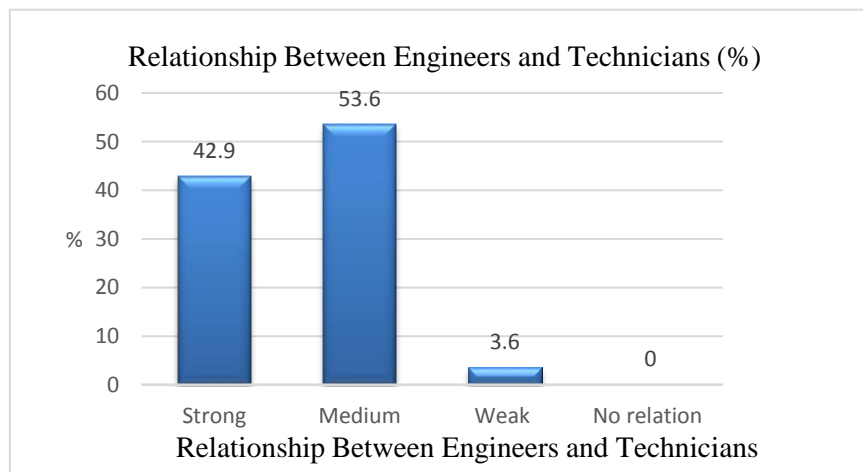


Figure 6.36: Relationship Between Engineers and Technicians (Source: author).

3-2 Relationship between engineers and managers

As can be seen from both Table 6.37 and Figure 6.37, among the 112 respondents only 25 (3%) agree that their managers contact them fairly often to listen to their opinions and suggestions regarding maintenance – they see the relations between themselves and their managers as active. More than double

this number, about 57 respondents, may find to hard to discuss maintenance related issues with their managers, and evaluate these relations as neither strong nor weak. 30 respondents (26.8%), however, see the relations between managers and engineers as weak. by which they mean that it is very rare for engineers to be contacted by their managers. Again, none of the respondents observed no relationship between engineers and managers in their firms.

Table 6.37: Relationship between Engineers and Managers (Source: author).

Relationship Between Engineers and Managers	Strong	Medium	Weak	No relation	Total
Factory A	7	13	10	0	30
Factory B	5	18	8	0	31
Factory C	7	15	5	0	27
Factory D	6	11	7	0	34
Total	25	57	30	0	112
Total %	22.3	50.9	26.8	0	100

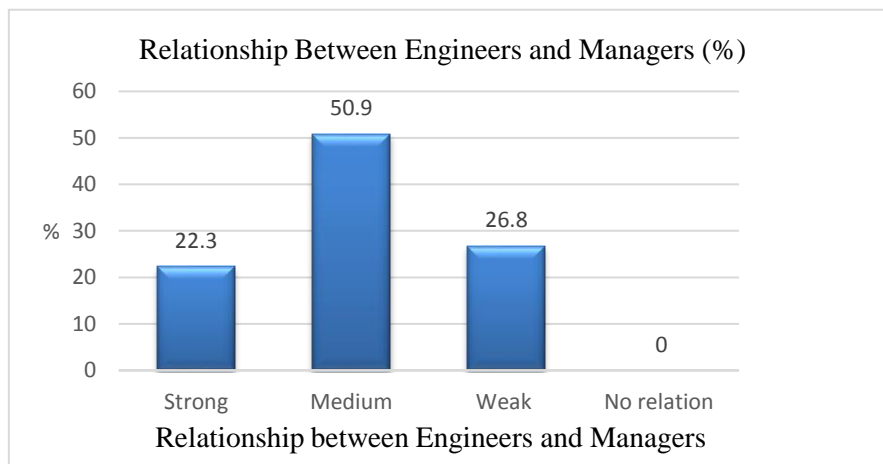


Figure 6.37: Relationship between Engineers and Managers (Source: author).

3-3 Relationship between managers and technicians

When respondents were asked to describe the relations between technicians and managers in their firms, it was found that, as in Table 6.38, only 2.7% (3 respondents) could contact managers at any time they wanted, and on this basis saw their relationship with managers as strong. This number increased more than five times, to 17 respondents who believe that the relations between technicians and managers were neither strong nor weak as they felt fairly likely to contact or be contacted by their managers. The biggest proportion of the surveyed staff (58, 51.8%) agreed with that it was very difficult for them to meet managers to discuss any issues related to maintenance and inferred from this that the relations

between themselves and management were weak. Figure 6.38, unlike the two previous questions, illustrates that more than 30% (34 respondents) could perceive no relationship between technicians and managers.

Table 6.38: Relationship between Managers and Technicians (Source: author).

Relationship between Managers and Technicians	Strong	Medium	Weak	No relation	Total
Factory A	2	4	11	13	30
Factory B	1	8	13	9	31
Factory C	0	3	17	7	27
Factory D	0	2	17	5	24
Total	3	17	58	34	112
Total %	2.7	15.2	51.8	30.4	100

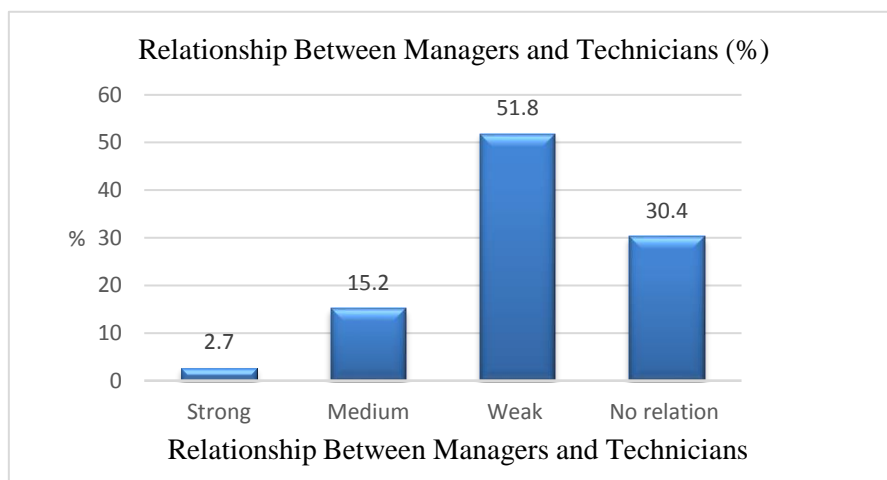


Figure 6.38: Relationship between Managers and Technicians (Source: author).

4 Maintenance backlog

The level of organisation at work can be measured by how quickly the maintenance workers respond to demand. To give an idea of this, the staff in this survey were asked to indicate if there was any maintenance backlog in their firms. As Table 6.39 shows, 41% (46 respondents) said that there was a continuous accumulation of maintenance work in their factories, while a maintenance backlog occurs sometimes, according to over half the 112 respondents (about 54.5%). Only 5 of the respondents (4.5%) mention the existence of an accumulation of maintenance, while none of the respondents reported no maintenance backlog of any kind.

Table 6.39: The Accumulation of Maintenance (Source: author).

Maintenance Backlog	Always	Sometimes	Rarely	Never	Total
Factory A	11	18	1	0	30
Factory B	13	16	2	0	31
Factory C	9	16	2	0	27
Factory D	13	11	0	0	24
Total	46	61	5	0	112
Total %	41	54.5	4.5	0	100

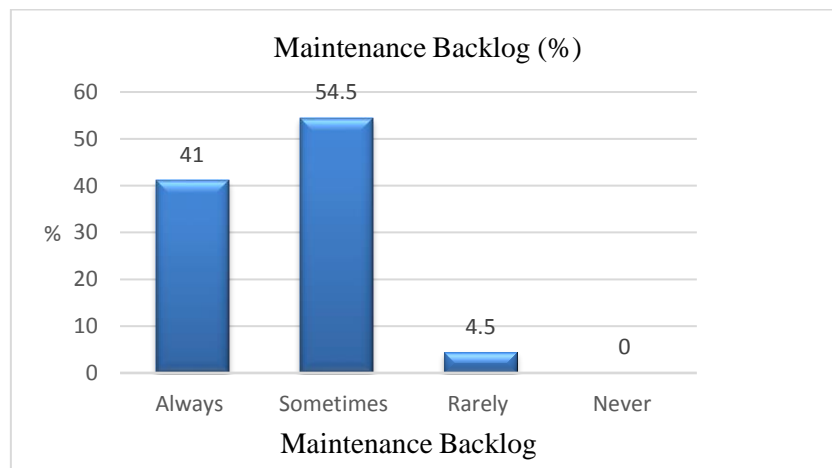


Figure 6.39: The Accumulation of Maintenance (Source: author).

5 Sufficiency of staff numbers

This question was designed to determine the participant's opinions on whether enough maintenance staff works on the shop floor, regardless of educational level, training, skills or experience. These results were intended to help clarify the proportion of qualified workers compared with the total number of maintenance staff on the shop floor. Only 20 respondents (17%), as shown in Table 6.40 and Figure 6.40, agreed that the number of people who are registered with the maintenance department is excessive. In contrast, the participants who believe that there is a need for more maintenance staff to fulfil their firm's maintenance requirements reached 58% of the total (65 respondents), more than three times the size of the first group. The remaining group, just 25% (28 respondents), was not sure whether the number of maintenance workers available was adequate.

Table 6.40: Adequacy of Staff Numbers (Source: author).

Sufficiency of Staff Numbers	Yes	No	Don't know	Total
Factory A	4	22	4	30
Factory B	6	16	9	31
Factory C	5	13	9	27
Factory D	4	14	6	24
Total	19	65	28	112
Total %	17	58	25	100

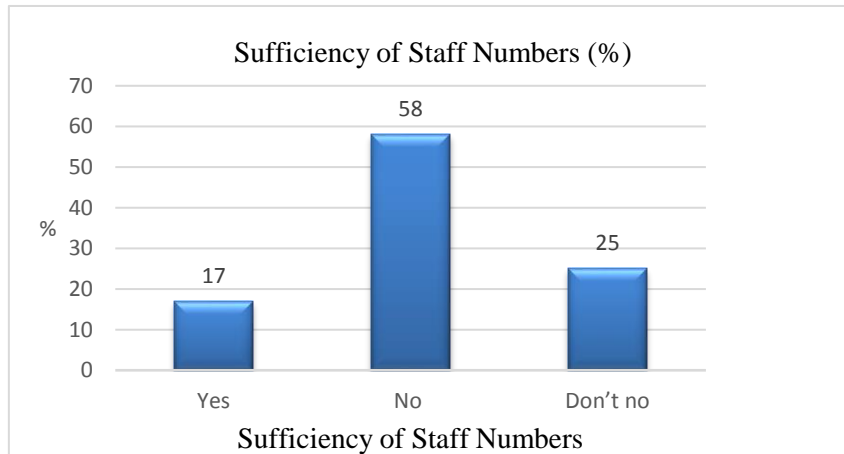


Figure 6.40: Adequacy of Staff Numbers (Source: author).

6 Percentage of qualified staff

The respondents who answered yes to the previous question were asked to state the approximate proportion of the maintenance staff who were eligible to undertake maintenance as required, i.e. the proportion who held certificates related to maintenance field or had received training, etc. As can be seen in Figure 6.41, the percentage of qualified workers was believed by seven respondents (36.8%) to be less than 25%. The remainder, more than 63% (12 out of 19 respondents) thought that 25 to 50% of maintenance staff were qualified. From Table 6.41, it can be observed that the highest proportion posted by the participants was 50%.

Table 6.41: Proportion of Qualified Staff (Source: author).

Percentage of Qualified Staff	Less than 25%	25 to 50%	51 to 75%	More than 75%	Total
Factory A	1	3	0	0	4
Factory B	3	3	0	0	6
Factory C	1	4	0	0	5
Factory D	2	2	0	0	4
Total	7	12	0	0	19
Total %	36.8	63.2	0	0	100

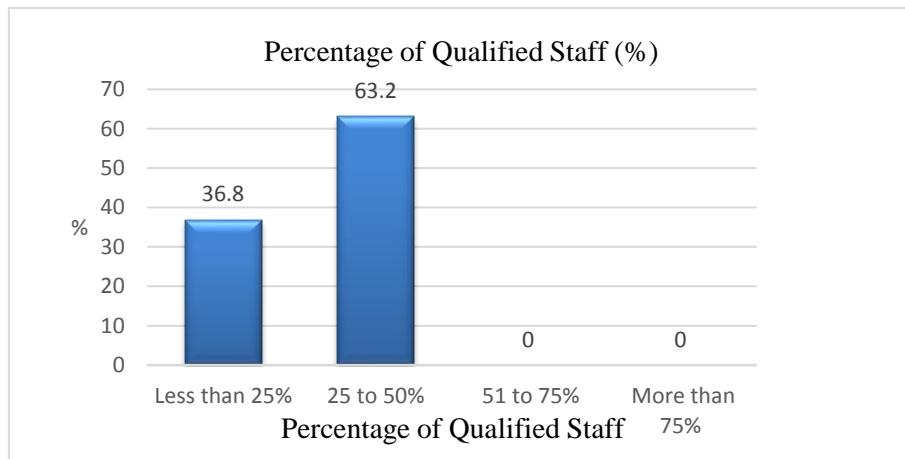


Figure 6.41: Proportion of Qualified Staff (Source: author).

7 Availability of maintenance tools

Table 6.42 illustrates that 41 (36.6%) of the respondents did not admit any shortage of maintenance tools in their factories, including hand tools such as screwdrivers and pliers, and/or power tools such as power drills and grinders. The respondents mentioned that these tools are always on hand. The percentage of participants who claimed that sometimes there was a shortage of maintenance tools in the four cement plants was 65 (58%). Figure 6.42 shows that only six respondents (5.5%) believed that there was a significant shortage of tools at maintenance sites. However, none of the participants went to far as to allege that maintenance tools were not available at all.

Table 6.42: Availability of Maintenance Tools (Source: author).

Availability of Maintenance Tools	Always	Sometimes	Rarely	Not available	Total
Factory A	14	16	0	0	30
Factory B	9	20	2	0	31
Factory C	8	16	3	0	27
Factory D	10	13	1	0	24
Total	41	65	6	0	112
Total %	36.6	58	5.4	0	100

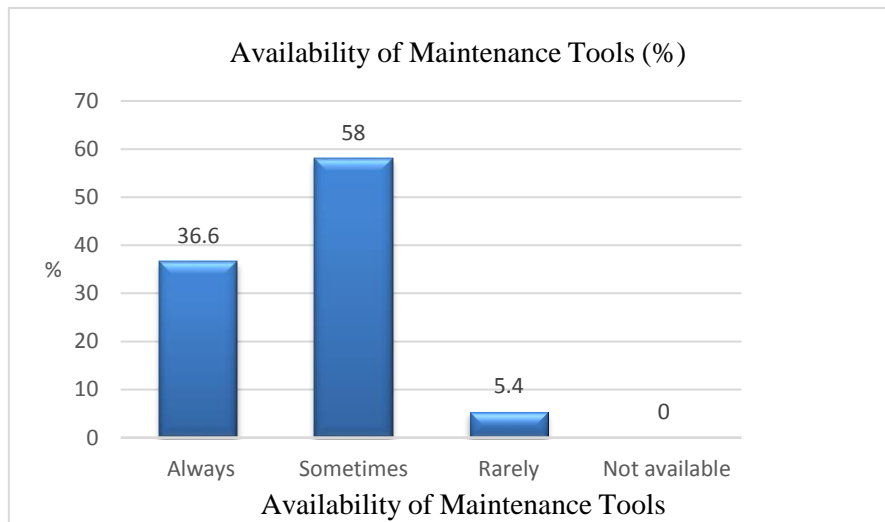


Figure 6.42: Availability of Maintenance Tools (Source: author).

8 Maintenance tools are stored properly

Since all of the surveyed staff agreed on the availability of maintenance tools, even if they are insufficient they were asked to indicate if these tools were kept in order in a clean place. The findings are presented in both Table 6.43 and Figure 6.43. Most of the respondents (75.9%: 85 respondents) conceded that their factories stored the maintenance tools properly, but only quarter of them, 27 respondents out of 112, mentioned to that there were no particular procedures to follow in storing the maintenance tools.

Table 6.43: Maintenance Tools are Stored Properly (Source: author).

Maintenance Tools are Stored Properly	Yes	No	Total
Factory A	24	6	30
Factory B	26	5	31
Factory C	18	9	27
Factory D	17	7	24
Total	85	27	112
Total %	75.9	24.1	100

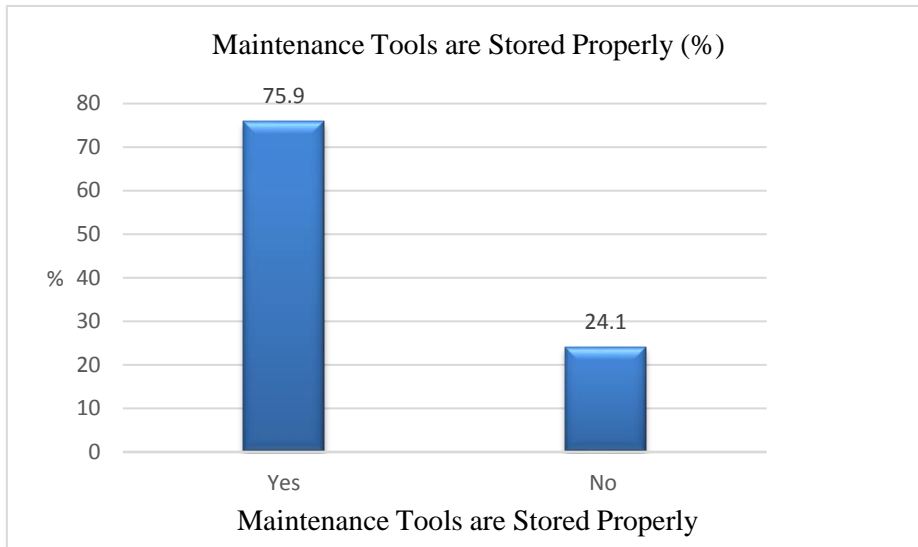


Figure 6.43: Maintenance Tools are Stored Properly (Source: author).

9 Reach the maintenance tools easily

To find whether the maintenance tools are stored in a suitable place, the respondents were asked if they could easily reach these tools when needed. As can be seen from Table 6.44, a sizeable majority of the sample (84.8%: 95 respondents) agreed that the maintenance tools were stored properly in their factories and could easily be located. The remainder 17 respondents (15.2%), had difficulty in accessing maintenance tools and answered no.

Table 6.44: The Possibility of Reaching the Maintenance Tools Easily (Source: author).

Reach the Maintenance Tools Easy	Yes	No	Total
Factory A	25	5	30
Factory B	24	7	31
Factory C	23	4	27
Factory D	23	1	24
Total	95	17	112
Total %	84.8	15.2	100

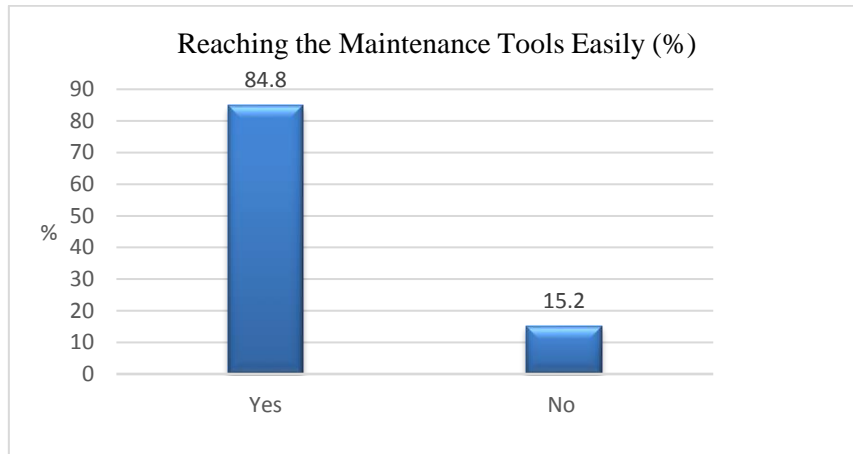


Figure 6.44: The Possibility of Reaching the Maintenance Tools Easily (Source: author).

10 Documentation of maintenance

The maintenance staff who participated in this survey were asked to indicate whether the maintenance activities are documented in their place of work. This question was asked because it was believed that documentation is an important aspect of measuring and improving maintenance. However, Table 6.45 and Figure 6.45 give a clear picture of a low level of maintenance documentation in the four targeted firms. The table suggests that only 20.5% (23 respondents) believe the factories to keep up a regular system of recording maintenance data, much outweighed by the 65 respondents (58%) who said that no records were kept of the completed maintenance tasks. 21.4% (24 respondents) judged that some but not all maintenance activities were documented in their plants.

Table 6.45: Documentation of Maintenance (Source: author).

Maintenance Activities Recorded	Yes	No	Sometimes	Total
Factory A	5	19	6	30
Factory B	5	20	6	31
Factory C	7	14	6	27
Factory D	6	12	6	24
Total	23	65	24	112
Total %	20.5	58	21.4	100

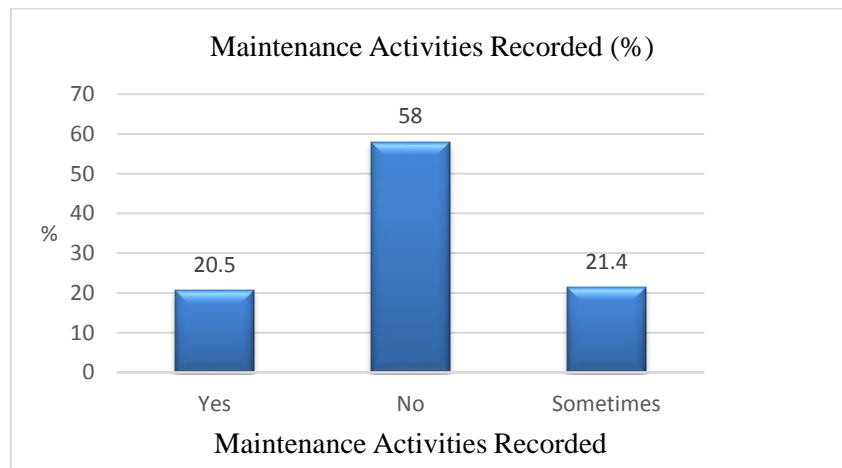


Figure 6.45: Documentation of Maintenance (Source: author).

11 Method of documenting maintenance activities

In the previous question, a total of 47 respondents (23 who answered yes and 24 who said sometimes) confirmed that a maintenance recording data system was in use in their firms. These participants were asked to list the methods by which maintenance was documented. The results, which are summarised in both Table 6.46 and Figure 6.46, indicate that 85.1% (40 respondents) found all maintenance activities were manually documented. In contrast, only 14.9% (7 out of 47 respondents in total) said that their factories used advanced methods such as electronic devices and software to record maintenance work.

Table 6.46: Method Used in Documenting Maintenance Activities (Source: author).

Methods of Documentation of Recorded Maintenance Activities	Manually	Electronically	Total
Factory A	10	1	11
Factory B	9	2	11
Factory C	12	2	14
Factory D	9	2	11
Total	40	7	47
Total %	85.1	14.9	100

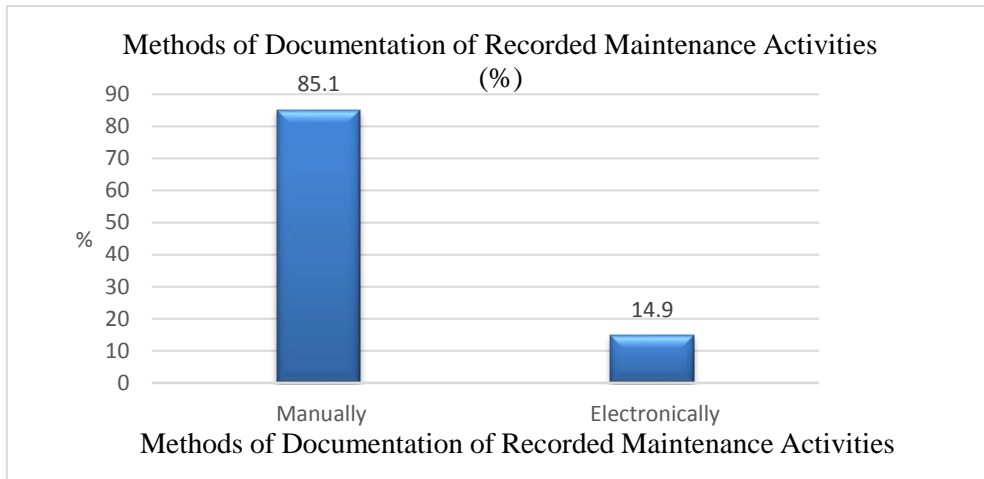


Figure 6.46: Methods for Documenting Maintenance Activities (Source: author).

12 Reasons for no records kept

As a result of question 10, the number of respondents who said there was no documentation for maintenance was 65 (58%). This question, the twelfth, sought to these respondents' views on the causes of this failure to document plant maintenance. The analysis, as shown in Table 6.47 and Figure 6.47, reveals that 43.1% (28 out of 65 respondents) linked this problem to the lack of interest from senior management. Only 9.2% (6 respondents) believed that there was no need for documentation. The staff underestimation of the need to keep records is one of the reasons why there are not kept, according to 31 respondents (47.7%).

Table 6.47: Reasons for Not Recording Maintenance Activities (Source: author).

Reasons for no records kept	Lack of Senior Management Interest	No Need for Documentation	Lack of Employee Awareness of the Importance of Documentation	Total
Factory A	7	2	10	19
Factory B	11	3	6	20
Factory C	4	1	9	14
Factory D	6	0	6	12
Total	28	6	31	65
Total %	43.1	9.2	47.7	100

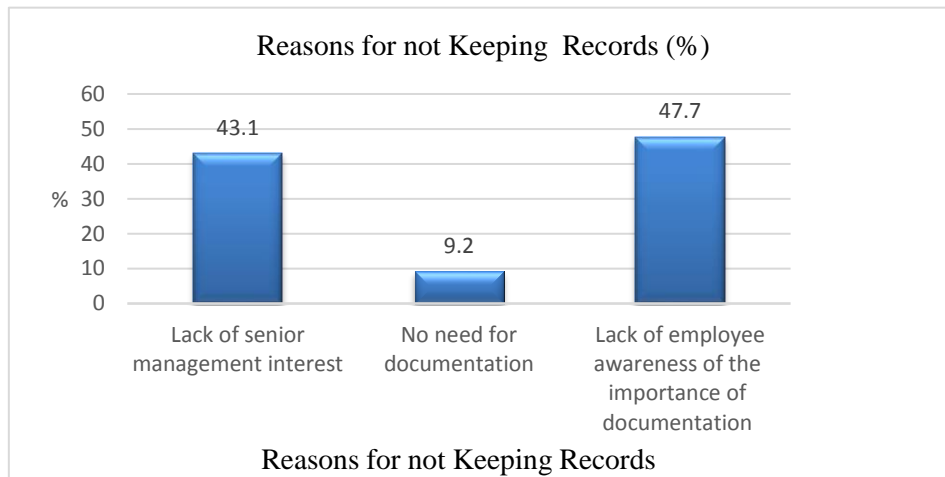


Figure 6.47: Reasons for Not Recording Maintenance Activities (Source: author).

13 Programmes to evaluate the effectiveness of maintenance

Assessing the current level of maintenance was the focus of this survey. Therefore, the participants were asked to indicate whether their firms adopted any programmes to judge the effectiveness of the maintenance implemented in their factories, such as comparing the maintenance results with earlier maintenance outcomes or measuring the ability of devices or machines to operate as required after undergoing maintenance. According to Table 6.48, 78.6% of the staff (88 respondents) agreed that no programme had been set up by their firm to evaluate the effectiveness of the maintenance carried out. The remainder, (21.4%: 24 respondents) believed the opposite – that some programmes are followed to assess the effect of maintenance.

Table 6.48: The Availability of Programmes to evaluate the maintenance effectiveness (Source: author).

Programmes to Evaluate the Effectiveness of Maintenance	Yes	No	Total
Factory A	6	24	30
Factory B	3	28	31
Factory C	5	22	27
Factory D	10	14	24
Total	24	88	112
Total %	21.4	78.6	100

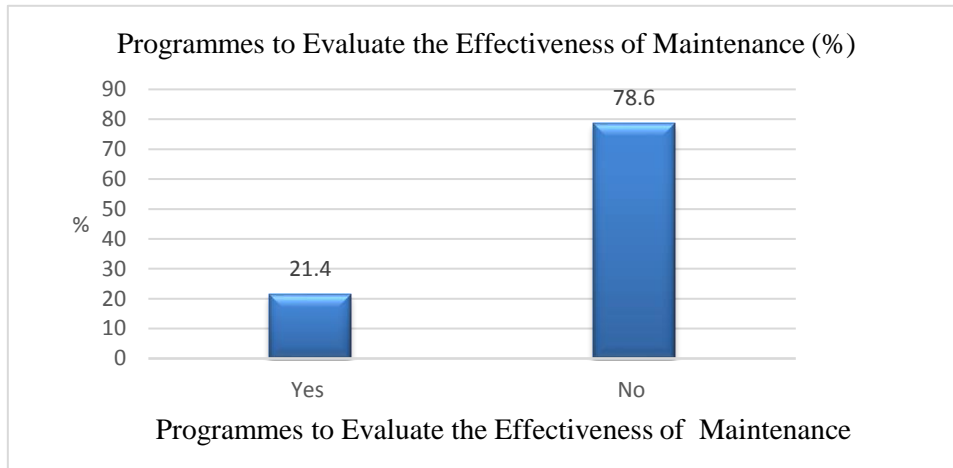


Figure 6.48: The Availability of Programmes to evaluate the Effectiveness of Maintenance (Source: author).

14 Employee participation in decision-making about maintenance

It was believed that involving members of the maintenance staff in the decision-making process would help to raise the quality of maintenance. To test this, the sample of respondents was asked to illustrate the extent of their participation in decision-making. Their answers are summarised in Table 6.49 and Figure 6.49. Of 112 respondents, only 11 (9.8%) saw themselves as part of the decision-making team and always participate in decision-making in their factories. The number of respondents who could sometimes participate in decision-making related to maintenance was 34 (30.4%). It is rare to engage the maintenance staff in decision-making according to 25% (28) of the respondents). 39 of those surveyed (nearly 35%) felt that they could only wait for orders but were not asked to participate in the decision-making in their factories.

Table 6.49: The extent of Employee Participation in Decision-Making about Maintenance (Source: author).

Employee Participation in Decision-Making	Always	Sometimes	Rarely	Never	Total
Factory A	4	9	8	9	30
Factory B	2	10	5	14	31
Factory C	3	8	6	10	27
Factory D	2	7	9	6	24
Total	11	34	28	39	112
Total %	9.8	30.4	25	34.8	100

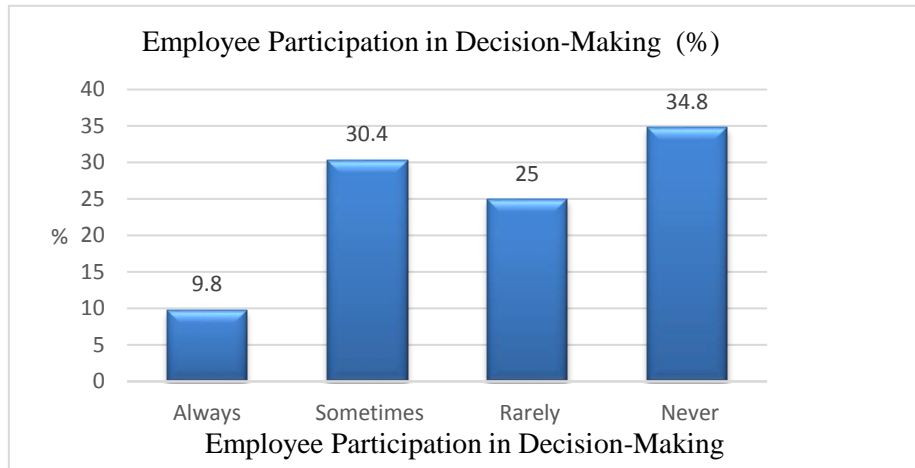


Figure 6.49: The extent of Employee Participation in Decisions-Making (Source: author).

15 Senior management's interest in employees' suggestions and views on maintenance

To evaluate the attention given by senior management to ideas that are proposed by staff with regard to maintenance, the staff were asked to state whether they felt they could share their ideas with senior management. The respondents' answers, which are presented in Table 6.50, make it clear that a substantial majority (88 respondents) of the employees consider that top management does not pay any attention to what employees think. In contrast, 21.4% (24 respondents) were satisfied with the senior management's attention to their suggestions and opinions.

Table 6.50: Senior Management’s Interest in Employees’ Suggestions and Opinions (Source: author).

Senior Management Interest of the Employees Suggestions and Opinions	Interest	No interest	Total
Factory A	7	23	30
Factory B	5	26	31
Factory C	9	18	27
Factory D	3	21	24
Total	24	88	112
Total %	21.4	78.6	100

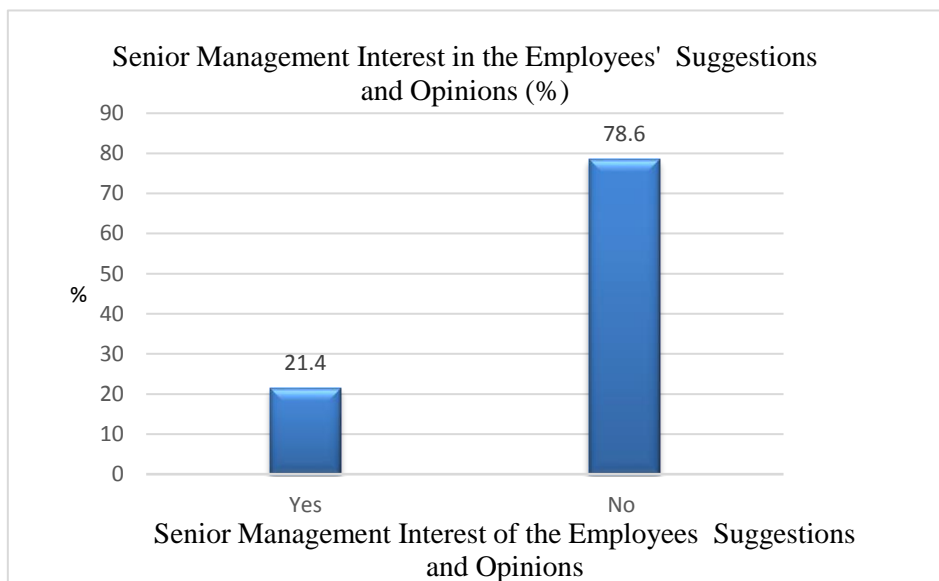


Figure 6.50: Senior Management Interest in Employees’ Suggestions and Opinions (Source: author).

16 Redistribution of maintenance tasks for better results

The participants from the four factories were asked what they thought about the possibility of obtaining better maintenance results through a redistribution of maintenance tasks. From both Table 6.51 and Figure 6.51, it can be observed that the number of respondents who strongly supported this statement was 25. More than 65% (73 respondents) stated that they supported the redistribution of maintenance tasks for better maintenance results. 8% (9 respondents) had no clear opinion on the possibility of improving maintenance through redistribution of maintenance functions; they neither agreed nor disagreed. Within this group of respondents, only 5(4.5%) felt that a redistribution of maintenance tasks would not make any difference in maintenance but no one strongly refuted the possibility.

Table 6.51: Maintenance Tasks Redistribution for Better Maintenance Results (Source: author).

Maintenance Tasks Redistribution for Better Maintenance Results	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree	Total
Factory A	13	16	1	0	0	30
Factory B	3	20	6	2	0	31
Factory C	2	21	2	2	0	27
Factory D	7	16	0	1	0	24
Total	25	73	9	5	0	112
Total %	22.3	65.2	8	4.5	0	100

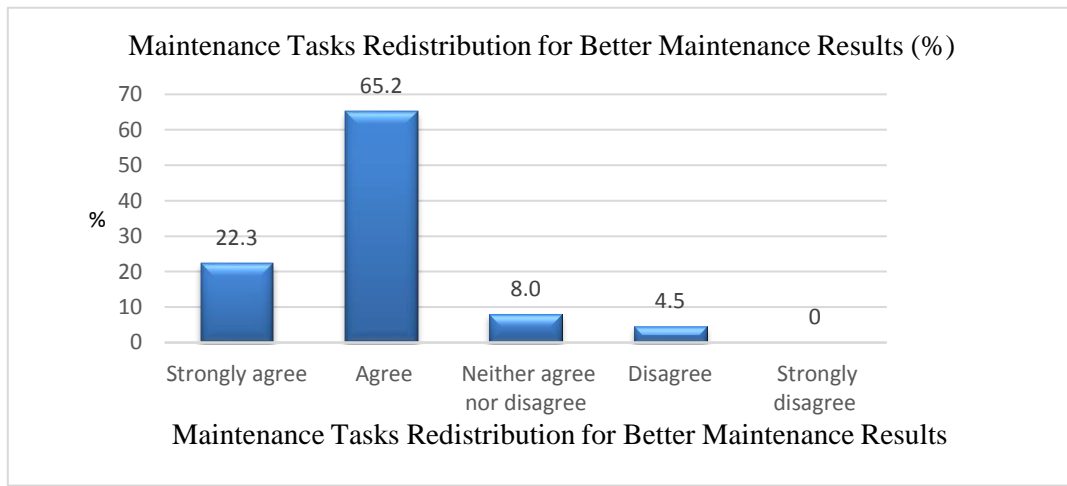


Figure 6.51: Maintenance Tasks Redistribution for Better Maintenance Results (Source: author).

17 The clarity of the factory's objectives to employees

The goals of an industrial project may reflect its strength. Through these goals, the activities related to the project such as the tasks of maintaining the production lines components can be classified according to pre-planned processes. This question was designed to explore the level of awareness among maintenance staff of their firm's goals and hence, identify their level of understanding of the role of maintenance in achieving these objectives. For this, the respondents were asked whether their firms' objectives were clear. The findings are illustrated in Table 6.52 and Figure 6.52. The vast majority, 97 (86.6%) of the respondents stated that they had sufficient knowledge of their firm's goals. Only 13.4 % (15 respondents) believed the reverse, admitting that they were not familiar with them.

Table 6.52: The Clarity of the Factory's Objectives to Employees (Source: author).

The Clarity of the Factory's Objectives to Employees	Yes	No	Total
Factory A	26	4	30
Factory B	26	5	31
Factory C	25	2	27
Factory D	20	4	24
Total	97	15	112
Total %	86.6	13.4	100

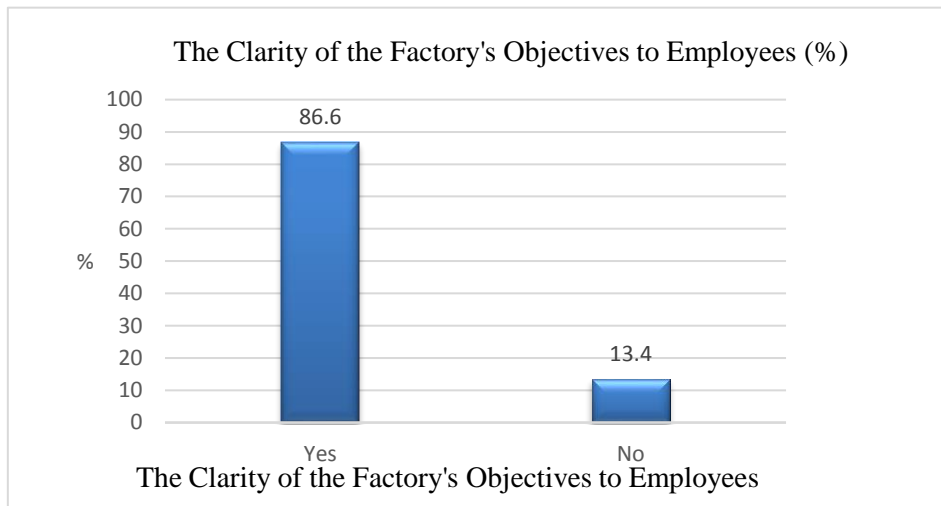


Figure 6.52: The Clarity of the Factory's Objectives to Employees (Source: author).

18 Clarity of assigned tasks to the maintenance staff

The surveyed staff were asked to indicate whether the tasks entrusted to them were clear and they could get full information about what they should do and how to do it. The answers to this question are presented in Table 6.53 and Figure 6.53. Most of the employees, 87 out of the 112 in this survey admitted the distinctness of their assigned tasks. From the point of view of 22.3 % (25 respondents), maintenance tasks need to be made clearer, for they admitted that the maintenance tasks assigned to them were not clear.

Table 6.53: Clarity of the Tasks Assigned to the Employees (Source: author).

The Tasks that are Assigned to the Employees are Clear	Yes	No	Total
Factory A	23	7	30
Factory B	23	8	31
Factory C	22	5	27
Factory D	19	5	24
Total	87	25	112
Total %	77.7	22.3	100

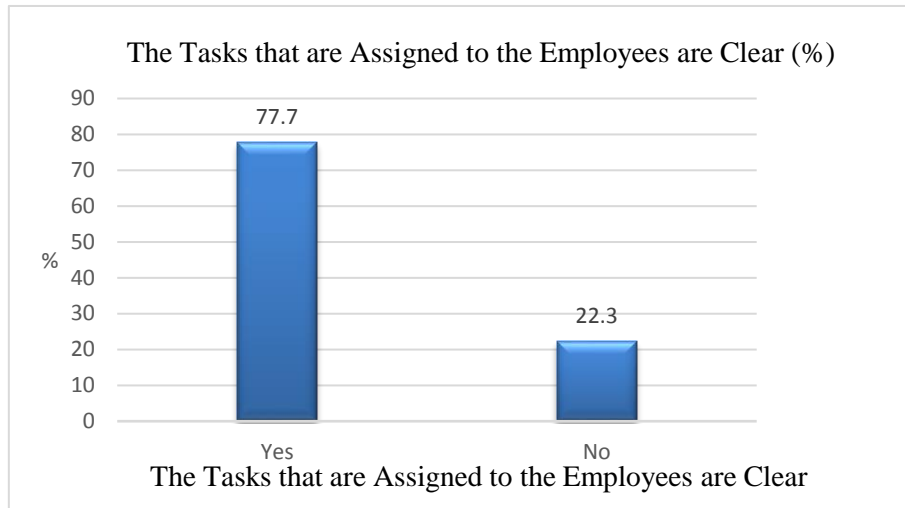


Figure 6.53: The Tasks are Assigned to the Employees are Clear (Source: author).

19 The existence of privileged employees in the factories

The presence of privileged workers sometimes reflects the motivation of those employees to carry out their duties. It also may sometimes be attributed to management bias favouring particular employees, or to the low standards established by the administration. This brief introduction suggests an urgent need to ask such a question. Moreover, the results shown in Table 6.54 make it clear that some employees are perceived to be privileged, as noted by 79.4% (80 of respondents). The remainder, who said that none of the employees was privileged believe that all staff members are on the same footing.

Table 6.54: The Existence of Privileged Workers in the Factory (Source: author).

The Existence of Privileged Workers in the Factory	Yes	No	Total
Factory A	21	9	30
Factory B	23	8	31
Factory C	21	6	27
Factory D	16	9	25
Total	80	32	112
Total %	71.4	28.6	100

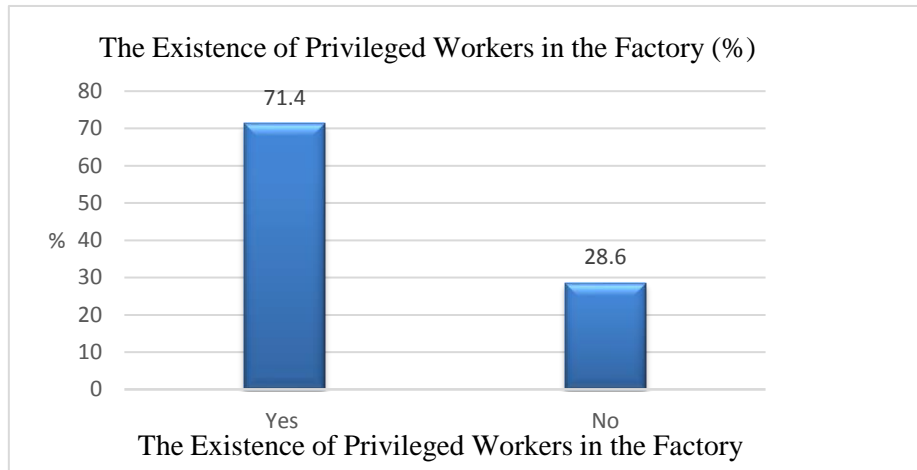


Figure 6.54: The Existence of Privileged Workers in the Factory (Source: author).

20 Reasons for privileging some

The respondents who thought there were privileged employees in their firms were asked to say what they thought were the reasons for this privileging. As can be seen from Figure 6.55 and Table 6.55, 47.5% (38 respondents) believe that the main cause of it was that they might be enjoying the support of the top administration. But in the view of 26.3% (21 respondents), it is only the desire to be creative that makes some of the workers privileged. The same proportion, 26.3%, believed that those employees had their personal goals and these made them look for privileged treatment.

Table 6.55: Reasons for Privileging (Source: author).

Reasons for Privileging	Receive Special Support from the Administration	Wish to be Creative	Have Personal Goals	Total
Factory A	12	5	5	22
Factory B	10	7	6	23
Factory C	6	6	8	20
Factory D	10	3	2	15
Total	38	21	21	80
Total %	47.5	26.3	26.3	100

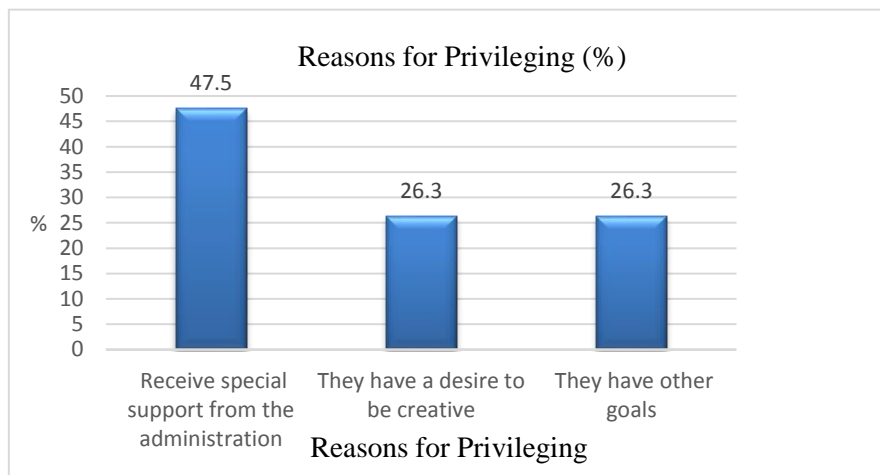


Figure 6.55: Reasons for Privileging (Source: author).

21 Effective maintenance can increase the efficiency of production systems

The staff who participated in this survey were asked to indicate whether the quality of maintenance has any positive effect on the efficiency of the production systems in their plants. In other words, this question was designed to explore the participants' opinions of the effect of improving maintenance on the level of performance of the production systems. The analysis of the answers reveals that the vast majority of respondents, 97 (86.6%) agree that the efficiency of production systems can be increased by improving maintenance. In contrast, only 13.4 (15 out of 112 respondents in total) took a different view, claiming that the quality of maintenance and the performance of the production systems were unrelated (see Table 6.56).

Table 6.56: Increasing the Efficiency of Production Systems through adopting proper maintenance
(Source: author).

Effective Maintenance can Increase the Efficiency of Production Systems	Yes	No	Total
Factory A	28	2	30
Factory B	24	7	31
Factory C	25	2	27
Factory D	20	4	24
Total	97	15	112
Total %	86.6	13.4	100

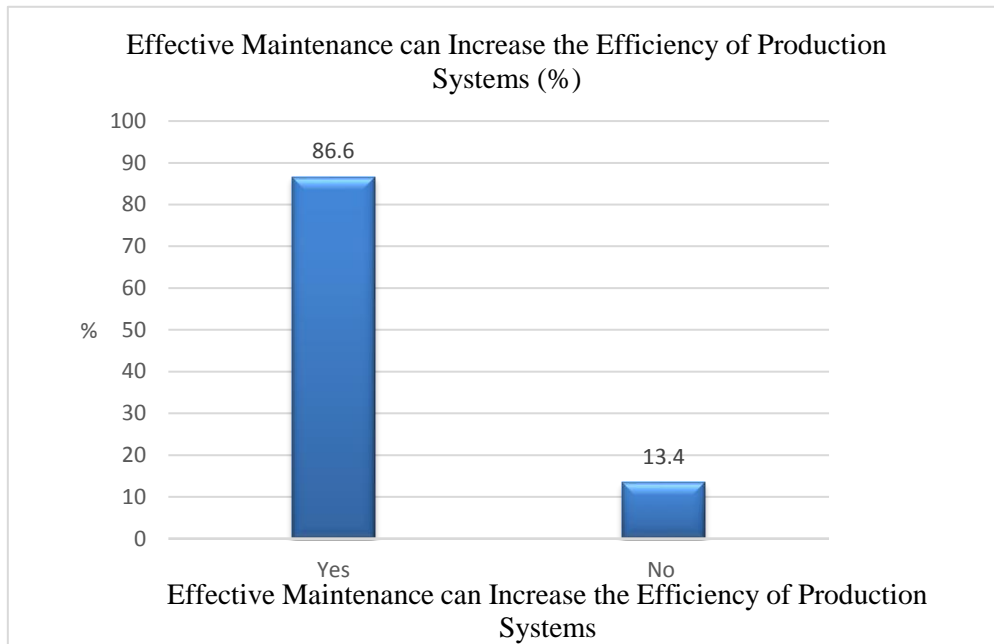


Figure 6.56: Increasing the Efficiency of Production Systems through adopting proper maintenance
(Source: author).

22 Previous attendance at training courses

Training is one of the most important factors by which the skills of maintenance staff can be improved and in turn, the reliability of maintenance can be increased. Therefore, this question was introduced to identify the personal development programmes offered to employees at work in the target plants. This covered a range of different courses lasting from one day to one year. The participants' answers suggested that nearly 43% of them (48 respondents) believed that they had received adequate training to support their skills in maintenance work, while 57.1% (64 respondents) said they had not received any training (see Table 6.57 and Figure 6.57).

Table 6.57: Previous Attendance at Training Courses (Source: author).

Previous Attendance at Training Courses	Yes	No	Total
Factory A	17	13	30
Factory B	10	21	31
Factory C	14	13	27
Factory D	7	17	24
Total	48	64	112
Total %	42.9	57.1	100

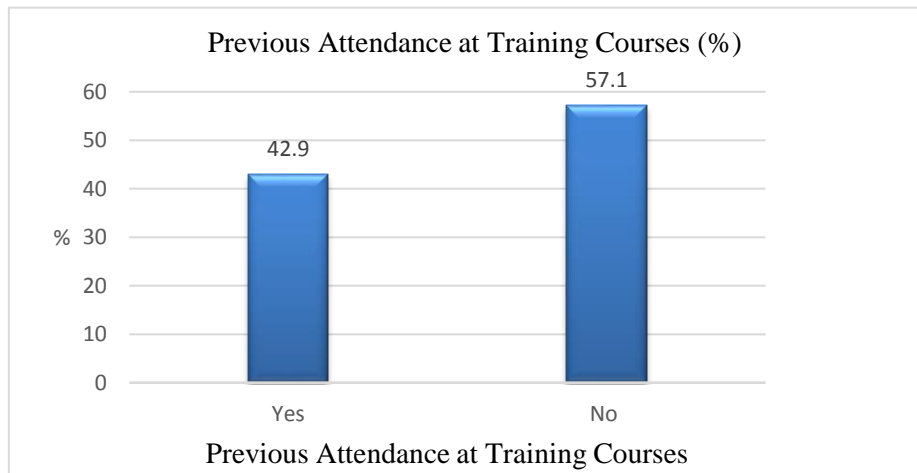


Figure 6.57: Previous Attendance at Training Courses (Source: author).

23 Type of training received

The respondents who answered that they had received training were also asked to describe the types of training courses they had attended, whether internal or external, and the findings are illustrated in Figure 6.58. These results show that more than 83% (40 respondents) confirmed that all the courses offered by their organisation were internal. The number of respondents who had been able to attend external training was only 8 (16.7%). From the same table, it can be noted that none of the staff had been offered both internal and the internal courses. Table 6.58 also shows that external training is more readily available to factory's D staff than those of the other factories.

Table 6.58: Type of Training Offered by Top Management (Source: author).

Type of Training Received	Internal	External	Internal and External	Total
Factory A	15	2	0	17
Factory B	8	2	0	10
Factory C	10	4	0	14
Factory D	7	10	0	17
Total	40	8	0	48
Total %	83.3	16.7	0	100



Figure 6.58: Type of Training Offered by Top Management (Source: author).

24 Reasons for the lack of training opportunities

This question was put to those who said that no training courses were available; they were asked to identify, from their own perspective, the reasons behind this failure. The results as shown in Table 6.59 clarify that 81.3% (52 respondents) link the unavailability of the development programmes to the lack of senior management interest. In the opinion of 12 participants (18.8%) lack of funding was the main reason for there being no such programmes, but none of the maintenance staff related this to any lack of workers desiring to improve their personal skills.

Table 6.59: Reasons for the Lack of Training (Source: author).

Reasons for the Lack of Training	Lack of Senior Management Interest	Lack of Funds	Lack of Desire to Receive Training	Total
Factory A	8	5	0	13
Factory B	18	3	0	21
Factory C	12	1	0	13
Factory D	14	3	0	17
Total	52	12	0	64
Total %	81.3	18.8	0	100

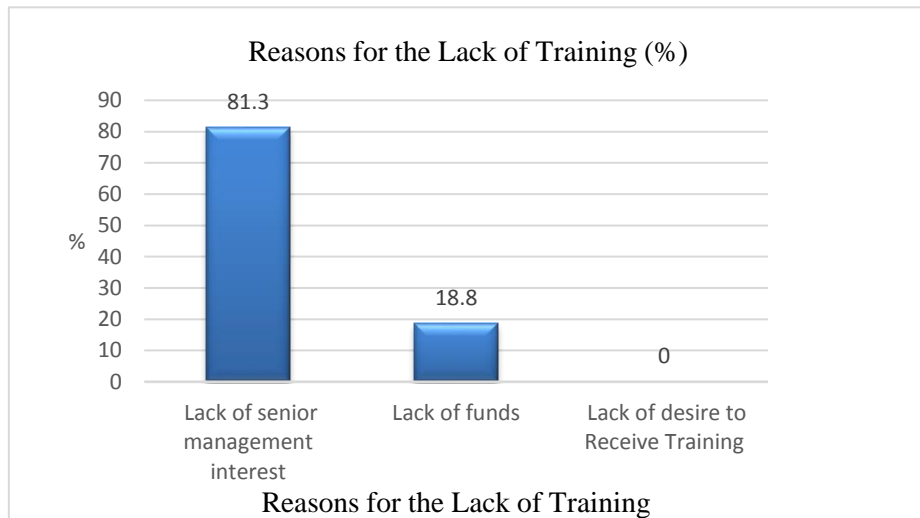


Figure 6.59: Reasons for the Lack of Training (Source: author).

25 The possibility of improving the employee's skills by training programmes

The employees who participated in this survey were asked to indicate whether they agreed that training courses were important for improving their skills at work. The results, as shown in Table 6.60 and Figure 6.60, illustrate that a considerable majority of staff, more than 88% (99 respondents), believed that the current level of staff performance could rise if they had sufficient training. In contrast, 13 respondents (11.6%) expected that training courses would not make any improvement to the skills of the maintenance staff.

Table 6.60: The Possibility of Improving the Employee’s Skills through Training Programmes
(Source: author).

The Employee's Skills can be Improved by Training Programs	Yes	No	Total
Factory A	26	4	30
Factory B	26	5	31
Factory C	25	2	27
Factory D	22	2	24
Total	99	13	112
Total %	88.4	11.6	100



Figure 6.60: The Possibility of Improving the Employee’s Skills through Training Programmes
(Source: author).

26 Monthly salaries meet the employees’ basic financial needs

It would go against the claims of human nature to omit a question on earnings; accordingly, the respondents were asked to identify how far they were satisfied with the level of income they received, since this would directly affect their level of job satisfaction. The findings, as shown in Table 6.61, identify only 33 respondents (29.5%) out of 112 who seem to be satisfied with the level of wages offered by their firms. In contrast, 70.5% (nearly 80 respondents) said that their monthly salary did not meet their basic financial needs.

Table 6.61: The Salary Meets the Employee's Basic Needs (Source: author).

The Salary Meet the Employee's Basic Needs	Yes	No	Total
Factory A	7	23	30
Factory B	8	23	31
Factory C	8	19	27
Factory D	10	14	24
Total	33	79	112
Total %	29.5	70.5	100



Figure 6.61: The Salary Meets the Employee's Basic Needs (Source: author).

27 Doing other work to supplement the income

To ascertain the willingness of senior management to pay adequate salaries to the four firms' employees, the 79 participants who said their wages were low were asked to state whether they worked elsewhere to supplement their income. The results of this question are shown in both Table 6.62 and Figure 6.62. 42 out of these 79 respondents (53%) took on extra work to raise their incomes. The number of participants whose salary from the factory was their only resource for meeting their basic financial needs was 46.8% (37 respondents).

Table 6.62: Those who Supplemented their Income by Other Work (Source: author).

Doing other Work to Supplement the Income	Yes	No	Total
Factory A	12	11	23
Factory B	11	12	23
Factory C	12	7	19
Factory D	7	7	14
Total	42	37	79
Total %	53.2	46.8	100

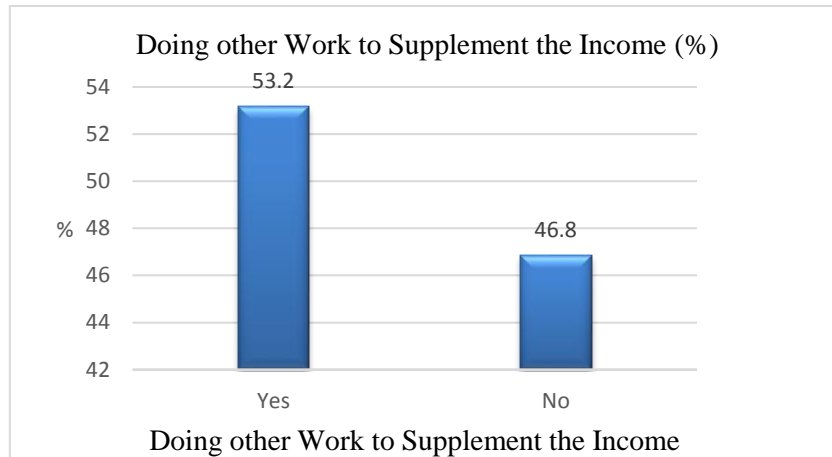


Figure 6.62: Those who Supplemented their Income by Doing Other Work (Source: author).

28 Well treated by senior management

It is believed that workers who are well cared for by top management are more motivated than other staff. This treatment reveals itself in many ways such as ensuring the availability of safety tools, providing them with suitable work clothes and giving them sufficient break time to cope with the workload. To explore this, the surveyed sample was requested to clarify whether they enjoyed an excellent treatment at the hands of senior management. As Table 6.63 shows, the number of staff who are treated in this way by their factories' managements was very low: only 5.4% (6 respondents). 59 respondents out of 112 in total were unsatisfied with senior management's attitudes and behaviour towards the maintenance staff. The employees, however, were sometimes well treated, according to 52.7% (59) of the respondents.

Table 6.63: Well Treated by Top Management (Source: author).

Employees Treated well by Senior Management	Yes	No	Sometimes	Total
Factory A	1	9	20	30
Factory B	1	14	16	31
Factory C	3	13	11	27
Factory D	1	11	12	24
Total	6	47	59	112
Total %	5.4	42	52.7	100

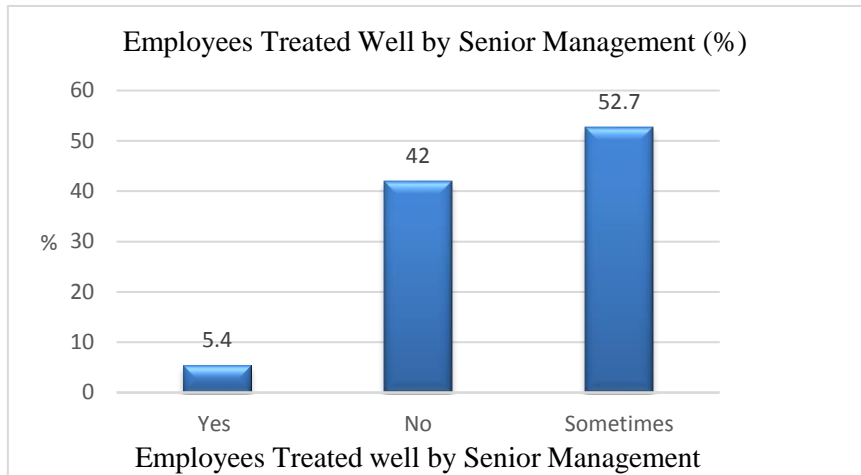


Figure 6.63: Employees Treated Well by Top Management (Source: author).

29 The monthly salary includes a performance-related incentive

The strategy of giving incentives tends to motivate staff to work harder. This question investigates whether an incentive system is being applied in these factories. According to the outcomes shown in Table 6.64 and Figure 6.64 only a small proportion of staff, 6.3% (7 respondents) were given a performance-related incentive at work in one of these four cement factories. A performance-related incentive is sometimes included in the employees' salaries, as witnessed by 24.1% (27 respondents) for example, when they do a big maintenance job, such as maintaining the main kiln without delay. The figure was three times as high (87:69.6%) for those who said they had received no performance-related incentives while working in these factories.

Table 6.64: The Salary Includes a Performance Related Incentive (Source: author).

The Salary Includes a Performance Related Incentive	Yes	Sometimes	No	Total
Factory A	4	16	10	30
Factory B	2	5	24	31
Factory C	1	3	23	27
Factory D	0	3	21	24
Total	7	27	78	112
Total %	6.3	24.1	69.6	100

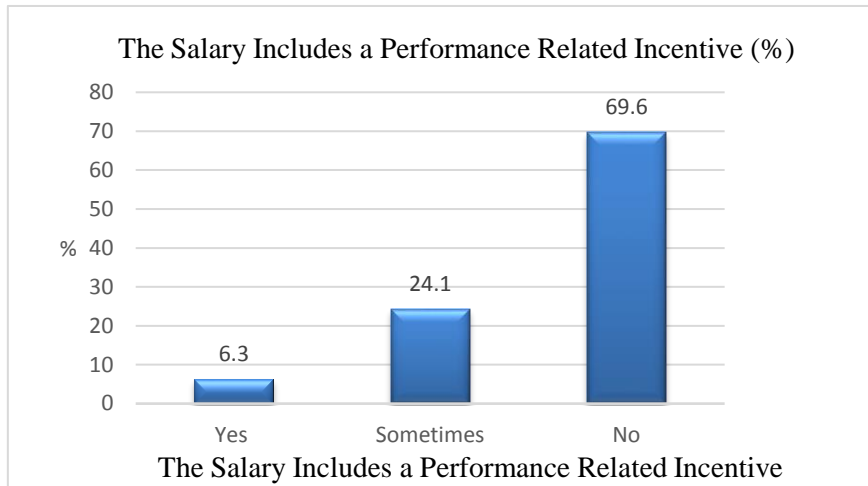


Figure 6.64: The Salary Includes a Performance Related Incentive (Source: author).

30 Certificate of appreciation received from the employers in the past

It could be argued that appreciation certificates are another way of improving employees' motivation and raising their morale. This question was asked to see the reaction of the targeted staff regarding the encouragement certificates awarded them by their organisations. The results, as can be seen in Table 6.65, confirm that only 18 of these respondents (just over 16%) had ever been awarded a certificate of appreciation in their experience of working for these firms. The greatest number of maintenance staff nearly 85% (94 respondents), said that they had never received a certificate of this kind.

Table 6.65: Received a Certificate of Appreciation (Source: author).

Certificate of Appreciation Received from Employers in the Past	Yes	No	Total
Factory A	3	27	30
Factory B	5	26	31
Factory C	2	25	27
Factory D	8	16	24
Total	18	94	112
Total %	16.1	83.9	100

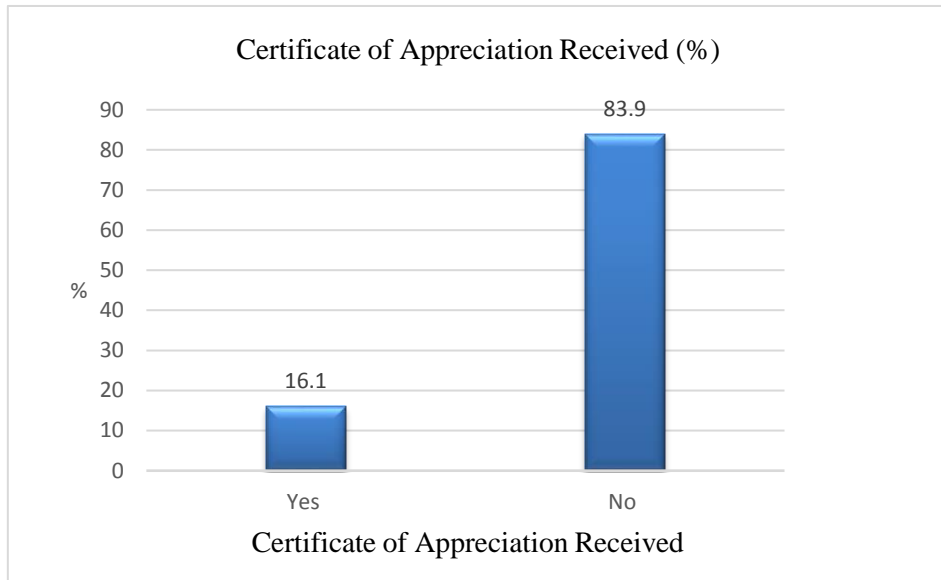


Figure 6.65: Received a Certificate of Appreciation (Source: author).

31 Change the job because of the dissatisfaction of the current position

The respondents from these maintenance departments were asked about their desire to move to another role at work. Table 6.66 and Figure 6.66 reveal that 36.6% of these employees was satisfied with their current position, and wished to remain in it. More than 63% (71 respondents) were not happy about their job situation and said that they would like to switch to another position at work.

Table 6.66: The Desire to Move to another Position (Source: author).

Change the Job because of Dissatisfaction with the Current Position	No	Yes	Total
Factory A	11	19	30
Factory B	13	18	31
Factory C	9	18	27
Factory D	8	16	24
Total	41	71	112
Total %	36.6	63.4	100

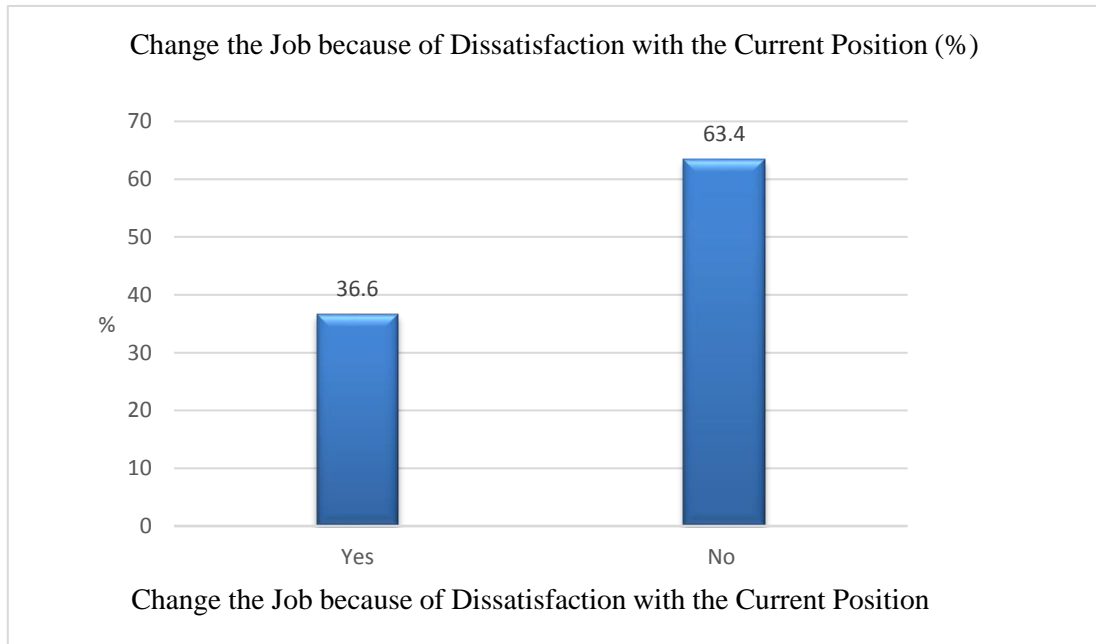


Figure 6.66: The Desire to Move to another Job (Source: author).

32 The existence of recreational programmes/trips organised by the factory

The state of motivation among employees is a major factor which can have a directly adverse effect on their morale. To find more about this, the surveyed staff were asked to indicate whether their institutions organise any recreational programmes or trips to enhance their psychological state and make them feel more relaxed. As can be seen from Table 6.67, the results of this question were unanticipated; none of the participants could ever remember such programmes being available at any time in their working lives in these factories.

Table 6.67: The Existence of Recreational Programmes/Trips (Source: author).

The Existence of Recreational Programmes/Trips Organised by the Factory	Yes	No	Sometimes	Total
Factory A	0	30	0	30
Factory B	0	31	0	31
Factory C	0	27	0	27
Factory D	0	24	0	24
Total	0	112	0	112
Total %	0	100	0	100

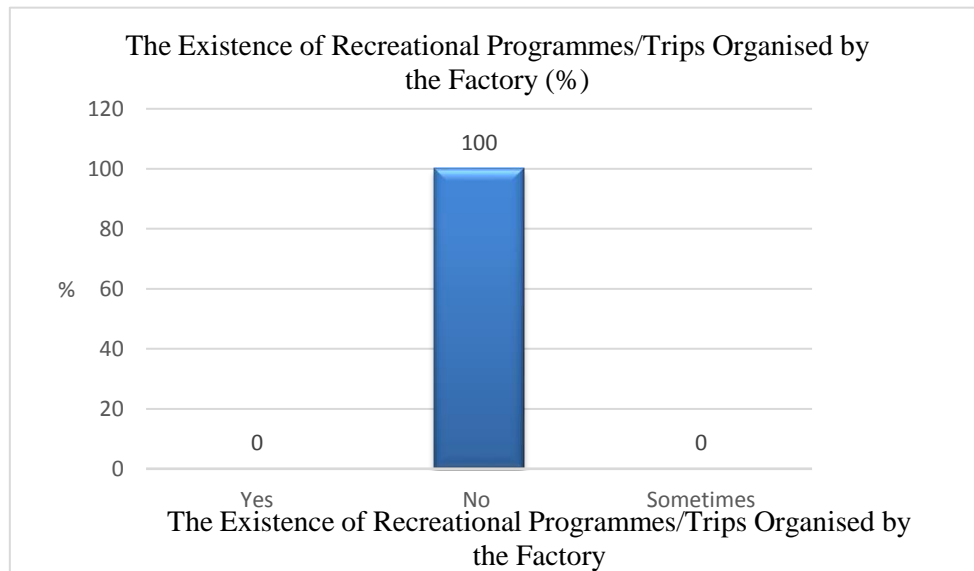


Figure 6.67: The Existence of Recreational Programmes/Trips (Source: author).

33 Adequate care received in case of work accident

The respondents from the four targeted cement plants were asked to indicate whether their organisation takes adequate care of them in the event of exposure to injury at work. The findings are presented in Table 6.68 and Figure 6.68. More than 14% (16 respondents) stated that they were able to get a high level of care when they were at risk of an accident at work. Meanwhile, 82 of the respondents believed that maintenance teams could sometimes receive adequate care in the case of accidents at work. But 12.5% of the participants complained that health and psychological services are not available in the event of a work-related accident.

Table 6.68: Received Adequate Care after a Work Accident (Source: author).

Adequate Care Received after a Work Accident	Yes	Sometimes	No	Total
Factory A	3	22	5	30
Factory B	3	24	4	31
Factory C	5	19	3	27
Factory D	5	17	2	24
Total	16	82	14	112
Total %	14.3	73.2	12.5	100

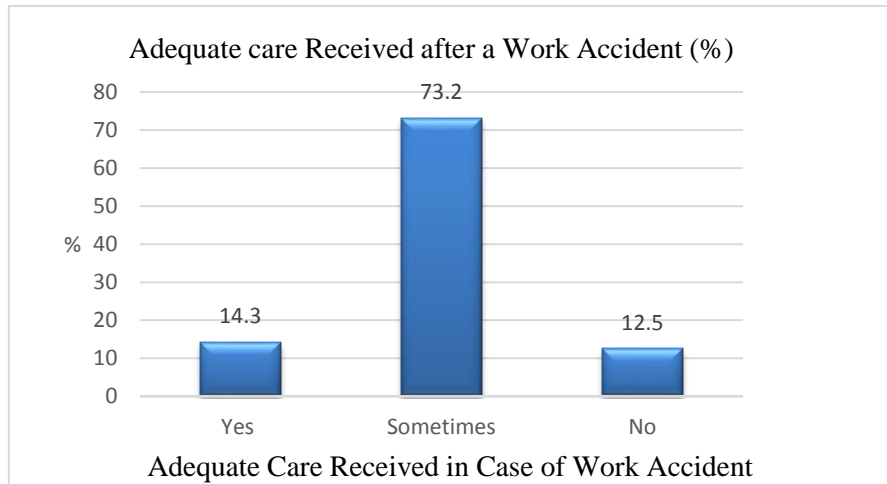


Figure 6.68: Received Adequate Care after a Work Accident (Source: author).

34 The availability of standards for security and safety

From the Libyan perspective, security and safety are always seen as the same entity; they are both very important for any organisation, whether health protection, the minimisation of risk to life and property or environmental conservation is at stake. Based on this, the participants were asked for information about the availability of security and safety standards in the factories where they work. According to the results shown in Table 6.69, the overwhelming majority of respondents, 105 (93.8%), agreed that standards of security and safety were available. Only 6.35 (7 respondents out of 112 in total) asserted that they were lacking in their factories.

Table 6.69: The Availability of Standards of Security and Safety (Source: author).

The Availability of Standards of Security and Safety	Yes	No	Total
Factory A	30	0	30
Factory B	27	4	31
Factory C	25	2	27
Factory D	23	1	24
Total	105	7	112
Total %	93.8	6.3	100



Figure 6.69: The Availability of Standards of Security and Safety (Source: author).

35 Compliance with the security and safety standards

Participants who admitted the availability of security and safety standards in their factories were asked again to show whether they were interested in complying with these standards. According to Table 6.70 and Figure 6.70, the number of workers who always complied with the firms’ standards of security and safety is very small, only 7.6% of the total. The standards of 20% (21 respondents) do not comply with the security and safety standards imposed on the four factories. However, the vast majority of employees in the survey adhered to these standards only in certain cases, for example, when their managers asked them to do so.

Table 6.70: Compliance with the security and safety standards (Source: author).

Compliance with Security and Safety Standards	Yes	No	Sometimes	Total
Factory A	4	3	23	30
Factory B	0	6	21	27
Factory C	2	6	17	25
Factory D	2	6	15	23
Total	8	21	76	105
Total %	7.6	20	72.4	100



Figure 6.70: Compliance with security and safety standards (Source: author).

36 The availability of a standby emergency system in case of fire or other contingency

It is believed that a standby emergency system would improve the work environment and make the workers more confident and comfortable when they carried out maintenance. For this reason, the surveyed sample was asked to indicate if their firms had any system to deal with emergency situations such as fire or any other contingency. The data shown in Table 6.71 indicate that the vast majority, 94 (83.95%), of respondents to the survey believed that there was an emergency system in place, should a fire break out or some other emergency arise. The number of workers who believed that their factories had no emergency system in place to control a fire or some other emergency was 18 (16.1%).

Table 6.71: The availability of Emergency Systems (Source: author).

The availability of Standby Emergency System	Yes	No	Total
Factory A	29	1	30
Factory B	25	6	31
Factory C	20	7	27
Factory D	20	4	24
Total	94	18	112
Total %	83.9	16.1	100

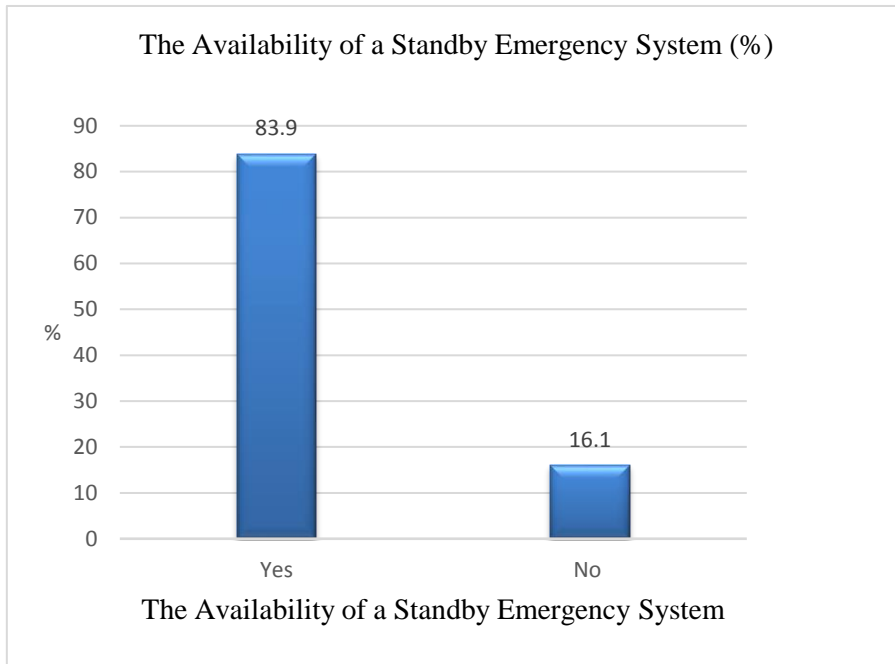


Figure 6.71: The availability of an Emergency System (Source: author).

37 Training received to deal with emergency situations

The participants were asked to clarify if they were offered training courses to deal with emergencies at work. The reason for this request is to explore the attention given by senior management to making employees aware of the actions that must be taken in such cases. The results of this question are shown in Table 6.72. More than 69% (78) of the respondents confirmed that health and safety training was not available in their factories, while 30.4% (34 respondents) had had a chance to attend such courses.

Table 6.72: Training received to deal with emergency situations (Source: author).

Training Received to Deal with Emergency Situations	Yes	No	Total
Factory A	26	4	30
Factory B	15	16	31
Factory C	19	8	27
Factory D	18	6	24
Total	78	34	112
Total %	69.6	30.4	100

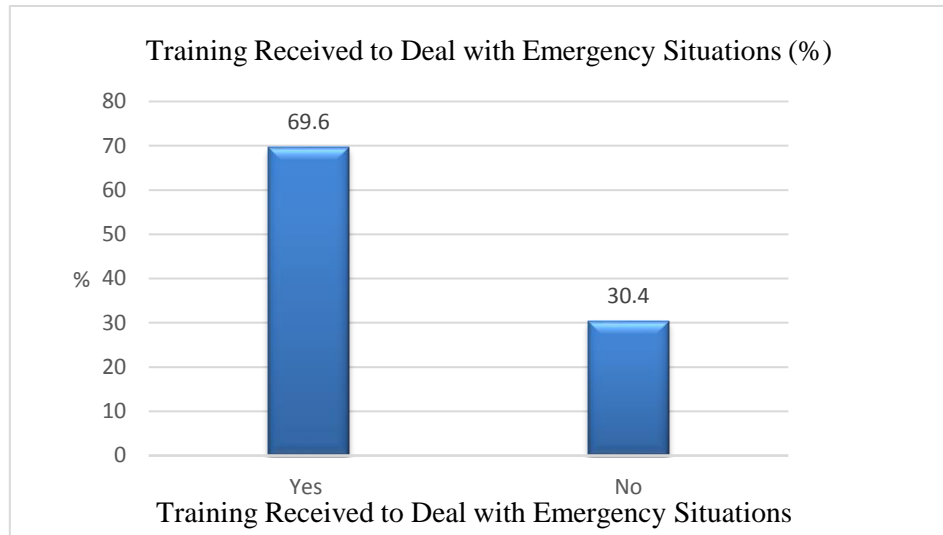


Figure 6.72: Training received to deal with emergency situations (Source: author).

38 Measuring pollutants

It was believed that maintaining employees' health and improving conditions at work could be a major factor in improving the capacity of workers to do their job better as well as contributing to preserve the environment of the community. For this, the participants were asked whether they knew of any programmes in place to measure the pollutants resulting from the plants' manufacturing operations and the amount and incidence of dust as a result of manufacturing processes; or devices to measure the gases produced from the manufacturing machines' exhausts. The findings of this question are shown in Table 6.73 and Figure 6.73. The levels of pollution were regularly measured, in the view of 22.3% (25) of the respondents). 33% (37 respondents), however, agreed that no such measurements were taken and no control exercised over the pollution levels emitted from manufacturing operations of their factories. 50 respondents (44.6%) claimed that industrial pollution was sometimes measured by staff in the cement firms.

Table 6.73: Pollutants Measured Properly (Source: author).

Measuring Pollutants	Yes	No	Sometimes	Total
Factory A	7	8	15	30
Factory B	6	10	15	31
Factory C	6	11	10	27
Factory D	6	8	10	24
Total	25	37	50	112
Total %	22.3	33.0	44.6	100

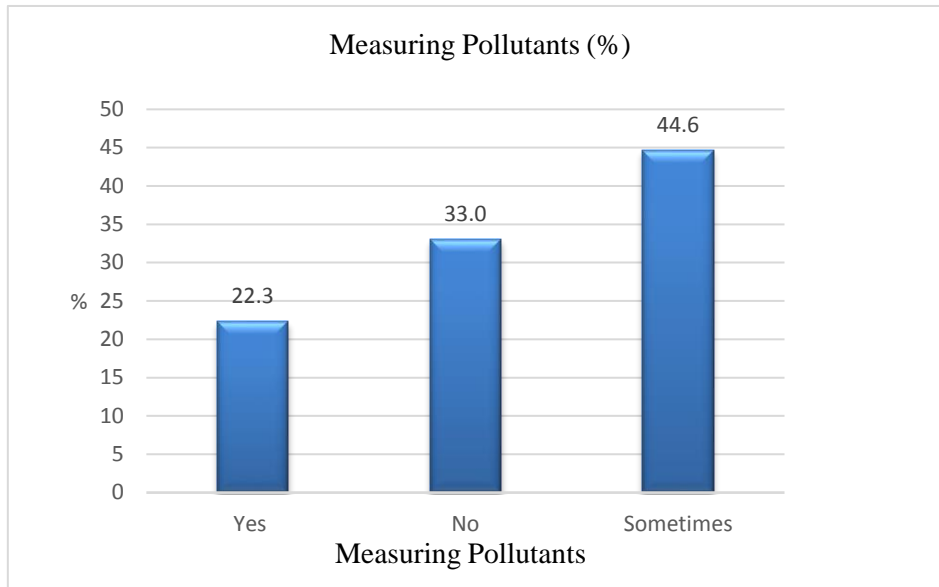


Figure 6.73: Pollutants Measured Properly (Source: author).

39 Waste is disposed of in an environmentally appropriate manner

The analysis of this question, as can be seen in Table 6.74 and Figure 6.74, reveals that only 5 (4.5%) of the sample believed that waste was used and disposed of in an environmentally friendly manner. This number was almost six times greater (29 when it came to the respondents who said that waste disposal was often performed in an environmentally appropriate manner. More than 49% (55 respondents), almost half the total stated that their plants sometimes use more environmentally friendly methods to recycle waste. Of the 112 respondents, only 13.4% judged that waste resulting from factories' manufacturing operations were usually eliminated in an environmentally inappropriate way. 7.1% (8) of the respondents confirmed that their firms had no programmes or plans for the disposal of waste in a manner appropriate to the environment.

Table 6.74: Waste Disposal in an Environmentally Appropriate Manner (Source: author).

Waste Disposal in an Environmentally Appropriate Manner	Always	Often	Sometimes	Rarely	No	Total
Factory A	2	3	21	4	0	30
Factory B	0	11	11	5	4	31
Factory C	2	10	7	5	3	27
Factory D	1	5	15	2	1	24
Total	5	29	55	15	8	112
Total %	4.5	25.9	49.1	13.4	7.1	100

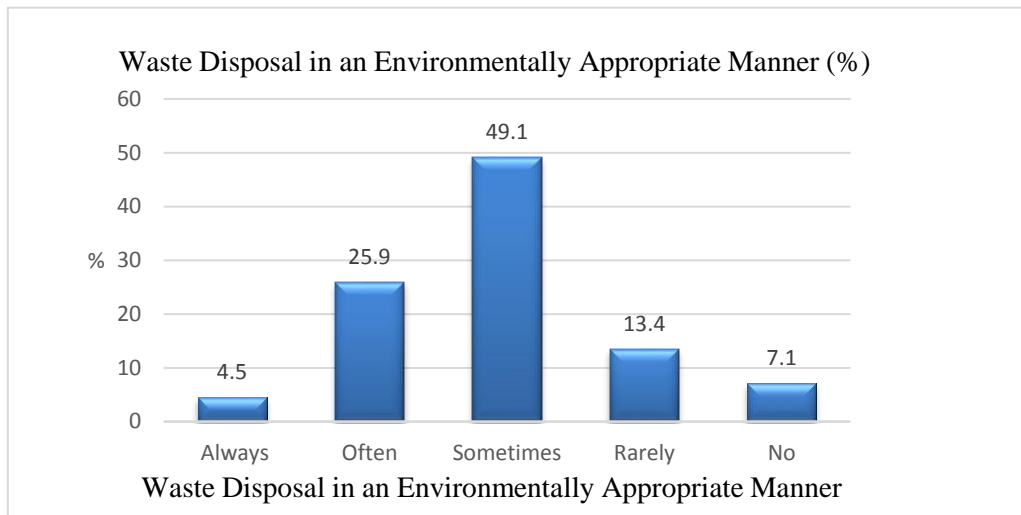


Figure 6.74: Waste Disposal in an Environmentally Appropriate Manner (Source: author).

The previous section presented the three parts of the quantitative findings. The next section focuses on the four case studies finding.

6.3 Interview Findings

6.3.1 Introduction and Characteristics of the Interviewees

The results obtained from the survey questionnaire show that some of the answers to the questionnaire were unclear or insufficient. For example, the survey respondents were not asked about the availability of plans to develop maintenance in their factory or the availability of sufficient numbers of skilled workers on the shop floor. Therefore, in-depth information was needed to fill such gaps and make the research results more meaningful. It was believed that such thesis data could be obtained only by asking experts in the field of maintenance and its practices. The position of these experts should directly relate to the area of research. In other words, the targeted participants for this aspect of the present study should have a clear knowledge and view of maintenance and its practices, in addition to their awareness

of management issues in the regard such as training programmes and staff efficiency. Moreover, some of the survey questions should be asked in interviews as well to measure the reliability level of the questionnaire. For instance, the survey sample was invited to refer to the availability of training courses. Such questions were also put to the interviewees, maybe in a different form. The answers from both questionnaire and interview participants would, it was thought, reflect the similarity or the difference of the answers by the two groups. This kind of triangulation would improve the chance of making a proper evaluation of the state of the targeted firms regarding maintenance issues. Therefore, a careful selection of interviewees was critical in helping to elicit the full meaning of the interview material and to provide the reader with the best possible understanding of the issues arising from the study.

For this purpose, 3 face-to-face semi-structured interviews were conducted in each of four Libyan cement factories. The targeted classes of interviewees were representative: maintenance managers, production managers and general supervisors of maintenance and production. A voice recorder was used in each interview and written notes were taken, which together supported direct observations as additional input.

As mentioned earlier, this phase has been developed in an endeavour to obtain in-depth information that could clarify and add richness to the quantitative data which have already been discussed in the first two previous sections of the present chapter. This section focuses primarily on presenting the results obtained from the interviews in the four factory of this multiple case study. As set out in the methodology chapter (Chapter 5), the recorded interviews were coded using thematic analysis. The data are presented below under these themes and the results are analysed in the next chapter. The findings in each case are followed by a frequency analysis aimed at identifying the main topics generated from the interviews according to their importance for maintenance and its practices; and at end of this section can be found a comprehensive frequency analysis for the four case studies together. The intention was to offer a general perspective on the current maintenance practices in these firms as a whole.

At the beginning of each interview, the same questions were asked. These questions sought personal information about the respondent such as his position in the factory and experience in the field of maintenance. The reason for asking was to help put the participant in the interview at his ease and thus

lead to a more successful and more fruitful interview. The interview questions were created to cover such aspects as maintenance staff and related issues, the current maintenance practices in the four targeted cement plants and the managerial practices with regard to maintenance.

6.3.2 Profiles of the targeted firms

Table 6.75 shows the basic information about the four targeted cement factories. The data include the factory's opening date, the type of product from each plant and the capacities for which these firms were designed. This information allows an appropriate judgment to be made of the importance of these factories in the Libyan industrial sector.

Table 6.75: Profiles of the Factories (Source author: based on Alahlia Cement Company, 2013).

Factory Name	Established	Production Type	Production Amount (Mt/Yr)
(A) Zliten	1984	Portland Cement	1 Mt/yr
(B) Lebda	1979	Portland Cement	1 Mt/yr
(C) Margeb	1968	Portland Cement	0.33 Mt/yr
(D) Souk Al-Khamis	1977	Portland Cement	1 Mt/yr
		Lime	0.1 Mt/yr
		Gypsum	0.009 Mt/yr

6.3.3 Participant' Background

It was believed that presenting background information about the respondents was very important. This kind of information gives the reader a chance to evaluate the quality of the interview. In other words, this information helps to understand those subjects which may influence the analysis of the data. Through the characteristics of the participants, a full and clear picture of their suitability for this study can be drawn. Moreover, understanding the interviewees' background sheds some light on the factors that could influence the maintenance practices in the targeted cement plants. Table 6.76 describes the participants on the basis of their position, level of education, length of experience in the plant maintenance field and working period in the factory.

Table 6.76: Background of Interviews Respondents (Source: author).

Factory	Position of the Respondent	Educational Level	Working Period in the Factory (years)	Experience in Maintenance (years)
A	MDM	Bachelor of Electrical and Electronic Engineering	20	6
	HOD	Bachelor of Electronic Engineering	27	15
	PDM	Bachelor of Mechanical Engineering	22	16
B	MDM	Bachelor of Electrical Engineering	19	15
	GSM	Diploma in Mechanical Engineering	23	23
	GSP	Bachelor of Mechanical Engineering	10	10
C	MDM	High Diploma in Electrical Engineering	22	22
	PDM	High Diploma in Electronic Engineering	20	9
	MRMD	Bachelor of Geology Engineering	17	4
D	MDM	Bachelor of Mechanical Engineering	21	7
	GSM	High Diploma in Mechanical Engineering	10	10
	PDM	Bachelor of Mechanical Engineering	12	4

MDM: Maintenance Department Manager
PDM: Production Department Manager
GSM: General Supervisor of Maintenance
GSP: General Supervisor of Production
HOD: Head of Operating Division
MRMD: Manager of Raw Materials Department

The presentation of the findings from the interviews, as noted above, is in alignment with the seven main themes already generated from these interviews. The interview results were coded and the codes were subdivided into smaller categories named sub-themes. These sub-themes were again grouped into the main themes reflected from the research questions. These main themes are classified as follows: (1) *Employee Output*, (2) *Improvements in Maintenance Strategy*, (3) *Quality of Maintenance Strategy*, (4) *Maintenance Output*, (5) *Maintenance Selection Procedures*, (6) *Production Line Improvements*, (7) *Management Performance*. Here it is worth mentioning that the employees' output reflects the efficiency of workers who attend to the maintenance as required; this efficiency may be affected by many factors, such as the staff's educational level and training and the management's support. Maintenance output means the outcome of the maintenance performed, which may be affected, for

example, by the maintenance workers' efficiency or the condition of the production lines. These themes were generated from different sub-themes (see Appendices 9.1 to 12). The findings were analysed to evaluate the efficiency level of the maintenance currently in place in the targeted cement plants. In this section, the interview results will be presented for each factory. Next, these themes are set out within the four plants with a view to generalising the four cases. Here it should be mentioned that not all the information obtained was considered equally important; thus, more concentration was needed on data that were seen to be valuable for the research. With this in mind, the findings of the interviews are presented below.

6.3.4 Factory A

Theme 1: Employee Output

The workers' output is usually reflected in their ability to tackle their maintenance jobs in the proper way. This theme, *Employee Output*, refers to the performance level of the employees in the perception of the respondents, which sometimes differed as the interviews proceeded. Indeed, the interview findings revealed a good employment system on the whole, but it seems that the efficiency level of maintenance workers was minimal. This is shown by the high number of workers who held unrelated maintenance qualifications. As a result, these employees had little awareness of maintenance practices.

“Despite the existence of an employment committee in the factory, the Ministry for Industry and the Ministry for Manpower send us new employees from time to time. The issue is that most of these workers need intensive training – their background is not related to the maintenance field” MDM –A.

The head of the operation division (one of the production department sections) added that the level of maintenance staff efficiency is affected by some political issues: the tribal system plays a major role in controlling senior management. Therefore, it is not easy to comply properly with the employment system. Both of the above respondents agreed on this and added that non-compliance with the employment system generates inactive workers and in turn poor maintenance. The manager of the production department took a different line; he related the weakness of the maintenance workers to the lack of appropriate training programmes offered by top management. He stated that the factory

encounters obstacles to the adoption of proper maintenance practices because the percentage of skilled staff is too low.

All in all, the respondents tried to evaluate the workers' output levels and describe the problems that could affect the efficiency level of these workers with regard to the maintenance practices in their factory. The participants agreed on these and stated that the employees' output did not meet the maintenance needs.

Theme 2: Production lines Improvements

The second theme identified within the interviewees' answers refers to the extent to which the production lines need improvement which is reflected by such factors as the reliability of the systems and the level of productivity. All the respondents believed that there is a significant need for improvement since their factory's production systems are very old, with adverse consequences for their reliability. The low productivity hinders the factory from achieving the amount of production that they aim for.

“The current efficiency of the production systems does not exceed 70% of the overall effectiveness, even in good conditions. Therefore, more effort is needed to produce the targeted amount of cement” MDM –A.

The head of the operation division stated that his factory's production lines had become unreliable. The most important reason behind this is that many of the system's components have not been renewed or replaced for a very long time. Therefore, more spending is needed, otherwise more time would be wasted in maintaining worn out machines. Even if they were maintained well, they would be unable to work fast enough to meet the production requirements. The production department manager agreed with this and added that most of these lines were manually operated, and hence hard to control. As a consequence, the fault could not be dealt with promptly.

All the interviewees, according to the above findings, believe that there is an urgent need for improvement in order to increase the efficiency of the production systems.

Theme 3: Quality of Maintenance Strategy

While the respondents emphasised the need for improvements in the current production components, they recognised the impact of a maintenance strategy on raising the reliability of the production lines. Although PM is used sometimes, the most popular approach to maintenance is to use the very traditional reactive strategy. The maintenance manager agreed, adding that it cost his firm many interruptions in production. No suitable plans were made to consider and adopt other possible strategies and they were chosen on the basis of staff experience. From the standpoint of the head of operations, the maintenance team spends more time than it should on maintaining a device or a component. In addition, more money is paid by the top management in the hope of reducing this time, but fundamentally it is the strategy that is ineffective. Enlarging on this point, he said that the firm suffered from an accumulation of maintenance work due to unplanned breakdowns. This backlog is also the result of the maintenance department's inability to distribute the maintenance tasks properly, again due to the inappropriate strategies adopted.

“In some cases, maintenance works take more time than they should. In my opinion, the maintenance department should develop plans for maintenance in advance. I'm sure that with such plans the maintenance time could be reduced. In addition, this would give the maintenance staff an excellent opportunity to become aware of works that should be done in the course of maintenance” PDM-A.

Theme 4: Maintenance Strategy Improvement

In close connection with the previous theme, all the interviewees judged that making any improvement in maintenance would reduce the cost and time spent on maintenance tasks and would also increase the reliability of the production lines. The efficiency level of many production lines should be raised to meet production requirements and proper maintenance would ensure that it was done. Any maintenance strategy is linked directly to the reliability of the production systems. This is what the maintenance manager referred to when he stated that the reactive strategy for maintenance had lowered the efficiency level of the production lines. To develop his theme, he said that sudden breakdowns occurred in one or more of the production lines because of sticking to the traditional strategy of fixing a machine or a device only after it breaks down. Such outworn strategy prevents the maintenance staff unable from diagnosing faults soon enough.

“Through my dealing with the maintenance department, I see them encountering obstacles such as unplanned stoppages in a production line, added to the inability of some workers to identify what has gone wrong. This gives me clear evidence that strategy of maintenance currently applied needs to be improved” **HOD-A.**

Another interviewee highlighted the agreement of all maintenance staff that maintenance needs to be improved. He related the absence of improvement programmes to the lack of senior management interest in supporting them. This suggests an urgent need to evaluate the current strategy of maintenance and thus help to make the production systems components more reliable, thereby increasing efficiency overall.

Theme 5: Maintenance Selection Procedures

This theme emerged from the interviewees’ belief that no plan is used in selecting a maintenance strategy. The maintenance department relies on staff experience to determine this choice. In other words, the maintenance staff adopt it blindly, since many of them are unaware of the importance of maintenance strategies, given their unfamiliarity with maintenance and its practices. This is bound to have an adverse impact on the quality of maintenance and hence on the efficiency of the production lines. The maintenance staff needs to be trained in maintenance related issues and practices.

“The current strategy was adopted only on the basis of experience gained from dealing with the production systems. The problem we face most is that many of the maintenance workers have no awareness of maintenance strategies. Some of them have no knowledge of the importance of maintenance improvement” **MDM-A.**

This was confirmed by the head of the operation division, who said that his factory had no plans that could be used for choosing a suitable strategy. He related this to the lack of expertise in the maintenance field. The production manager was convinced that no programme for creating the appropriate strategy could be made in his factory because such programmes need specialists, who were not on the staff. All the respondents agreed that not adopting a suitable strategy has a significant negative impact on many aspects of the production process. For example, poor maintenance lowers the efficiency of the production lines, causing it to take longer than it should to diagnose faults. Therefore, the stoppage is likely to last longer than expected.

Theme 6: Maintenance Output

Maintenance output usually reflects the quality of the maintenance work at the worksite. The maintenance output reveals the quality of maintenance strategy, workers performance and management engagement for evaluation. These factors can be seen also in the efficiency of the production lines. However, in this factory, it seems that the employees were unable to perform the assigned maintenance tasks as they should have. This is due to several factors, mentioned by the manager of the maintenance department; for instance, the negative influence of the social culture on the employees' behaviour. This can be seen in non-working hours wasted by many of them during production time, when they work on unrelated activities. The lack of senior management interest could be another factor. This could be evidenced by the shortage of spare parts and lack of documentation. Such factors can play a major role in reducing productivity. Moreover, relying on the experience of many workers lowers the quality of maintenance, making the maintained equipment or machines less reliable. The production manager continued that adopting an ineffective approach to maintenance could have poor consequences for the ability of the maintenance staff to carry out maintenance work as they should.

“Many points that should be concentrated on more when improving maintenance; for example, improving workers' capabilities through providing sufficient training can contribute to raising their efficiency and thus increase the quality of maintenance” HOD-A.

Theme 7: Management Performance

In the view of maintenance department manager, outsourcing maintenance in many cases means adding to the cost of maintenance for the factory. Outsourcing results from the current staff's inability to deal with complex faults. In addition, the factory faces delays in maintenance work from the complex regulations surrounding the supply of spare parts. Such delays in turn lower a firm's chances of competing with others. Therefore, senior management should pay more attention to improving employees' skills and should arrange to have necessary spare parts provided in good time. In addition, maintenance employees cannot perform their jobs properly in their present conditions:

“There is mismanagement; for example, we observe in our factory that non-maintenance or non-production staff are paid at what we call a technician's rate. This makes the maintenance and production workers less motivated” PDM-A.

Surely, this can only have a negative effect on staff behaviour, reducing the quality of the maintenance output. However, all the respondents agreed that communications between them and top management was good; this raises the level of their department's performance and thus that of the whole factory. This could be a good indicator of an increased possibility of improvement.

6.3.5 Frequency Analysis

In order to measure the occurrence of the key factors generated from the interview transcripts according to their importance, Table 6.77 and Figure 6.75 illustrate the list of themes cited in the face to face interviews. The most frequently cited theme is *employee output* (34 times). The maintenance manager repeated that many times in his interview: many workers need intensive training to raise their efficiency in performing maintenance. This suggests that, in the participants' opinion, the efficiency of workers can play a significant role in the success of maintenance and thus increase the efficiency of the production systems through ensuring the reliability of their components. *Maintenance output* could be another important theme, mentioned 20 times by the interviewees. This can be seen, for example, in the response of the production manager who spoke more than once of the need for qualified workers to ensure the success of maintenance and increase the efficiency of the production lines. At the same time, the *quality of maintenance strategy*, *maintenance strategy improvement*, *management performance* and *production lines improvements*, cited 16,16,14, and 13 times respectively seem less important; the interviewees did not refer to them as much as the previous themes. The answers from the participants did not support the idea that *maintenance selection procedures* could influence maintenance practices in the factory.

Table 6.77: Frequency Analysis of Factory A (Source: author).

Number	Theme	Frequency				Rank
		A-1	A-2	A-3	Total	
1	Employee Output	13	15	6	34	1
2	Production lines Improvements	2	5	6	13	6
3	Quality of Maintenance Strategy	5	8	3	16	3
4	Maintenance Strategy Improvement	9	5	2	16	4
5	Maintenance selection Procedures	5	2	2	9	7
6	Maintenance Output	8	6	6	20	2
7	Management Performance	5	4	5	14	5

A-1: interviewee number 1, factory A

A-2: interviewee number 2, factory A

A-3: interviewee number 3, factory A

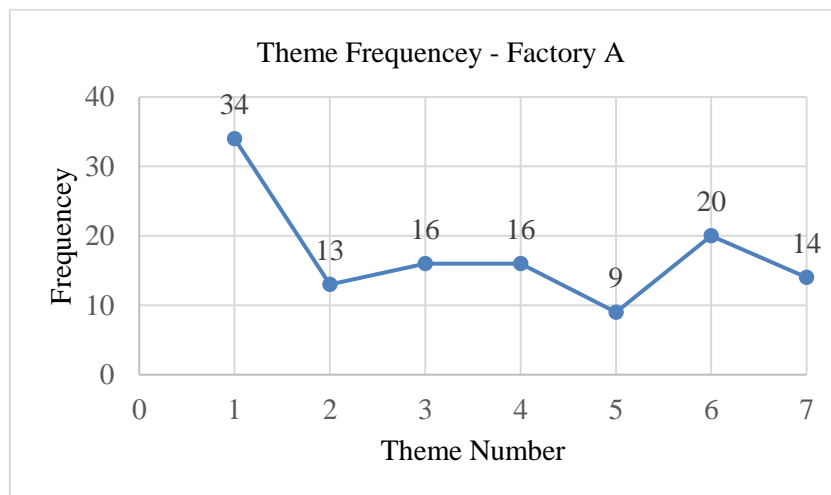


Figure 6.75: Frequency of Analysis in Factory A (Source: author).

6.3.6 Factory B

Theme 1: Employee Output

This theme was supported by evidence that most of the staff rely on experience in assessing maintenance work. Therefore, the quality of maintenance is usually lower than required and as a result the reliability of production lines is poor. This issue, as stated by the maintenance manager, sometimes forces the factory to outsource maintenance, adding to the cost and time required. He explained the main reason behind this: that some of the staff members held unrelated maintenance certificates. This meant that they needed more training. The respondents related this to the government's policies, which are

reflected in the weakness of senior management's performance. It is defeated by the employment system.

“In fact, there are good employment standards but not complied with. This is because the factory is subjected to public sector requirements and has to follow the state's policies. As a result, about 90% of the factory's staff are employed either by the Ministry for Industry or for Manpower” GSM-B.

The general supervisor of production mentioned that the reliability level of his factory's systems was considered low, with unplanned delays and stoppages, owing to the reliance on workers' experience in performing maintenance. Many of the maintenance workers are not aware enough of maintenance and its practices.

Theme 2: Production lines Improvements

To be able to compete with others the conditions of the production systems should meet the production requirements. Achieving the targeted amount of production reflects the efficiency of production lines. One of the interviewees stated that his firm had to deal with old production systems. The evidence for this is that many of the production lines are manually operated and slow, preventing the targeted amount from being produced. Continuing unplanned breakdowns are other problems caused by the retention of old systems.

“We deal with old systems and so it is not easy to achieve the required amount of production. We suffer from sudden stoppages which need more time and more spending to remedy soon enough. As a result, we have less chance to be competitive” GSM-B.

Theme 3: Quality of Maintenance Strategy

The quality of maintenance strategy regarding maintenance practices has often been reflected in the quality of maintenance work. In this factory, all the respondents' answers affirmed that their factory adopts a very traditional and inappropriate strategy of maintenance. The manager of maintenance gave some evidence of this when he complained of frequent breakdowns in the production process since maintenance is not planned the system depends on fixing a machine only the breakdown or fault appears. Such an approach causes a maintenance backlog, sometimes stopping the whole system from working and leading production fluctuation or breakdown. This is related to the lack of training programmes which should have developed the skills of the staff to improve the strategies of

maintenance. In addition, it relates to the failure, on grounds of cost, to employ experts to create such plans. Improving the maintenance strategy could be linked to the condition of the production systems:

To improve the current strategy of maintenance we need to increase the efficiency level of the production lines. For this, many components of the production lines need to be replaced and the skills of the maintenance staff should be increased” GSP-B.

The above makes the point that the factory cannot achieve the targeted amount of production using its current strategy of maintenance. In other words, to reach the required efficiency of the production lines, the approach currently in place should be improved.

Theme 4: Maintenance Strategy Improvement

This theme emerged from the views of the participants as an essential step in improving the efficiency of the whole production system. It could benefit the system by reducing the maintenance costs and the number of unplanned stoppages, said the manager of the maintenance department. He went so far as to claim that a good strategy for maintenance means would improve its quality and hence its reliability. To be competitive with other plants, the reliability of this factory’s production lines must be increased as far as possible. This can be done by adopting a more appropriate strategy of maintenance.

“Competition with others requires that the reliability of the production systems should be at the highest level. This can only be achieved through the application of suitable maintenance.” GSM-B.

Good training is needed and specialists will make a great difference to the choice of suitable forms of maintenance. The general supervisor of production agreed with and emphasised that senior management should support maintenance improvement programmes because it would affect the factory’s profits by reducing the spending on maintenance and increasing the efficiency of the production lines.

Theme5: Maintenance Selection Procedures

The respondents were in agreement that experience is the factor most used in selecting the strategy of maintenance in their factory. The main reason behind this is the lack of a sufficient number of skilled staff on the shop floor.

“We had no programmes or plans for adopting the current strategy. In fact, some workers hold unrelated maintenance qualifications and others need to be trained. Even so, many of them are experienced in maintenance as they have been working in the factory for a long time” MDM-B.

The general supervisor of maintenance stated that, in addition to the traditional strategy, preventive maintenance was adopted. This strategy was chosen as part of the productivity plan and suggests that maintenance is sometimes pre-planned. The general supervisor of production agreed with his colleagues about reactive maintenance and added that such methods of choosing a strategy are ineffective. Instead, a team to set up and develop programmes for maintenance strategies is needed. The absence of appropriate methods of choosing maintenance strategies can be seen in the frequency of unplanned breakdowns, pointing to ineffective maintenance.

Theme 6: Maintenance Output

The findings on maintenance output seem to show the significance of efficient workers for the quality maintenance. This is what the maintenance manager clarified in advocating greater attention to maintenance work to increase its quality and reliability. The workers should be evaluated on the level of their efficiency in action. The consequent training programmes could then increase this efficiency until it reached the highest possible quality. The lack of management interest is seen by the general supervisor of production as another factor that could affect the maintenance output. This respondent affirmed that many employees are unmotivated because they are still waiting for privileges such as bonuses and allowances. This inescapably has a direct impact on their desire to work as they are required to. The weakness of senior management representatives was pointed out, in failing to obtain spare parts when needed and in its failure to support many needed programmes, such as planning improvements to production lines.

“More attention should be given by the senior management to reduce the time that it takes to order spare part. The other issue is that it should distinguish between maintenance and production workers and other staff in the factory, each according to their efforts. Moreover, I’m sure that developing a good rewards system would make a big difference to the workers’ motivation to do their assigned tasks better” **GSM-B.**

Theme 7: Management Performance

Good communication between departments and top management would help to minimise many obstacles such as delays in production. Connections could be made between representatives in many forms, such as sharing production, operation and maintenance reports, as well as the information

exchanges on improvement programs. It is believed that this would help to improve the overall efficiency of the plant. However, the participants all agreed that they had excellent relationships with each other. This level of reaction reflects the success of top management's performance vis-à-vis the factory. The firm's performance could be negatively affected by the government's policies. This is because top management often has no absolute right to spend on such programmes, as seen for example in the low level of training.

“Although training is very important in improving staff skills and increasing their ability to undertake work in the proper way, we just put on internal courses of training, which are inadequate. These programmes are in short supply and therefore the management has to have permission from a higher authority to put them on” MDM-B.

6.3.7 Frequency Analysis

In the findings, the interviewees emphasised the influence of *employee output* on the maintenance practices in their factory. The theme occurs 22 times in this factory's interviews, as can be seen from both Table 6.78 and Figure 6.76. The maintenance manager believed that relying on experience in doing maintenance job is the factor that could most negatively affect the efficiency of workers in finishing maintenance as required, while the general supervisor of maintenance linked it to the non-compliance with the employment criteria, in that the background of some employees is unrelated to the maintenance field. The findings point to *Maintenance Strategy Improvement* as the second most important theme, heard 17 times during this set of interviews. The maintenance manager and general supervisor of maintenance repeatedly mentioned that a new maintenance strategy was needed to make it successful and thus increases the firm's ability to compete with others through strengthening the reliability of the production line. From the same table, it is clear that *Maintenance Output, Quality of Maintenance Strategy, Production lines Improvements and Maintenance Selection Procedures*, cited 14, 13, 13 and 10 times respectively, had less influence on maintenance practices in the factory. In the same vein, the results clearly indicate that *Management Performance* was felt to have no significant impact on the maintenance, coming up only four times.

Table 6.78: Frequency Analysis of Factory B (Source: author).

Number	Theme	Frequency				Rank
		B-1	B-2	B-3	Total	
1	Employee Output	9	6	7	22	1
2	Production line Improvements	6	2	5	13	4
3	Quality of Maintenance Strategy	4	4	5	13	5
4	Maintenance Strategy Improvement	6	4	7	17	2
5	Maintenance Selection Procedures	4	2	4	10	6
6	Maintenance Output	7	3	4	14	3
7	Management Performance	2	1	1	4	7

B-1: interviewee number 3, factory B

B-2: interviewee number 2, factory B

B-3: interviewee number 3, factory B

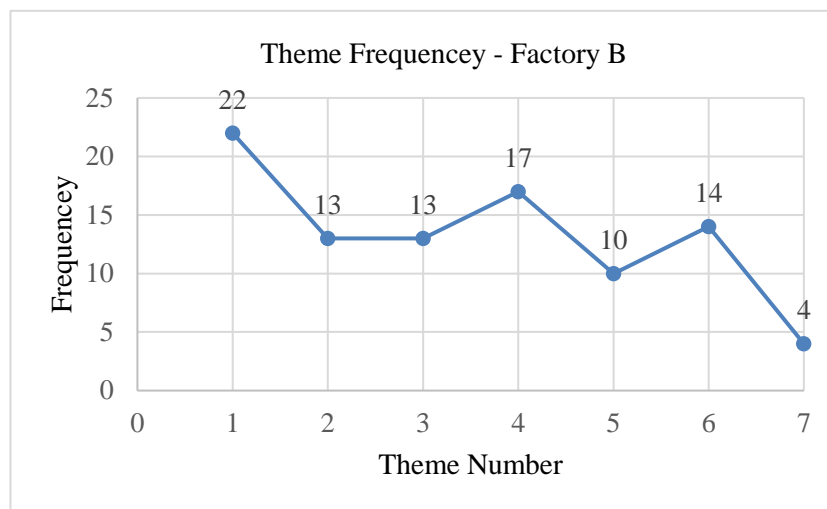


Figure 6.76: Frequency Analysis of Factory B (Source: author).

6.3.8 Factory C

Theme 1: Employee Output

The first theme identified through the answers of the targeted participants in this plant referred to the ability of the maintenance workers to do maintenance job as required. In this factory, it seems that the efficiency of some workers was minimal because maintenance practices were not part of their background.

“Although many of the workers can do maintenance as required, we cannot hide the fact that some workers suffer from a lack of knowledge of maintenance and its practices because they are not specialised in the maintenance field” MDM-C.

Many of the maintenance staff members work below minimum efficiency, according to the production manager. He related this to unwillingness of the workers to do their jobs as required because they would have liked the volume of work that they did to be reflected in the size of their wage; they thought that senior management did not give them the support that they deserved. This interviewee went so far as to link this with the government policy of limiting the power of management at the plant. The manager of raw materials department agreed with this view and cited another damaging consequence of the centralised government for the efficiency of workers; he blamed the powerlessness of the factory to design its own employment programme on the country's regulations, which reserve this task for Ministry of Industry and the Ministry of Manpower. This generated ineffective employees, including maintenance workers, and in turn to less reliable production lines.

Theme 2: Production line Improvements

The opinions of the interviewees on the performance efficiency of the production systems can be identified under this heading. From the interviews, it is clear that the great age of the components of the production systems is the factor with the most significant effect on the systems' efficiency. The current condition of some production lines is poor, making the production rate of these lines substandard. This was mentioned by the director of maintenance. The manager of the raw materials department agreed with this and added that the production lines should work faster to produce as much cement as was needed. Because of the low productivity, the factory could not compete with others even in the local markets and particularly not with the cement producers from other countries:

“The improvement programmes are essential to keep pace with new technologies. This could give us the opportunity to stay in the competition area either locally or globally. Improvement programmes would inevitably result in raising the efficiency of the production line components and thus the targeted amount of production could be achieved” **MDM-C.**

This interviewee linked the lack of improvement plans to the lack of interest of top management in supporting such programmes.

Theme 3: Quality of Maintenance Strategy

It seems clear that most interviewees agreed in principle to some extent that the maintenance strategy adopted in their factory was ineffective. Their evidence for this was the frequently unplanned stoppages of some components of production systems.

“In some cases, we were forced to outsource to finish the maintenance. Unknown failures are the reason for this” MDM-C.

The manager of the raw materials department repeated more than once his condemnation of a non-effective strategy of maintenance, which he confirmed from the accumulation of maintenance work that occurs from time to time in the factory. Although both the other interviewees reported that advanced strategies such as preventive maintenance were sometimes applied, they added no value to maintenance because they were carried out randomly with no previous plan, according to the production manager. He also mentioned that a new maintenance strategy was needed to ensure the reliability of the maintenance work itself so as to achieve the highest level of production line efficiency.

Theme 4: Maintenance Strategy Improvement

The answers obtained from the interviews show the absence of an appropriate strategy for the factory to improve the quality of maintenance. Some factors could be hindering the improvement in maintenance strategies. For example, the maintenance manager believed that the lack of interest from senior management is the most important barrier precluding any improvement. It was shown by the lack of funds to support such a programme and the complex policies that the factory had to implement instead. The manager of the raw materials department considered that the ignorance of the maintenance staff was seen as the main impediment to improved maintenance strategies.

“The improvement of staff skills is the most important step. I’m sure that a team with a high level of awareness regarding maintenance and its practices would mean more chance of a proper approach to maintenance” PDM-C.

Theme 5: Maintenance Selection Procedures

All the interviewees were in agreement that their plant’s strategy, reactive strategy, was chosen on the basis of staff experience in dealing with production devices and machines. They did admit that

preventive maintenance is sometimes carried out according to the annual productivity plan. This strategy gives a factory a good chance of increasing the reliability of some production components. The maintenance manager affirmed that some of the production line components, such as the main kiln, need to be maintained in advance. This is because letting it fail would have serious consequence on the kiln itself and the whole system and therefore, its maintenance is planned.

Theme 6: Maintenance Output

The results obtained from the maintenance work usually reflect the success of the maintenance itself. This means that the efficiency of the maintenance workers can be measured through the quality of their work. The answers of the interviewees suggest that the quality of maintenance outputs is not high, since most of the maintenance work is limited by the staff's expertise.

“The maintenance that is carried out cannot meet the required purpose because it is performed only after a failure has occurred. This is due to some maintenance workers' lack of awareness of the proper methods of implementing maintenance and making it successful” MDM-C.

The manager of the production department endorsed this view and added that some of the workers held irrelevant maintenance certificates. Their skills needed to be diverted to this kind of maintenance. The view of the director of the raw materials department was different; he claimed that maintenance quality could rise if some improvements could be made to the components of the production lines; the factory's production lines were superannuated.

Theme 7: Management Performance

With regard to the facilities provided by the top management, all the interviewees believed that more power should be given to the senior management to facilitate the decision-making regarding the plant, especially when it came to maintenance issues. At least one good sign is that there is no discord between the departments. This can be seen from their regular meetings, especially between the maintenance and production departments. The maintenance manager was proud of the good relationship with the factory's other departments. He made formal contact with other departments through what are called

work orders, which allow them to control and reduce some problems of maintenance and related issues. Some maintenance work is done in response to other departments' reports.

6.3.9 Frequency Analysis

Table 6.79 and Figure 6.77 show that the most frequently cited theme in this set of interviews was *maintenance output*, repeated 19 times by the interviewees. Both the manager of the maintenance department and the director of the raw materials department see the lack of awareness among some workers regarding maintenance and its practices to be the most influential factor on the quality of maintenance achieved. The maintenance manager went further, directly linking the maintenance output to the efficiency of the production lines. Relying on experience undoubtedly affects the employee output which in turn has a big impact on the results gained from maintenance as seen by both departmental managers (of raw materials and production).

According to the responses of the participants, *quality of maintenance strategy*, cited 12 times, had a significant influence on maintenance practices. Although the interviewees used different terms, these all led to the same meaning, which can be summarised as follows: the targeted amount of production can be achieved through continuity in production, in other words, by keeping the number of unplanned stoppages as low as possible. This depends on choosing an appropriate strategy for maintenance to ensure its success. As the same table shows, *maintenance strategy improvement* is seen to be as important as the previous theme was, and was also cited 12 times. All the interviewees were agreed that current maintenance strategy needed to improve to increase its chances of success. The maintenance department manager and the raw materials department manager believed that the weakness in managerial performance was the main obstacle to improvement in the strategy applied. The complicated procedures that senior management adopted bore this out. These themes were followed by *production line improvements*, *employee output* and *management performance*, cited 11, 10, and 8 times respectively, which may have less influence on the success of maintenance within their factory. *Maintenance selection procedures* probably do not have any great impact on the current maintenance practices, as it was cited by the interviewees only four times.

Table 6.79: Frequency Analysis of Factory C (Source: author).

Number	Theme	Frequency				Rank
		C-1	C-2	C-3	Total	
1	Employee Output	4	4	2	10	5
2	Production line Improvements	3	6	2	11	4
3	Quality of Maintenance Strategy	3	5	4	12	2
4	Maintenance Strategy Improvement	3	5	4	12	3
5	Maintenance selection Procedures	2	1	1	4	7
6	Maintenance Output	6	6	7	19	1
7	Management Performance	1	1	6	8	6

C-1: interviewee number 1, factory C

C-2: interviewee number 2, factory C

C-3: interviewee number 3, factory C

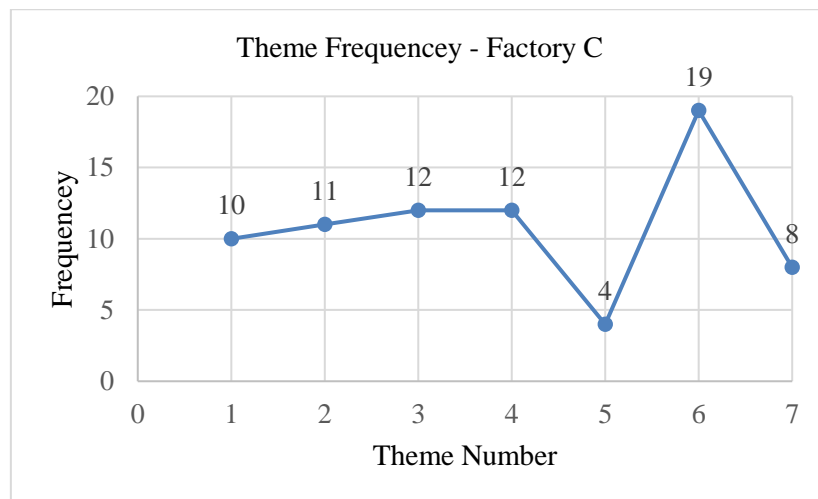


Figure 6.77: Frequency Analysis of Factory C (Source: author).

6.3.10 Factory D

Theme 1: Employee Output

The first theme identified through the answers of the targeted participants in this factory highlighted the ability of the shop floor workers to perform the required work as they should. However, it was evident that the workers' knowledge of maintenance and its practices was poor, owing to irrelevant qualifications. This is what the manager of the maintenance department believed. He added that this was also why intensive training was needed, to cut the delays in completing maintenance work.

*“Although the number of maintenance staff is sufficient in total, maintenance work takes, in some cases, more time than it should to finish. Hence, delays in production. More technical workers are needed to ensure that maintenance tasks are quickly dealt with **GSM-D**.*

The production manager related such issues to the lack of senior management interest, clarifying this by saying that the minimum wages of the employees should be increased in line with the volume of work assigned to them. In addition, the weakness of the employment programme in the factory causes the admission of unskilled workers.

Theme 2: Production lines Improvements

To decrease the number of production system breakdowns, the reliability of the components of these systems should be as high as possible. The reliability of the systems components usually indicates the efficiency level of these systems. In this factory, it seems that the advanced age of the production lines has a negative effect on the production processes. The unplanned stoppages that the production team encounter from time to time is evidence of this.

“We are dealing with systems that need some improvement because many of their machines are manually operated and they need to be monitored continuously needed to avoid unexpected failures”
MDM-D.

Through increasing the efficiency of the systems, the targeted amount of production can be ensured. This would give the factory a good chance to emerge into the competitive market. This was the opinion of the general supervisor of maintenance. The production manager believed that the plant was still facing obstacles to producing the targeted amount of cement to make it competitive with other manufacturers.

Theme 3: Quality of Maintenance Strategy

Another theme identified within the respondents' answers refers to the effectiveness of the maintenance strategy currently in place. The maintenance manager judges that what is mostly practised in the factory is preventive strategy. It is adopted in compliance with what is called the annual productivity plan. Although this strategy is seen as one of the developed strategies, its results for production is still insufficient. This manager believed that an effective strategy should be chosen by specialists in maintenance and should take account of many factors such as the factory's objectives and the condition of the production systems. The selection of a suitable strategy for ensuring the success of maintenance

work demands suitable equipment. This would also guarantee meeting some requirements such as increasing the efficiency of production systems.

“We cannot ensure the success of this strategy or any others under the present circumstances of the production environment, in particular with the current condition of the production lines which is mostly poor” GSM-D.

This view was endorsed by the production manager who claimed that the failure to implement an appropriate maintenance strategy related to the fact that most maintenance workers rely only on experience at work. As a result, the factory sometimes faces unexpected stoppages which lead to production fluctuations.

Theme 4: Maintenance Strategy Improvement

Closely connected with the above findings, adopting the appropriate strategy is clearly needed to avoid system breakdowns during production. It would also save time and cut the extra spending on maintenance.

“In some cases, we are forced to increase spending on maintenance in order to overcome some of the problems that face us during the production processes, especially sudden faults, caused by the adopted strategies being unclear to many of the workers” MDM-D.

To avoid the losses in production caused by the production lines being down, the general supervisor of maintenance recommended improving maintenance through determining maintenance requirements such as workers' skills and evaluating the efficiency of the components of production lines.

Theme5: Maintenance Selection Procedures

The methods of selecting a maintenance strategy could affect the quality of the maintenance itself. In other words, if a maintenance team is good it will have suitable procedures for choosing the right maintenance strategy. In this factory, according to the maintenance department manager, maintenance is adopted only to follow the annual productivity plan. Therefore, he stated, we are mostly forced to implement preventive maintenance. Although this strategy is advanced, we need to consider other factors when choosing a maintenance strategy, such as the availability of skilled staff. The general supervisor presented a different picture, affirming that maintenance was undertaken only when some

failure was reported. Not following any procedures when choosing a maintenance system may be related to the lack of senior management interest in plans to support improvement.

“Some good plans for adopting the appropriate maintenance exist. All we need is the financial support to activate these procedures” PDM-D.

Theme 6: Maintenance Output

The quality of maintenance usually depends on factors such as the efficiency of the maintenance workers, the efficiency of production systems and the interest of top management in supporting such programmes. In this factory, one problem is that some workers cannot complete their tasks as required. The absence of skilled workers is the most influential factor.

“Some employees need technical support to complete the required maintenance work properly and on time. This is because those workers have taken little technical understanding of the production machines or devices.” MDM-D.

The view of the general supervisor of maintenance was the same; he stated that there are too few specialised workers in the maintenance field. This is clear from the delays in finishing maintenance work. The views of the production manager coincided with those of the maintenance manager on the failure of maintenance outcomes to meet their designed purpose due to the low efficiency of the workers.

Theme 7: Management Performance

The findings of this theme send a message to top management to give more attention to some areas that would increase both the employees' efficiency and the reliability of the production systems. The maintenance manager believed that some of the workers are unwilling to do the jobs assigned to them, for they work hard and get little. As a result, the quality of maintenance is poor. The lack of spare parts is another grievance that should be focused on, since delays in getting new parts hold up the maintenance work and thus production. The maintenance manager believed that improving the rewards programmes and restructuring the wage system should motivate workers to perform their assigned work better:

“Although bonuses are available, there is still no clear programme through which these rewards can be distributed fairly among the workers” GSM-D.

With regard the communication between the departments and top management, it seems that the maintenance and production managers were in general agreed that the level of communications is sufficient. But the general supervisor of maintenance realised that it was not possible to follow a clear programme when departments needed to communicate with each other, and least of all with senior management. He added that this due to the unclear strategy of the factory overall.

6.3.11 Frequency Analysis

The numbers presented in Table 6.80 and Figure 6.78 confirm that the *quality of maintenance strategy* is the most influential factor in adopting proper maintenance and ensuring its success; this was cited 15 times. The maintenance department manager supported this, stating that the success of the current maintenance strategy could not be ensured unless suitable plans for strategies were creating through which a suitable form of maintenance could be adopted. Relying on experience is considered the most influential factor on choosing a strategy. This was discussed by the general supervisor of maintenance, with whom the manager of the production department agreed. *Employee output* was the second most important theme, with 12 mentions in the interviews. The findings were that special training is needed to increase the efficiency of many workers who implement maintenance and kindred issues. Many workers held irrelevant maintenance certificates, hence had limited ability to perform maintenance as required. The participants' views suggested that *maintenance output*, *production line improvements*, *maintenance strategy improvement*, *maintenance selection procedures*, cited 9, 9, 8 and 7 times respectively, have less influence on maintenance practices in their factory. The efficiency level of *management performance* is satisfactory. The respondents hardly mentioned any significant managerial impact which might hinder their factory's successful implementation of maintenance strategies.

Table 6.80: Frequency Analysis of Factory D (Source: author).

Number	Theme	Frequency				Rank
		D-1	D-2	D-3	Total	
1	Employee Output	3	5	4	12	2
2	Production line Improvements	3	4	2	9	4
3	Quality of Maintenance Strategy	6	3	6	15	1
4	Maintenance Strategy Improvement	5	2	1	8	5
5	Maintenance selection Procedures	2	1	4	7	6
6	Maintenance Output	3	4	2	9	3
7	Management Performance	2	2	1	5	7

D-1: interviewee number 1, factory D

D-2: interviewee number 2, factory D

D-3: interviewee number 3, factory D

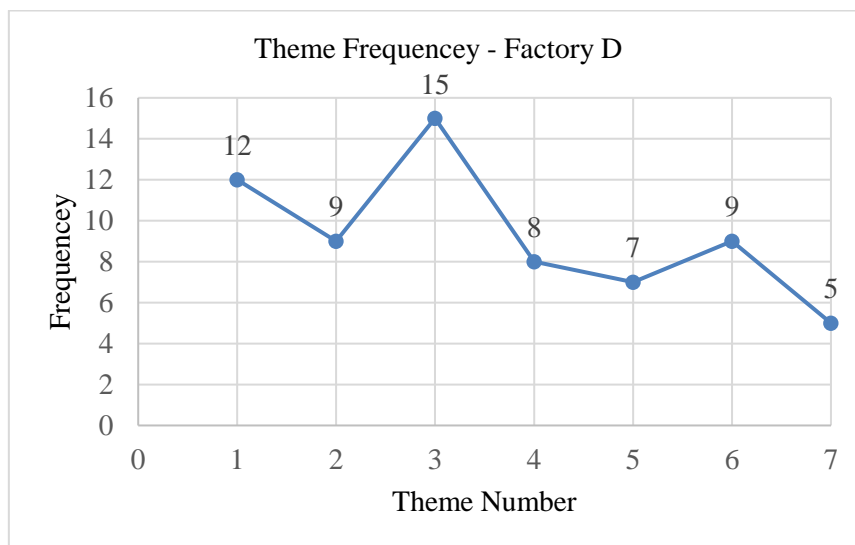


Figure 6.78: Frequency Analysis of Factory D (Source: author).

6.4 Findings from the Observations

As discussed in the methodology chapter, the triangulation of data can enhance the credibility of the research. In this study, the plan was to observe four factories directly as part of the triangulation. Unfortunately, of these four plants, only one was able to give permission to visit its site for this purpose. This direct observation provided information related to the site's maintenance practices (see the observation check sheet in Appendix 7). However, in reviewing the observation data against the quantitative and qualitative data that have been already discussed, it is clear that the information gathered from observation would not add any further value to the research. Therefore, although it provided an opportunity to triangulate, it will not be considered any further.

6.5 Cross-Case Studies Comparison

6.5.1 Cross-Case Studies Findings

The maintenance practices and their related issues were presented for each firm individually. This section combining the results obtained from the four cement factories aims to give a clear view of maintenance and its practices in these four cement plants as a single set. It is hoped that these findings will help to evaluate the current situation through identifying any barriers or obstacles which might hinder the success of maintenance.

Theme 1: Employee Output

The first theme identified throughout the interviewees' answers referred to the problems and obstacles that might reduce the ability of the workers to do the assigned tasks quickly and as they should. Although the vast majority of participants of the four cases acknowledged the existence of recruitment standards, the level of complying with these standards was poor. This can be seen from the presence on the staff of some ineffective workers who held non-maintenance certificates or had a minimal level of education. As a result, they were rarely efficient. The interviewees who agreed with this view stated that many workers rely only on experience in performing maintenance duties. Other respondents from factories A, C and D attributed the poor performance of the workers to a lack of proper training. They believed that intensive training could improve the skills of workers, which in turn would increase the chance of adopted a successful maintenance strategy.

“Honestly, a good number of our workers, especially non-maintenance qualified, need special training programmes or rehabilitation, so as to get full benefit from their effort and raise the level of maintenance output” GSM-D.

The managerial performance was presented by many respondents in the four targeted firms as a factor which may have a strong effect on employee efficiency. The respondents in factories B and C completely agreed that greater attention should be paid by the senior management to supporting the employees and motivating them to undertake the assigned tasks as expected. This encouragement could come from rebuilding the wage system to take account of the volume of work expected. None of the respondents in the four plants tried as they should have to link the ability of those workers in their

maintenance tasks with the work environment which can be influential in many ways such as the application of safety and security standards.

Theme 2: Production lines Improvements

This theme emerged from the interviewees' remarks with regard to the efficiency of the production lines in their factories and how the conditions of these lines could affect or be affected by maintenance. There was no difference between the results on this point in these case studies; all the respondents were in agreement that improvements are urgently needed to raise the efficiency of the production lines. Their reason was that most of the production lines' components are old and slow to operate. Therefore, more spending is needed as well, since too much time is wasted in maintaining these components. However, such improvements would increase the opportunities for successful maintenance and make it easier. A good number of participants from firms A, B and D (7 out of 12 in total) believe that the reliability of maintenance is directly linked to the efficiency of the production lines. They stated further that the selection of an appropriate strategy of maintenance is mostly based on the condition of the production lines.

“Reactive maintenance is adopted mostly in our factory. This is mainly due to the fact that the success of any improvements in the maintenance strategy currently in place cannot be ensured in accordance with the current situation of many production lines” GSM-B.

These respondents showed another instance of the conditions of maintenance work influencing the production systems by repeating that the reliability of many production lines in their factories was poor and hence continuously liable to sudden faults. These sometimes cause an accumulation of maintenance jobs and thence to shutdowns in some production lines and ultimately stoppages in production.

Theme 3: Quality of Maintenance Strategy

This theme was consistently found in the various views of the respondents. The vast majority of those interviewed (10 out of 12) believed that their factory had an ineffective strategy of maintenance. Some of them could present evidence which was not always the same. For instance, but not limited to, at least one interviewee in each case spoke of his factory's inability to adopt an appropriate strategy for maintenance, owing to the poor condition of some production lines. Two participants representing

factory D judged the lack of sufficient skilled and qualified staff to be the main obstacle to improving the strategy of maintenance used in this factory. These discussions continued with other respondents from firms A, B and D who were convinced that a good number of maintenance workers rely on experience alone in performing maintenance jobs.

“It is not possible to adjust the effectiveness of the current maintenance strategy because maintenance work is adopted randomly. We benefit from the staff members’ familiarity with the production line components. Consequently, we rely on the perceptions of workers to identify failures, as well as the maintenance the needs to be carried out” MDM-A.

In contrast, preventive maintenance is sometimes used, as acknowledged by all respondents in firm C, in addition to one from B and one from D. These interviewees insisted that the strategies of maintenance in their factories are chosen on the basis of a specific study which represents what is called a productivity plan. Therefore, there is nothing wrong with this strategy. However, such a claim was rejected by the vast majority of the other interviewed. For example, the maintenance managers of factories A and B affirmed that the maintenance spending there was much higher than it should have been because of the poor maintenance strategy that was adopted. Others from case A went further and declared that an unplanned maintenance strategy lowers the level of maintenance output. As a result, unplanned breakdowns of production lines are more likely to occur in production time. Here it should be mentioned that none of the respondents could recognise the influence of managerial performance on choosing appropriate maintenance strategies. The success of performance could be linked in many ways with a suitable strategy, such as financial support for developing or introducing plans to create or improve strategies of maintenance in these factories.

Theme 4: Maintenance Strategy Improvement

The success of maintenance itself can testify to the effectiveness of the adopted strategy of maintenance. This is what the respondents in the four factories believed. Half of them, at least one in each case, highlighted that the current strategies in their plant need to be updated. There is more than one reason behind these demands. For example, one respondent from factory A and one from factory B believed that the production levels in their factories were limited because of the low efficiency of many production lines. This mainly resulted from adopting an ineffective strategy for ensuring the

maintenance success and thus increasing the efficiency of these lines. The view of the maintenance manager of factory B was that adopting an appropriate strategy of maintenance would help to reducing the reliance on outside experts for finishing maintenance, and would even assist the unskilled workers to do their job better. Moreover,

“I believe that introducing a clear plan for maintenance will lead to a good distribution of tasks. Therefore, the chance of properly performing maintenance would be increased” PDM-D.

Although the emphasis of these respondents was on introducing new strategies for maintenance which would ensure the success of maintenance, half of them (6 out of 12) perceived some obstacles to improvement. According to these participants, more attention should be given by the top management to supporting such programmes. This may be a representative conclusion, since the general supervisor of maintenance in factory B acknowledged the need to simplify managerial procedures when ordering spare parts and also to provide the financial support to purchase these parts promptly. This was very important for improving the production lines and thus making it possible to introduce the proper maintenance strategies. One of the respondents in firm A summarised this findings when he proposed the introduction of a system called the integrated maintenance system through which improvements to maintenance could easily be made.

Theme5: Maintenance Selection Procedures

This theme emerged from the interviewees' acknowledgement of the methods used in choosing the maintenance strategy to adopt in their factories. Out of 12, eight participants agreed that the selection of maintenance relies mostly on the experience of the maintenance staff.

“We benefit from the workers' experience in dealing with the production lines for long periods when performing maintenance work” MDM-C.

Still, they kept repeating during the interviews that there was a significant need to improve the strategies of maintenance currently in place in their factories to increase the efficiency of the production lines and thus meet the production requirements. Most of them conceded that this was not easy. The maintenance manager of plant A and both the raw materials and maintenance managers of firm C said that the awareness level of workers regarding maintenance and its importance should be increased so they could

help to create programmes of improvement. This finding was confirmed by the general supervisor of production in plant B who suggested that it was better to use experts for in improving the maintenance in their factories to ensure the success of such attempts. He went even further, saying that intensive training was needed for many members of the maintenance staff to sharpen their skills and give them the chance to create effective plans for maintenance. The general supervisors of production in factories A and B and the general supervisor of maintenance in factory D believed that the inability to follow a proper strategy of maintenance is related to the poor conditions of many of the production line components. Only one participant cited the lack of senior management interest in supporting such programmes as the main obstacle to improving current maintenance.

In contrast was the view of four interviewees, all the managers of plant C and the maintenance manager of firm D: that some methods existed for choosing an appropriate maintenance strategy. They held that maintenance in their factories was in line with the annual productivity plan. This was built upon the reports from the maintenance and production departments taking into account the targeted level of production.

Theme 6: Maintenance Output

The quality of maintenance can be seen in the efficiency level of the production lines. This theme, *Maintenance Output*, refers to what the participants perceive as the level of maintenance adopted in the four cement factories. The respondents' answers clarify that the outcomes of maintenance work are affected by certain factors. Most of the interviewees, and at least two in each factory, link the maintenance output to the ability of employees to performing maintenance correctly. For example, at least one respondent from each firm directly linked the lowness of the maintenance output to the reliance of many workers on experience alone when performing maintenance. Three respondents from factories A, B and D went further and connected the low level of maintenance to the absence of sufficient qualified staff and the unfamiliarity of some workers with maintenance and its practices. This originally resulted from their not complying with employment standards. Proper training is needed to raise the efficiency of shop floor workers in carrying out their maintenance tasks. This is what the maintenance

manager and general supervisor of production in factory B affirmed, in the belief that this resulted from the lack of interest among top management in supporting the employees. This was endorsed by four participants, one from each plant, who acknowledged that a good number of employees are unwilling to perform the assigned tasks as they should. The absence of motivation results from the lack of senior management interest in providing such facilities as commensurate rewards and salaries.

The views of the maintenance managers in firms A and D and the general supervisor of maintenance in factory B were different. They believed that the lack of spare parts and the delay in procuring them are typical of the weak performance of management. In some cases, it is also represented by the stoppage of one or more of the production lines.

“We suffer from the stoppage of production for hours and even days. The maintenance workers would have been able to finish maintenance work, in many cases, within one hour and avoid such breakdowns if the needed spare parts had been provided” HOD-A.

Theme 7: Management Performance

While some interviewees talked about the factors that might have significant influence on the success of maintenance, such as the efficiency level of the employees, many other participants could also recognise the impact of management practices on maintenance work. The vast majority of the respondents, 11 out of 12, were satisfied with the communication methods adopted by the top management as represented by the regular meetings controlled by senior management. The opinion of the general supervisor of maintenance in plant D was different. He claimed that no clear programme can be followed when the departments need to communicate with each other or, even worse, with senior management. He related this problem to the lack of clarity of the factory’ strategy overall. Although the high level of communication could be a good sign of management’s interest in improving the factory’s efficiency as a whole, two of the three interviewees from factories B and D, affirmed that a good number of employees are unwilling to perform their assigned tasks as required. These respondents related this matter to the inability of the top managements to provide employees with due rewards and bonuses. As a result, the efficiency of some workers is less than it should be and in turn lessens the firm’s chance of competing with others.

“We need to adopt a program through which we can create excellence among employees, each according to his effort. We notice that many of the active workers complain of not being distinguished them from others. There are some programmes which we cannot improve, but we do believe that they need to be given more attention as they have negative effects on the desire of workers to do their work as they should. For example, the bonuses and allowances programmes need to be improved” **MDM-D.**

Seven interviewees from the four firms, three each from A and B and one from D, were in agreement that training programmes require more support from top management. Some of them mentioned that the skills of many workers need to be improved to meet the maintenance requirements. Others stated that more spending on training courses was needed to avoid outsourcing to finish maintenance work and reduce unplanned breakdowns in the production lines. The maintenance managers of factories A and B and the production manager of factory C mentioned that the level of managerial performance is controlled by the complex policies of the state. The evidence of this, as some of them said, was that there was a continuous delay in providing the needed spare parts because of the long and complex procedures for ordering them.

6.5.2 Frequency Analysis

Table 6.81 and Figure 6.79 were developed to illustrate the impact of these themes on the practices of maintenance in the chosen factories. From the table, it can be observed that the maintenance currently in place has been affected mostly by *Employee Output*. Statements to this effect were made 78 times altogether in the interviews. For example, all the respondents in the factory B were in agreement that the skills of many workers need to be improved so they could perform the assigned tasks better. This was supported by the production manager of factory D who said that a good number of workers held irrelevant maintenance qualifications. The findings point to the fact that all the interviewees confirmed *Maintenance Output* as the second most important theme, repeating this 62 times. All the participants from factory C, in addition to the maintenance manager from factory A, confirmed that relying on experience alone has a direct negative impact on the success of maintenance, while the general supervisor of maintenance in firm A sees the inability of senior management to provide the needed spare parts without delay generally reduces the reliability of maintenance. *Maintenance Strategy Improvement* was cited 52 times during the interviews; this could be another factor which has major

consequences on the current practices of maintenance. The *Quality of Maintenance Strategy* and *Production lines Improvements* can play vital roles in the success of maintenance; these were cited 49 and 46 times, respectively. Clearly, however, *Management Performance* and *Maintenance Selection Procedures*, repeated 31, and 30 times respectively, are seen as less important if the number of citations is considered decisive.

Table 6.81: Comprehensive Frequency Analysis (Source: author).

Number	Theme	Frequency					Rank
		AT	BT	CT	DT	Total	
1	Employee Output	34	22	10	12	78	1
2	Production lines Improvements	13	13	11	9	46	5
3	Quality of Maintenance Strategy	16	13	12	15	49	4
4	Maintenance Strategy Improvement	16	17	12	8	53	3
5	Maintenance selection Procedures	9	10	4	7	30	7
6	Maintenance Output	20	14	19	9	62	2
7	Management Performance	14	4	8	5	31	6

AT Total Frequency in Factory A
 BT Total Frequency in Factory B
 CT Total Frequency in Factory C
 DT Total Frequency in Factory D

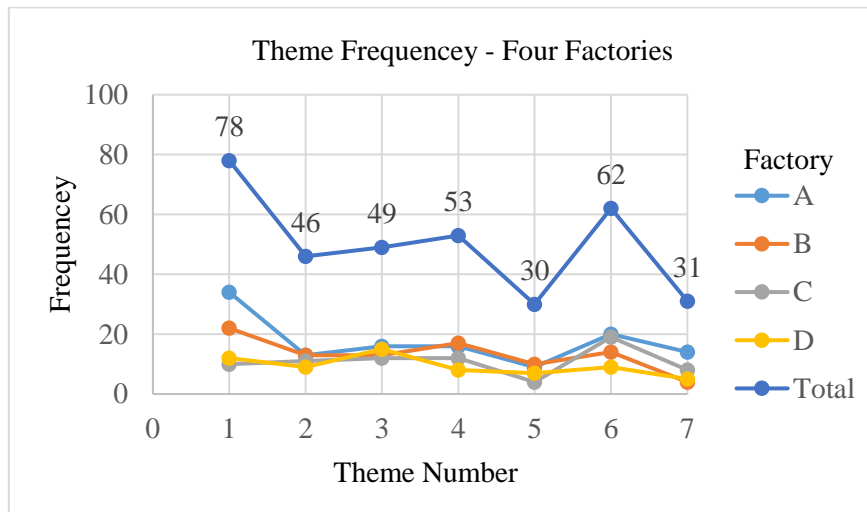


Figure 6.79: Comprehensive Frequency Analysis (Source: author).

Chapter Summary

This chapter focused on the findings that have emerged from the data collected by mixed methods. The survey questionnaire was adopted as the main approach followed by face-to-face semi-structured

interviews to cover any details that had been missed or could not be covered through the questionnaire. The survey questions were divided into three parts, namely, Characteristics of the Research Population, Maintenance Practices and Management Related Issues. This classification was made so that the findings would be easy to analyse and discuss, making the evaluation process more reliable. The interview results were presented using both the methods of within-case analysis and cross-case analysis. This approach meant that the findings of each case were presented separately before the results of the four cases were merged and presented as a whole, to reveal any similarity or difference among these findings. Some quotations were introduced to substantiate the discussion of the interview results. It was believed that the proper evaluation of the factors generated from the interview answers was essential to enhancing the credibility of the interpretation and analysis of the results. To this end a separate frequency analysis was made for each case study and for the set of four cases a set. This also, it was hope, would increase the chance of drawing valid conclusions about the research issues of the study. The findings are interpreted and discussed in detail in the next chapter.

CHAPTER 7: Analysis of the Key Findings

7.1 Introduction

The key findings of the collected data from the four case studies were presented in the preceding chapter. Their main aim was to draw a clear picture of these results through which a proper analysis and discussion could be made to fill the research gap which was identified in the literature review (see Chapter 1.5). Therefore, the analysis should give appropriate answers to the following research questions:

- 1- What maintenance strategy currently in place in the four cement factories?
- 2- What is the awareness level regarding maintenance, its practices, and its importance?
- 3- What are the barriers and difficulties affecting maintenance within the targeted plants?
- 4- What factors are likely to affect productivity from a maintenance perspective?
- 5- To what extent the level of adopted maintenance can be effected by the managerial performance?

To this end, this chapter focuses mainly on interpreting and discussion of the survey questionnaire findings, supplemented by analysis of interview material to clarify any points of confusion and provide additional explanation. In addition, data gathered from direct observations are also used to triangulate the data from the survey questionnaire. This analysis is supported by evidence from the literature review above.

The attempt here is to increase the understanding of the maintenance practices in the targeted cement factories; it presents the differences in the levels of maintenance practices among the case studies. It also focuses on the obstacles and problems which affect the success of maintenance in these firms. On this analysis, a conceptual model for implementing a suitable strategy will be developed. In this chapter the main factors are developed in parallel with the research questions. These factors are identified as follows:

Demographic information; this factor was generated to explore any maintenance staff related issues which might hinder their ability to do maintenance properly such as their age, their qualification level

and their experience in the work field. Therefore, this factor is related to the research questions two and three. The current maintenance practices which reflect the level of adopted maintenance and highlighted on strategies used when performing maintenance. This factor generated from the first research questions. The obstacles and barriers hinder the success of maintenance in the four factories under investigating which can be seen in many aspects. The conditions of the production components are considered one of these elements as good conditions of the production lines would make maintenance mission more efficiently. The surrounding environments of maintenance which can be represented, for example, in the availability of effective ventilation system. This can have a significant impact on workers efficiency and in turn on maintenance process. Therefore, this factor is more related to questions three and four of the research.

The fourth factor has been generated from the research question number five since the managerial performance plays a great role in the success of maintenance. The management interest in providing maintenance requirements such as spare parts can help in increasing the reliability of the adopted maintenance. Moreover, providing workers with some facilities such as bounces and incentives would make a big different through enhancing the motivation of those employees in performing maintenance as should. Table (7.1) illustrates the relationship between the research questions with regards to the generated factors to gain a thorough understanding of the current maintenance practices in the targeted cement factories and explore any obstacles or barriers that might have an impact on implementing of maintenance.

Table 7.1: The Relationship between the Research Questions with Regards to the Main Factors
(Source: author).

Factor	Research Question				
	1	2	3	4	5
Demographic information		√	√		
current maintenance practices	√				
The obstacles and barriers that may have an impact on maintenance			√	√	
the managerial performance					√

7.2 Quantitative Analysis

The questionnaire survey was conducted to elicit the views and perceptions of the shop floor staff including engineers, technicians and workers regarding maintenance and its practices in their factories. This analysis helps to increase the understanding of the efficiency level of the maintenance currently in place in the targeted cement factories. The data analysis was conducted using an Excel worksheet and the findings were primarily based on descriptive statistics. The analysed results of the questionnaire were used as input in the second section of the research conducting multiple-case studies in the four cement factories. The next section presents an analysis of the findings gathered from the survey questionnaire with a major focus on the following issues: *demographic information; current maintenance practices; the obstacles that may impact on maintenance; and the level of managerial performance with regard to maintenance.*

7.2.1 Demographic Information

According to findings in Chapter 3.2, the population statistics in Libya, which were last taken in 2010, estimate the proportion of women to men as 50% of a total of 6 million. In spite of this, 100% of the survey respondents were men. This finding was, of course, anticipated in a country of this kind. This result confirms the results of the literature review which indicated that the structure of the Libyan community is influenced by tribal laws. Under them, women may not do jobs which require direct contact or direct participation with men. All-Hawaat (2004, p.4) found in his research that the level of women's representation in the formal Libyan economy is very low. Moreover, the nature of the cement industry requires much physical strength which may not fit in with most women's physical and psychological makeup.

According to the data findings, the youngest participant was 24 years old, while the oldest was 59 years old. However, most of the participants, more than 80% in total, were aged between 21 and 39. These findings are in line with the result in Chapter 3.2 which concluded that persons in the age-range 24 to

55 dominate the structure of Libyan society. In the Libyan cement industry, this could also be a significant advantage; since maintenance staff should be physically fit enough to do maintenance work.

With regard the educational backgrounds of the respondents, it is clear that a total of 78 out of 112 respondents (nearly 70%) had been educated to diploma or secondary school levels or below. These levels could be a drawback to promotion if they had received no previous training in maintenance. These results also indicate that the low wages on offer may inhibit people who hold high qualifications, bachelors' or masters' degrees, for example, from joining cement manufacturing firms, which in turn means that the centralised government can influence the cement industry sector.

The findings from the survey reveal how some respondents acquired qualifications in the maintenance field to measure their ability to do maintenance work properly. The numbers of participants whose qualifications were irrelevant to the maintenance field and who are qualified in it by experience alone, added together, account for 66 respondents (58.9%). This percentage is high enough to indicate that the cement industry in Libya is, like its other industries, easy to enter. The main reason behind this, as noted above, is that the structure of Libyan society is influenced by tribal laws. The tribe usually supports its members in employment even when they are not qualified or not skilled. This result is consistent with the fact that these firms, like others, have far too few regulations and do not implement their rules for recruitment effectively. In other words, the tribal laws outweigh the plant's requirements regarding employment. This fact is borne out by the poor performance of the Libyan industrial sector.

The questionnaire results show that there is a good number of the staff who work as engineers (about 33%) and more than half of the respondents (61 out 112 in total) used to be technicians. If these staff members could undergo sufficient training, such high figures could indicate an increased chance of successful maintenance as well the possibility of making improvements in the current level of performance. In other words, the positions of those participants should be supported by training in relevant areas to enhance their skills and reach the minimum efficiency required. However, this analysis is consistent with the results of the educational levels, which showed that a considerable number of respondents are well educated (to diploma or first degree level).

To identify the respondents' experience and the general stability of their work background, they were asked to indicate the length of time that they had been working in this factory. In general the experience of the vast majority of respondents was between 5 and 30 years. This gives clear evidence of how loyal workers were to their factories.

This result is inconsistent with the view of the GCP (2003, p.32) cited in Grifa (2006, p. 177) that due to instability in the Libyan industrial sector and its operating environment, cement manufacturers had lost a great many of their most qualified and experienced employees. However, in this aspect, it can be said that a longer period of continued employment means more experience and more exposure to the same work environment. This is what Huber et al., (1993) confirmed: the employees with longer full-time work experience will be more familiar with the production systems and the work environment and will be ready to participate in site improvement. As clarified earlier, most of the staff seem to have had sufficient experience. But experience alone may be worthless if they are unqualified or untrained, since knowledge is essential. In other words, experience is needed to support knowledge, but not vice versa.

The survey findings have shown that, the shop floor staff have a significant amount of experience in maintenance exceeding 30 years for about 31 of respondents. However, about 94.6 percent of the staff had a work experience of between 21 years and 30 years. Comparing these results with the years of experience in the factory reveals that a good number of respondents have approximately the same length of experience. This outcome means that the respondents' experience is mainly associated with maintenance in the cement factories. At the same time such a high percentage indicates the heavy reliance on experience when carrying out maintenance. This is what some of the participants confirmed during one of the informal discussions with them: they complained that no strategy for undertaking maintenance is applied. Others added that many employees are not specialists in maintenance and simply proceed according to experience and that this results in the frequent suspension of maintenance work and thus sometimes to the stoppage of production systems. This analysis supports the findings of the literature review which say that the cement industry in Libya lacks qualified and trained maintenance staff. The same can be seen from other evidence, such as the maintenance backlog and the unplanned

stops in production. However, if the staff was qualified and well trained their experience in a certain field could give employers a great opportunity to raise the quality of maintenance and make improvements.

7.2.2 Current Maintenance Practices

This part analyses the factors that may influence the level of maintenance adopted in the cement factories. These factories include their assessment of the level and types of maintenance being practised and the workers' understanding of the technical issues which might affect both maintenance output and production processes, together with their awareness regarding maintenance strategies, its applications and relevant issues.

Descriptive statistics were used to convey the fundamental attributes of the data and to identify any differences in the factories' views on maintenance and its practices.

Although nearly 95% of the respondents can easily deal with the devices and machine components of the production systems in their factories, a high proportion (more than 65%) of them are unable to run or maintain the more sophisticated devices. This is consistent with the fact that most of the shop floor staff rely on experience to operate and maintain the production lines and their components. The inability of those respondents to tackle advanced technologies such as computerised machinery means that the level of its maintenance outcomes would be inadequate and unreliable. In addition, the response of the staff to identify its failures is poor.

While most of the respondents acknowledged the existence of manuals for operating and maintain advanced machinery, it is clear that they cannot benefit from them. This result underlines the inability of many of them to deal with complex machines. Only one explanation for this can be offered: most Libyan industrial organisations cannot impose their own employment standards on staff because the centralised government has right to draft workers where it chooses.

The survey captured information on whether the respondents would recognise any technical problems that resulted in a breakdown of the production systems during the production process. All the

respondents agreed they could recall one or more of production lines in their factories stopping. This non-production time is mostly due to electrical or mechanical faults. It should be noted that more than 62 percent of the participants predicted such breakdowns as likely to occur in the production systems in their factories twice per month or more. This very high percentage reflects either the low efficiency of the employees in doing maintenance work or the apparent failure of the managerial staff to understand the importance of supporting programmes of maintenance improvement. Of course, the continuous running of operations and continued existence of these firms is likely to be at risk without such programmes. These results are supported in the survey findings itself; nearly 70 percent of the respondents acknowledged that they had difficulty in diagnosing failures in the production systems. The evidence given by Hokoma et al. (2008) reveals that technical expertise and trained personnel are needed to increase the overall efficiency of Libyan cement factories. Essmui et al. (2013) adds that top managements in the Libyan industrial sector is, in general, are unable to fulfil the conditions for running production systems. The participants also supported the above analysis; more than 91% of them confessed that their factories outsourced their maintenance work. This finding gives clear evidence of the low efficiency of the respondents to do what is assigned to them.

In relation to the occasions when maintenance is instigated, the findings supply detailed information about the different results from the four factories. In the view of more than 36 percent of the participants in factory A equipment is maintained according to a specific and known schedule. In contrast, 22 out of the 24 respondents in factory D affirmed that no scheduled maintenance was in place there. However, speaking generally, most of the respondents in the four factories agreed that maintenance work is done only when a machine or device fails or breaks down. One can conclude from this that the absence of planned maintenance could be linked to both the lack of staff awareness and management's failure to take any interest in improving the current state of maintenance.

Regarding the availability of devices to monitor the production line components, it is clear that monitoring systems are used in the cement factories; nearly 94% of the respondents confirmed that they could control the production machines and devices by means of the available monitoring systems. This

high percentage was a surprise, contradicting the earlier analysis which said that many factories faced unplanned breakdowns in their lines more often than twice a month. These systems might have been old and not calibrated for a long time. Again, the respondent's answers contradicted this. 88.3% (88 of the 105 respondent who acknowledged the existence of monitoring systems) emphasised the availability of programmes to calibrate the monitoring system. Graisa's study (2011) of the Libyan cement industry, however, found a lack of calibration in the monitoring systems. This absence can be seen in the errors of diagnosis in the warning indicators, which would in turn badly affect productivity.

One of the key findings generated from the questionnaire answers was that the reactive strategy played the greatest role in implementing maintenance work in the cement factories. The evidence came from 25 out of 32 respondents (78.1%), who had already mentioned that one or more strategy is applied in their factories. These participants affirmed that this approach is the most widespread in their factories. However, the 32 participants were offered a range of choices to specify the basis on which the strategy was chosen. As expected, more than half of them, 14 respondents (56%) used their experience in selecting maintenance. This figure supported the earlier analysis which says that the awareness of many of the employees with regard to maintenance needs to be increased. Most of the other participants, 76 respondents supposed that the theories of 'run to failure' or 'if there is a problem, fix it' are the best known approaches to maintenance. These approaches were extracted in informal discussions with many of them when conducting the survey. The underlying issue here is that those people could not recognise that these theories are other names for a 'reactive strategy'. In this sense, it seems that all firms of this kind have either a wide gap in understanding the importance of maintenance and its practices, or have very limited management support. Graisa & Al-Habaibeh (2010) and Ogajl & Probert (2006) claimed that the knowledge of maintenance staff needs to be as high as possible to ensure the application of the proper maintenance. Tourki (2010) mentions that the senior management in Libya's cement industry does not give sufficient attention to maintenance improvement programmes. Thus, the output of maintenance usually cannot meet its minimum objectives. Moreover, these facts are confirmed through the low efficiency of the maintenance applied. More than half the respondents (56.3 %) acknowledged that the maintenance level in their departments needs to be improved to meet the minimum conditions

for reliably operating the production lines. This analysis means that the conditions that would ensure successful of maintenance should be realised. This task can be achieved by increasing the staff skills and knowledge which in turn requires appropriate training programmes. Here it can be concluded that it is crucial for all the targeted cement factories to work seriously on introducing an appropriate strategy.

The aim of this research is to introduce a modern strategy through which the level of maintenance efficiency can be increased to achieve the maintenance objectives. One of these solutions for this may be RCM. Taking the simple definition of RCM, which was given to the participants when handing out copies of the survey questionnaire, it was surprising to find that a good many of them (33 out of 112) knew something of it, perhaps under another name. However, it seems that there is an urgent need in the four factories to look for ways of raising the efficiency of maintenance. This could be done by providing the staff with appropriate training programmes for increasing their knowledge. This possibility derives from the belief of 91 respondents out of 112 that the reliability of the production lines could be increased by introducing suitable strategies of maintenance. This high percentage gives an encouraging sign of the motivation of shop floor staff to engage in such programmes. Although the lack of RCM knowledge among the participants is extreme, seven of them, from factories A, B and C, affirmed that there were attempts to implement this modern strategy in their factories.

7.2.3 The barriers and obstacles that may have an impact on maintenance

The volume of information gained by the team about the machines and devices they were about to fix is one of the key factors through which the team's efficiency level can be measured. This measurement is needed, since the ability of the shop floor workers has a direct impact on maintenance outputs which in turn leads to deteriorating reliability in the production lines. This is why the knowledge of 49 respondents (34.8%) should be improved to make them more familiar with the specifications, the operating methods and the purpose of the production systems and their components. The lack of it reflects either a lack of proper training offered by senior management or a lack of staff qualified in this field of work, which again results from not being able to apply appropriate standards of employment. Agnaia (1997) states that the Libyan community including its government members is mostly bound by

tribal laws and deepened his argument by acknowledging that tribal support is constantly needed in everyday life, for instance, in getting a job or enhancing one's position at work, regardless of the qualifications or experience required. The other point to make here is that almost 70% of the respondents said that they knew of some maintenance strategies. This result is somewhat inconsistent with the above analysis, since many respondents had previously admitted that their awareness of the equipment that they were about to fix was limited, possibly linked to the knowledge level of maintenance strategies. The respondents who thought they had a sound knowledge of maintenance strategies were asked to identify some strategies. Unfortunately, the results were unlike what was expected – only 11 of them could identify more than one strategy for maintenance. In addition, about 39 of these 78 respondents recognised only reactive strategy, which is considered a very traditional approach. This number included five respondents who stated that they knew other approaches to maintenance. In informal discussion some of them identified 'run' to failure' as an approach, not knowing that this is simply another name for 'reactive strategy'. That the vast majority of the respondents, including those who said that they already knew some strategies of maintenance, had a strong desire to improve their knowledge of maintenance strategies gives cause for optimism and would increase the possibility of improving their skills.

It was important to extract the extent of the respondents' ability to label the strategy used, if any, when undertaking maintenance. This is because the level of maintenance adopted usually reflects the capacity of the respondents to address the problems that might hinder the success of maintenance. In addition, it is important to determine the extent of senior management's interest in supporting the maintenance activities in the four targeted factories. However, the results show that only 32 respondents out of 112 could recognise at least one maintenance principle in their factory, while four more were not sure if their firms applied any strategy at all in maintaining the machines or devices. This judgement is already confirmed in the literature review, which has been found that no maintenance strategies at all were applied in the cement factories. The findings imply that factory C favours the adoption of one or more of maintenance strategies, as stated by 11 out of its 27 respondents (40.74%). This percentage is high compared with the other firms' results: 23.3%, 25.8% and 25% for plants A, B and D respectively.

From this analysis, it is clear that the maintenance awareness level of the shop floor workers is very low. Therefore, more attention to increasing staff knowledge and skills is urgently needed. This task should be done along with developing new programmes for maintenance strategies that try to precisely identify any obstacles that might be encountered in the implementation of proper maintenance strategy. The participants in this survey were given again the opportunity to discuss, from their perspective, what factors would be likely to have a significant impact on adopting an appropriate strategy for maintenance. It was found from the survey results that there is a significant deficiency in the managers' performance. Evidence was given by about 60 respondents who believed that the top management in their factory had no plan to support a programme for improving the current maintenance that would help the maintenance staff to work better. This lack was likely to affect staff motivation and lower their performance level. Some of the other respondents emphasised that senior management should provide some facilities, such as financial support, to increase the chance of successful maintenance. Indeed this fund could be spent in several ways; for example, to encourage staff motivation by raising their salaries or by developing maintenance programmes. Only six respondents believed that the maintenance work should only be done when needed, in the belief that there was no need for maintenance strategies. In other words, a machine or a device should undergo to maintenance work unless there was a problem or breakdown. This analysis gives a clear idea of how important it is for staff skills to be at the highest possible level to ensure the minimum requirements of maintenance are reached.

The initial results of the survey questionnaire suggest that the low level of workers' performance is not the only factor that has a direct impact on maintenance quality. The respondents believed that there are other factors which could have a dramatic effect on the success of maintenance. Of 112 respondents, 59 (52.7%) saw that the level of management support plays a major role in helping the maintenance staff to do their work better. This can be seen in management's attitude to providing such facilities as proper training courses. Elmagri, (2013) and Hokoma et al., (2008) explained that the low productivity in the cement factories results from poor maintenance which in turn is due to the inability of top management to employ technical experts and trained personnel as basic requirements . The technical problems could be another obstacle that may impede the success of maintenance work. These problems

are mostly indicative of the poor condition of the production line components. Many of the respondents, as illustrated earlier in this section, contended that the production in their firms stopped twice or more per month. Originally, these breakdowns resulted from the poor condition of some of the production lines, regardless of the level of maintenance. This analysis means that not even a minimum output of maintenance work can be ensured owing to the situation of the production line components. In other words, maintenance alone cannot bring a machine or a device back to the required level of efficiency. Indeed, the maintenance output is directly affected by the condition of the production line components. This analysis is consistent with the literature review findings, which state that the production systems must be highly reliable to increase the chances of implementing proper maintenance.

A great number of the research participants (78 out of 112 in total) find the level of their awareness and understanding of maintenance importance is sufficient. This finding was unexpected, given that the qualifications of a good number of respondents were unrelated to the maintenance field and many others could not identify any strategies of maintenance. It is believed that the knowledge of the maintenance staff could help in choosing a suitable form of maintenance. However, this finding is different from the research outcomes of Graisa & Al-Habaibeh (2010), which state that training courses are needed to make all workers carrying out maintenance should be more aware of its importance and its strategies.

With regard to the level of management support regarding maintenance and its practices, the respondents were given the opportunity to specify whether, in their opinion, their management gave sufficient attention to maintenance programmes. More than 60 percent of the respondents confirmed that their factory had no maintenance plans. There is an undoubted deficiency in introducing maintenance plans because the reactive strategy, which is very traditional, is mostly adopted in these firms although it cannot meet basic requirements, especially in large plants such as cement factories. From this, one can conclude that the maintenance staff should create suitable programmes for maintenance. This needs to be done along with providing the required facilities to ease the introduction of these plans. Through planning in advance the efficiency of maintenance could be increased, thus ensuring the reliability of production lines. This result agrees with Shafeek (2012) who stipulates that

planned maintenance is essential to ensure continuous productivity in the cement industry. It was not surprising to find from the survey results that the vast majority of respondents believed that improving maintenance would have a significant positive impact on the reliability of production lines in their factory. It would reduce the number of unplanned stoppages in production.

The survey findings show that, as more than 63 % of respondents are aware, there is a shortage in the availability of maintenance tools. This is possibly due to poor communication between maintenance staff and the top managers or to the very limited response from senior management asked to provide the needed tools. This analysis suggests that technical reports about maintenance along with scheduled meetings between top management and maintenance and production staff would help to bring everyone up to date with all maintenance related issues. However, it is clear that, as admitted by most of the respondents, the available tools are usually kept in a safe clean place. This is considered a good indicator of the desire of the staff to complete their assigned tasks as they should. If so, then training courses would be effective in improving the skills of such employees. The above findings are confirmed by nearly 85% of the surveyed staff, who affirmed that they could easily reach maintenance tools when needed.

The findings clarified that all the firms have suffered from an inability to complete maintenance on time, pointing to three possible scenarios. The first one says that insufficient attention to maintenance is paid by top administration, who should ensure that all the required facilities should be available. This parallels very closely the previous analysis which emphasises a lack of management interest in supporting maintenance. At the same time, it is highly likely that the skills of staff need to be improved to meet the basic requirements of maintenance, for instance by raising their knowledge and providing them with suitable training courses in maintenance and its practices. This factor is discussed several times in the literature review. The third scenario, which is also likely to exist, is that both scenarios together could affect the process of maintenance from first to last. However, since the second probably has the greatest influence on cement plants, it was mandatory to get the views of the respondents regarding the availability of sufficient skilled staff on their shop floor. The purpose of this is to avoid

any unfair bias towards one of the above suggestions and to gain deeper knowledge of the problem. The findings suggest that more than half of the respondents would advise employing more workers to help to doing the maintenance work properly and promptly. Although some of the respondents find the number of workers on the shop floor (including engineers, technicians and workers) sufficient, only 50 percent assessed their work as efficient. Essmui et al. (2013) and Hokoma et al. (2008) agreed with the third scenario and stated that the huge gap in maintenance awareness among both administrators and employees is the biggest obstacle, causing e maintenance accumulation in many Libyan cement plants.

7.2.4 The level of managerial performance with regard to maintenance

There was general harmony amongst most respondents about the scarcity of positive attitudes in the top management to supporting maintenance and related issues. Here it should be mentioned that a few respondents thought that the top management support was sufficient. This group may be in a social position to receive special support from their manager. This analysis suggests that a focus on maintenance should be a priority for the factories, because the required efficiency of the production lines to ensure the continuity of productivity can be achieved only through reliable maintenance. However, a lack of senior management interest would be sure to lead to reduced levels of maintenance output. The survey finding gave evidence of the previous analysis; more than 70% of the respondents experienced difficulty in communicating with their top managers. This makes the senior management insufficiently awareness of the problems encountered by maintenance staff in doing their jobs. Despite the poor relations between managers and other staff, the shop floor workers unite firmly with one another, as the respondents' answers testify. This unity and need for support from the top management together imply the ideal conditions for carrying out maintenance work properly.

The lack of documentation mentioned by 65 respondents is further evidence of not applying proper standards of maintenance in the four cement firms under investigation. It is believed that the failure to record maintenance activities would make future maintenance difficult, because information on what has been done previously is very important for countering problems that have accrued since then and helping to make critical decisions. In addition, the improvement process needs full details about the

history of the production line components. However, the failure to record maintenance activities may be ascribed to the unskilled staff, who had too little knowledge of the importance of documentation. The vast majority of those participants who admitted the existence of documentation confirmed that maintenance activities are recorded manually. One can conclude that the top management seems uninterested in engaging in improvement programmes which clarify the causes of weakness in performance. In this regard, the shop floor staff cannot adjust the level of maintenance implemented for the same reason.

The top managers should cooperate more with their employees. For example, they should allow the workers to participate in the decision-making process, given that these employees are more familiar with the production lines. Therefore, their opinions regarding maintenance are greatly needed. Moreover, not listening to them de-motivates the staff, who may feel that they work in dictatorship.. According to Graisa (2011), the decision-making process belongs only to the managers in all Libyan organizations. Hence, the senior management pays no attention to what the employees think. This gives a good reason for the level of maintenance output to be very low, with direct negative impact on productivity.

There was general agreement amongst the respondents (73 agreed and 25 strongly agreed) on improving maintenance through a re-distribution of the maintenance tasks. From this finding, one deduces that the respondents are motivated psychologically to engage in improvements processes. This may be due to the spirit of perseverance which is generated by the geographical character of Libya. The above analysis suggests that sufficient support from the top management, could give a great opportunity to get full benefit from this motivation. The first step that can be taken in this regard is that the senior management should set up each factory's objectives and make them clear to its employees. Thereby the productivity requirements of the factory could be rearranged according to their importance. This in turn would increase the chance of finishing tasks more easily and quickly. Such an initiative could start by avoiding any special attention to certain workers merely in support of tribal or regional interests. If this step is ignored, the enthusiasm of the employees in these factories will decline. The evidence came from more

than 70% of the respondents who affirmed that their senior management does not treat them according to the effort they put in to completing the assigned tasks. Further to what was presented above regarding the readiness of employees to contribute to the improvement process, the vast majority of those respondents confirmed that the production lines could operate more efficiently if maintenance work were applied using suitable strategies. This acknowledgement also reflects the familiarity of the staff with the production line components in their firms.

From the survey findings it is easy to observe that despite the respondents' acknowledgements of the existence of many problems hindering them from perform maintenance as required, a good number of them are ready to attend training courses either internally or externally. The only conclusion to draw here is that the background of those employees is not related to their present work. Therefore, even sensitive training programmes would be not as effective as they should be. This lack is surely related to the inability to adopt or follow employment standards. Returning to the findings, it is obvious that top management could not provide more than half of the shop floor staff with adequate training to improve their skills and increase their knowledge. This is what nearly 100% of the staff mentioned, even though they hoped to increase their own skills through proper training courses. This presents training as a very critical aspect which must be focused on when making any improvement. Graisa & Al-Habaibeh (2010) believe that the lack of adequate training programmes in maintenance techniques is one of the biggest barriers to the proper application of maintenance.

The desire of employees to do the assigned tasks could be affected by some financial aspects.

In the four cement factories, it seems that most of the shop floor staff (79 respondents out of 112) were unsatisfied with the level of the wages offered by their firms. In addition, it is very unlikely that many of the staff members receive a performance-related incentive. This matter greatly affects the ability of workers to do their job as they should, making the reliability level of maintenance work sub-standard. But when more than half of respondents must take another job to raise their incomes it is inevitable. . The others who do not take on extra work may share their lives with others such as parents or spouses. It is believed that this shortage in management encouragement stemmed from the political system in

Libya which give managers no absolute power to use their organization's income. According to most participants, it seems that the top management did not pay enough attention to its employees. This resulted in the existence of frustrated workers. As a result, their motivation would be less, which in turn leads to a loss of capacity to do the maintenance work properly. The results suggested that the management of the four factories should look deeply at other ways to improve the employees' motivation and raise their morale, by, for example, providing adequate care for staff involved in a work accident, giving certificates of appreciation to people who worked hard and organising, for the first time, recreational programmes and trips. Here it cannot be ignored that some of those who get such certificates may be receiving special support from management. This was why more than 63% of respondents were unhappy with their current job and strongly desired to work somewhere else.

Adopting security and safety standards is essential. Imposing such standards usually reflects the interest of top management in provide employees with an appropriate work environment. In this sensitive aspect, the survey results confirmed that safety and security standards are widely adopted in the four cement factories. This is a very good sign of senior management's interest in taking full care of their employees as well as protecting the environment. The point that should be mentioned here is that the vast majority of the respondents (97 out of 112) do not comply with these standards. This very high percentage was surprising; it would increase the level of risk at work both for workers and the world around them. One possible conclusion to draw is that the level of knowledge with regard to issues of security and safety, as in so many aspects, is low. This emphasises the need for comprehensive training to fill the gap.

According to 94 of the respondents, a standby system is available to deal with emergencies such as a fire. Indeed, every plant must have a standby emergency system. Despite the availability of this system in all the factories under investigation, a good number of shop floor staff were surprisingly unable to attend any training courses on safety and security. In this regard, there is clearly to little measurement and control of the level of pollution emitted from chimneys. Not giving adequate attention to this important matter is a serious matter because pollution has a negative impact on both the health of people

in the nearby farms and the surroundings themselves. This lack is surely due to the lack of management's responsibility for reducing this pollution.

7.3 Qualitative analysis

To explore the maintenance related issues of the present research further, the views of maintenance and production managers were seen as very important for getting more in-depth information about maintenance and its practices in the four cement factories. In addition, they would help to fill any gaps resulting from the survey analysis and in turn help the development of the conceptual model.

This mixed method research collected both quantitative and qualitative data. The last section of this chapter analysed the data from the questionnaire survey. This section, analysis of the interviews focuses on analysing the interview findings.

As the main aim of this research is to develop a model for implementing a suitable strategy for maintenance in the four Libyan cement factories. Therefore, the seven recognised main themes have been categorised to suit the same factors that have been named in quantitative analysis section which initially generated from the research questions as a follow: demographic information; current maintenance practices; the barriers that may have an impact on maintenance; and the level of managerial performance with regard to maintenance. The main purpose for this was to unify the methods of analysis of both quantitative and qualitative data so to make the discussion of the research results more realistic and capable of being dealt with when developing the model. Table 7.2 shows the relationship between the research questions with regards to the developed themes.

Table 7.2: the Relationship between the Research Questions With Regards to the Developed Themes (Source: author).

Theme	Research Question				
	1	2	3	4	5
Employee Output		√	√		
Production lines Improvements				√	
Quality of Maintenance Strategy	√		√		
Maintenance Strategy Improvement				√	
Maintenance Selection Procedures		√			√
Maintenance Output,	√				
Management Performance			√		√

7.3.1 Demographic Information

From the interview findings it is clear that most of the respondents held a bachelor's degree. This, in addition to their familiarity with administrative issues related to maintenance, meant that the level of awareness of these respondents with regard to maintenance and its practices would be high. Such an inference is confirmed by the long experience of most of the interviewees either in the field of maintenance or in holding their current position, which more than half of them reached more than 20 years ago. This all suggests that the answers given by the respondents were trustworthy and therefore they can be confidently used as a primary source of information.

7.3.2 Case A analysis

7.3.2.1 Current Maintenance Practices

All the respondents agreed that reactive approach is the strategy used for implementing maintenance work. In his research on some Libyan cement factories, Graisa (2011) found that the only method used at factory level was "if there is a problem, fix it". This traditional strategy resulted in many interruptions to production because reactive maintenance mainly consists in fixing a failure after it has occurred or repairing a machine after a breakdown.

"We still apply very traditional strategy called reactive maintenance or unplanned maintenance. This strategy is adopting on the theory of fix a machine or a device after stop or breakdown. Therefore, the costs and time of such strategy can't be controlled" **MDM-A.**

Al-Muhaisen & Santarisi (2002). Ogajl & Probert (2006) stated that the Libyan cement industry should focus on introducing planned strategies, instead of taking the reactive approach which usually gives unreliable output. The workers are unable to introduce any other strategy for maintenance because they are not familiar with the importance of maintenance strategies as a result of their unfamiliarity with maintenance as a concept and its practices. This incapacity stems from many of them having qualifications unrelated to maintenance. The interviewees believed that the efficiency of the workers could play a significant role in the success of maintenance. But the efficiency performance level of

some production lines in practice is very low. Therefore, conditions in the production lines make it impossible to improve maintenance.

7.3.2.2 The barriers and obstacles that may have an impact on maintenance

According to the findings from factory A, a significant gap can be seen between the level of the shop floor staff skills and the maintenance output. This emerges from the interviewees' account of the efficiency level of many workers as among the greatest obstacles to the success of maintenance and often results in sudden breakdowns in one or more of the production lines. Of course, the employees should have enough knowledge of their work to carry out their assigned tasks as required. Although all the respondents claimed that training is widely available for almost every member of the shop floor staff, the efficiency levels of many workers are still below the minimum. This weakness clearly implies that the training courses offered by top management are not sufficient. In other words, such programmes should be pre-planned to raise staff skills. However, senior management are not interested in supporting any new improvement projects (Tourki (2010)). Factory A has no plan to improve its current maintenance, relying, as most of the shop floor staff do, on their experience to carry out maintenance tasks. This firm sometimes outsources maintenance which means that maintenance costs even more. Here it can be concluded that intensive training is needed to raise the efficiency of the workers. Moreover, the effectiveness of the production lines would increase if the success of maintenance output could be guaranteed. The negative influence of social culture on the employees' behaviour is another barrier to the success of maintenance. Top management is too weak to discipline the shop floor workers, who chat with others, use their personal phones or go out shopping or to visit friends in working hours. Agnaia (1997) found that family ties and personal relationships have a significant impact on the behaviour of both managers and workers, visible in their non-compliance with work requirements, such as coming to work late and spending time at work on unrelated pursuits.

7.3.2.3 The level of managerial performance with regard maintenance

The firm was not interested in supporting any plans to improve the current level of maintenance. This is obvious from the lack of maintenance experts who are needed when improvement is sought. There is

also a great shortage of spare parts, but these should always be to hand to avoid delays in maintenance and their consequences. The management adopts such complex regulations when ordering spare parts that their arrival is always delayed. Non-compliance with employment standards is further evidence of the weakness of top management. Although the respondents acknowledged the availability of these standards senior management has no absolute right to choose employees. Unqualified workers lower the quality of maintenance, with inevitable results on the ability of firm to compete with others. Many of the shop floor workers are unmotivated. They complain regularly that they work hard for low wages. Top management has no clear plan to enhancing the desire of its workers to improve the maintenance in their plant. Unfair treatment of employees is one of the biggest obstacles to the success of maintenance, because of its adverse effect on employees' performance in this industry (Elmagri, 2013). But the results also showed that the level of communication between the departments of maintenance and production is sufficient. They make great efforts to respond to each other when required. This may indicate increased possibilities of improvement.

7.3.3 Case B analysis

7.3.3.1 Current Maintenance Practices

In this factory, it is evident that most of the shop floor staff rely on experience alone in maintenance tasks. This means that no strategy at all is in place in this firm. The respondents mentioned that additional costs are usually incurred to finish maintenance on time by the factory's outsourcing the work. The general supervisor of production stated that preventive maintenance is sometimes applied in accordance with the firm's annual productivity plan. This means that a plan to adopt a particular strategy was made at some point. All the same, this respondent contradicted himself by agreeing with other interviewees who said that the firm had no procedures to select strategies for maintenance. The most accurate view among the interview findings is that the vast majority of workers are unable to deal with maintenance issues as they should. Therefore, experts in the field of maintenance and its practices are needed to make improvements in the current maintenance practices. Cassady et al. (2001) states that only successful industrial institutes can recognise that the presence of effective maintenance programs

is essential for successful maintenance. Workers should undergo training because many of them have skills of maintenance which are inadequate. According to the interview findings in this plants, maintenance and its applications all too evidently need to be improved. This is the way through to ensure the success of maintenance, underlying reliable production lines. One of the interviewees explained that the plant faces frequently breakdowns in the production processes because of the absence of plans for maintenance which led to the general dependence on fixing machine only after faults or breakdown. The Executive Director of one of the Libyan cement plants, confirmed in an interview that introducing an adequate strategy for maintenance is urgently needed to achieve satisfactory levels of production (World Report, 2004).

7.3.3.2 The barriers affecting maintenance

The low efficiency of production systems is the greatest obstacle to the competitiveness of this factory in the cement industry. Therefore, it might be said that the production lines should be improved before introducing a strategy for maintenance. On the contrary, other findings show that the low efficiency of the production systems is directly linked to the inability of maintenance staff to adopt a suitable strategy for ensuring successful maintenance can be ensured. This would avoid any damage or harm to the production line components. In other words, proper maintenance would maintain the reliability of the systems. The interview results show that training is needed for almost all the staff because the maintenance output mainly depends on the efficiency of these employees. The Libyan cement factories are incapable of implementing proper maintenance due to the lack of adequate training programmes in maintenance techniques (Graisa & Al-Habaibeh, 2010). Given this urgent need for training, the interview results illustrate that evaluating the current level of performance efficiencies of maintenance staff should be the priority of the top management. As soon as this assessment is complete, proper training can be provided. The results also point to the low motivation of many members of the shop floor staff. Therefore, the training programmes will be ineffective unless the sufficient attention is given to these workers by the top management. For example, the rewards system need to be improved and bonuses should be paid according to a worker's effort to carry out his tasks as required. The maintenance

workers should not have to face delays in getting spare parts which often delay their work, especially because some faults lead to interrupted production if quick action is not taken.

“The spare parts are the most needed in this time. Many of these parts are locally available, but the problem lies in our inability to provide these parts in a timely manner due to complicated administrative procedures” MDM-B.

In addition, failure to respond quickly to breakdowns may lead to further serious problems in production. This is why spare parts should always be available; otherwise such delays are serious enough on their own to rule out improvements in maintenance; ordering spare parts should be clear and simple.

7.3.3.3 The level of managerial performance with regard to maintenance

Good management should be aware that occasional system upgrades are essential. The production line components should undergo improvement so they can meet the new production requirements as well as allowing more efficient maintenance procedures. In this plant, it is clear that the senior management has no desire to make any improvements to the production lines and would not even be interested in supporting its staff if they introduced such programmes. This is clear from the low efficiency of some production lines and the inability of the maintenance staff to work as they should. Disharmony between senior management and the employees is a foremost reason for the failures of maintenance (Hayes & Pisano, 1996). Therefore, the management should benefit from the high level of communication that the maintenance staff have with other departments to share ideas about improving the performance of the whole factory. The employees' ideas can be presented to specialised institutes to improve further and adapt for use. All the respondents agreed that the top management should look for ways to approach higher authorities more easily. This analysis reflects the inability of the senior administration to manage the factory efficiently.

7.3.4 Case C analysis

7.3.4.1 Current Maintenance Practices

Firm C reveals a remarkable number of unplanned failures in the production process. According to the results from the interviews, this is typically due to the ineffectiveness of the strategy followed in

carrying out maintenance. All respondents agreed that reactive strategy is the approach most frequently adopted there. The managers believed that an effective strategy should be introduced. Their reason was that stoppages in the production process cannot be accepted because these breakdowns may have a significant negative impact on some of the production line components. In other words, serious damage to some components of the production systems, such as the main kiln, are very likely to occur if they are stopped in mid-production. It is very costly and takes a considerable time to bring such devices back to working order. The interview results show that the maintenance department has to outsource work in the end maintenance, because most maintenance workers cannot easily identify the cause of a failure. The manager of the raw materials department repeated that adopting reactive maintenance often causes maintenance work to accumulate. Although the managers of the maintenance and raw materials department acknowledged that preventive maintenance is sometimes adopted, the production management confirmed that there are no pre-plans according to which maintenance can be successfully undertaken. This inconsistency of views among the interviewees is evidence of the absence of a strategy for undertaking maintenance. None of the respondents have a clear perception of what is going on in this plant regarding current maintenance practices. Low maintenance output can be seen, as the results illustrate, in the low reliability of the production lines which in turn causes fluctuating production. From the above analysis, it can be concluded that training programmes are needed to fill the knowledge gap resulting from the lack of maintenance related qualifications.

7.3.4.2 The barriers and obstacles that may have an impact on maintenance

Despite the availability of sufficient shop floor staff, engineers, technicians and technical assistants, the level of maintenance output is low. The main reason for this is the low efficiency of many staff. This corroborates the opinion that the maintenance staff has too little awareness of maintenance practices and their importance. Too few staff are qualified, while many of them hold irrelevant maintenance certificates. One of the managers acknowledged the absence of specialists in the maintenance field. A related obstacle was the absence of training programmes to combat this state of affairs; as in the previous case analysed, none of the respondents mentioned either the lack or the availability of training courses

in the factory. The interview results themselves confirmed the lack of training, which is borne out by the inability of many shop floor staff to deal with maintenance activities appropriately.

“Although the availability of many workers with good experiences in completion maintenance job, the training remains very important in giving an opportunity to an employee to improve his skills which in turn will increase chance of success of achieved work.” MRMD-C.

Along with the need to provide the current staff with sensitive training courses, it would better to introduce programmes for employment to avoid the presence of unskilled workers in the future. This strategy would help the shop floor staff to increase the overall efficiency of production lines, a necessary first step when the components are worn out or superseded. In contrast, the interview findings affirmed that the lack of sufficient funding to support such programmes is yet more evidence of the weakness of senior management.

7.3.4.3 The level of managerial performance with regard to maintenance

From the respondents' answers regarding management performance efficiency, it is clear that more attention should be given to the workers. Management should concentrate on finding how to encourage the shop floor staff to do their assigned tasks better, starting by rewarding employees according to their efforts. In addition, the salaries should meet the volume of work assigned and be competitive with wages in other industrial organisations. The top management is not keen on considering ways of adopting training programmes to attain the firm's goals. It can be concluded here that the overall policies of the top administration need to be updated before the firm can meet the new requirement to remain competitive market. This improvement could be addressed either through the issues discussed above or by re-considering other things such as the provision of spare parts. Even though senior management does not adequately communicate with the factory's departments, the relationship between these departments is considered cordial. Work orders, a kind of connection procedure, are adopted to contact other departments formally, according to the maintenance manager. These good relations are confirmed by the regular meetings of departmental staff, maintenance and production in particular. They give an opportunity to share information and knowledge with all other departments and even between the

workers in the same departments. The top management should capitalise on this unity by providing such facilities as electronic documentation.

7.3.5 Case D analysis

7.3.5.1 Current Maintenance Practices

Unlike the findings from the two previous factories, those in factory D suggest that preventive maintenance is its most popular approach. The respondents affirmed that this strategy is chosen because of the specific requirements of maintenance. In other words, the factory adopts this strategy because of its pre-planning. Its annual target of cement production is determined in advance in an annual productivity plan and the maintenance processes are scheduled accordingly. At first glance, this strategy seems impressive, since it is considered a scheduled approach. The interview results, however, show the contrary. The people who were responsible for implementing this strategy omitted some aspects which are essential to ensuring the success of maintenance. Among these missing aspects are the availability of sufficient skilled workers and the clarity of the factory's objectives. Alsellani, (2011) emphasises that the managers in these four cement plants are inexperienced but workers need to be trained, otherwise the application of maintenance inevitably fails. One of the respondents analysed the factory's failure differently; he stated that maintenance work was done only after a failure or breakdown of equipment. This analysis is more logical, since the other interviewees had already mentioned that their preventive strategy lacked some basic requirements. Again, these findings are supported by the fact that unplanned stoppages in production lines are likely to result from the low reliability of the components of these lines.

7.3.5.2 The obstacles that may impact on maintenance

Although, as has already been discussed above, preventive maintenance is seen as an advanced strategy, the reliability of production cannot be ensured. According to the interview results, it is obvious that specialists are needed to improve the efficiency of the maintenance in this plant. The results show that the knowledge of many of the shop floor staff regarding maintenance and its importance need to be improved.

“The problem that we are experiencing, as most public sector companies suffer from, is that there are a good number of non-active workers. Those workers are not able to perform maintenance as required due to their low educational level, as well as some of the others, held certificates unrelated to maintenance such as refrigeration or air conditioning diplomas” MDM-D.

Indeed, the high awareness among some workers of maintenance and its applications means that adopting more efficient strategies is a feasible ideal. Hokoma et al. (2008), in his research on the Libyan cement industry, acknowledged that a maintenance strategy that can be relied upon to ensure the success of maintenance is missing. This absence is due to an insufficient understanding of maintenance in terms of its requirements and conditions, together with the types of strategy that are needed to practise it to a high standard. The manager of the maintenance department mentioned that the problem with implementing an adequate approach for maintenance does not lie with the approach itself but with the lack of skilled staff who could apply suitable maintenance efficiently. The findings illustrated that a good number of shop floor members are unqualified in the maintenance field. It can be concluded from the above analysis that the aspect most needing to be focused on is plans to setting up training courses. This aims to increase the knowledge level of employees since staff skills should be at the top of the development programme agenda. All those interviewed agreed that maintenance should be carefully selected to ensure that the highest level of reliability in the production lines of the production process was reached. This could be measured only by a reduction in the number of unplanned stoppages in production time. According to the outcomes of interviews, the low reliability of the production lines, which can be seen in the inability of the plant to produce competitive amounts of cement, is the biggest obstacle to staying safely in the cement market.

7.3.5.3 The level of managerial performance with regard maintenance

The quality of maintenance can in many points be directly linked to the performance of management. In firm D, it is apparent that more attention should be given by the senior management to making the employees more motivated to finishing the assigned tasks as they should. Comparing the provided stipends with the volume of work achieved would do much to achieve this purpose. The benefit of this improvement would surely help to raise the current low quality of maintenance. Graisa & Al-Habaibeh (2010) notice big differences between the cement factories in Libya and in the UK in performance

efficiency. For example, the workers in Libyan firms have little of the competitive spirit and the ambition to develop their individual skills of workers in Britain plants. Graisa & Al-Habaibeh show that the lack of adequate training programmes, incentives and encouragement is the main reason for such differences. Moreover, the firm D's policies regarding ordering the needed spare parts needs to be updated to avoid any delay in providing these parts. One of the directors stated that the maintenance department needs to be given more autonomy; then it could directly make some of the necessary arrangements to ensure the flow of production. The decline in the productivity of this industry is mostly due to weaknesses in its management and financial performance (Alghadafi & Latif, 2010). A good rewards system can play a great role in increasing the quality of maintenance adopted. The workers focus efficiency would be improved if they were given a bonus for completing their jobs in every detail. This would not be easy to do, because the level of communication between the factory management and departments is low. To assess the workers' efforts, the senior management needs to contact its employees either directly or through their managers; then the volume of rewards could be assessed.

7.3.6 Cross-case studies comparison

In illustrating the level of maintenance and its practices that was undertaken by the cases under review, this part aims to determine any similarities and differences in these four case studies with regard to maintenance and its practices. It does so by highlighting the following main factor: the Current Maintenance Practices, the Barriers and Obstacles that may Impact on Maintenance and the Level of Managerial Performance with Regard to Maintenance.

7.3.6.1 Current Maintenance Practices

Regarding the maintenance currently in place in the four cement factories, the findings show that preventive maintenance is sometimes adopted, in firms B, C and D as acknowledged by five respondents from these factories. This approach is adopted according to a pre-plan called the annual productivity plan. Despite those respondents' acknowledgments of the availability of scheduled maintenance, there is almost a consensus to be derived from the other interview findings in the four factories that reactive maintenance is in fact the variety most often used. This strategy is ineffective in the belief of many of

those interviewed. The maintenance managers of factories A and B admitted that maintenance spending is much higher than it should be because of the low level of the maintenance strategy in force. Therefore, using this approach is ineffective in attaining the factories' goals. Essmuis et al. (2013) confirmed that today's competitive environment obliges industries to achieve full productivity while minimising spending. Cassidy et al. (2001) believe that successful industrial organisations are those which recognise that the presence of effective maintenance programs is essential to the success of maintenance. However, others from firm A stated that the number of sudden stoppages in the production process in their factory is remarkable. The reliability of the production lines in these firms is low, due to not adopting an appropriate strategy for maintenance. This can be seen, according to one respondent from firm A and one from firm B, in the fluctuations in production. However, the vast majority of the interviewees who acknowledged the use of reactive strategy as the primary approach to implementing maintenance in their plants confirmed that the cement factories must rely on staff experience in implementing maintenance. The evidence came from some of the respondents from factories A, C and D when they attributed the low level of workers performance to the lack of proper training. Graisa & Al-Habaibeh (2010) found, in their study of these plants, that most of the shop floor workers are enabled to implement maintenance efficiently due to the lack of awareness of the importance of maintenance and the strategies for carrying it out. Moreover, the maintenance manager of the firm A mentioned that the staff benefits from their familiarity with the production lines components in overcoming any faults or breakdowns that are accused in the production process. The maintenance manager of the factory B added that adopting an appropriate strategy of maintenance would help in reducing the use of outside experts in finishing maintenance. From the above, it can be concluded that the level of maintenance adopted is very low to not following proper strategies through which the success of maintenance can be ensured. Therefore, ways of improving the current practices of maintenance should be addressed in-depth. The next two parts concern the obstacles that may impede maintenance and the level of managerial performance in this regard, with some issues that may hinder the application of an effective strategy for maintenance.

7.3.6.2 The barriers and obstacles that may have an impact on maintenance

It is evident from the interview findings that there is a discrepancy to analyse in the perception of levels of achievement. First the interview findings show that the level of complying with employment criteria is low. Evidence for this was given by more than half of the respondents in the four factories, who agreed that many of the shop floor workers are unable to perform their job properly and have their low efficiency levels. The main reason behind this, as affirmed by most of the interviewees, is that many of these workers held irrelevant educational certificates or had a minimal educational level. Therefore, their maintenance work must depend on experience alone. In addition, most of these employees are influenced by the social culture which directly affects the efficiency of the shop floor staff. Evidence comes also from Agnaia (1997) who states that interceptions in production are often caused by the employees' behaviours. They spend a good part of their working hours in talking to their visitors or attending to other concerns, such as shopping. Here it should be mentioned that the vast majority of the interviewees in these factories believed that proper training programmes could improve the skills of the employees and reduce the knowledge gap regarding maintenance. With sufficient training, the workers would be more aware of maintenance, its practices and its importance (Graisa & Al-Habaibeh, 2010). Some interviewees from cases A and C mentioned the importance of awareness of maintenance and its practices among the shop floor staff; they said that the knowledge level of the workers should be increased so they could help to create improvement programmes. This suggests that intensive training courses are essential for every member of the shop floor staff. The general supervisor of maintenance in firm D stated that proper training is needed to full benefit from the workers' energies in raising the level of maintenance output. The vast majority of the respondents also emphasised the effects of the condition of the production lines on the quality of maintenance. The reliability of maintenance is directly linked to the efficiency level of the production lines. This is confirmed by seven of the participants representing firms A, B and D. They went on to discussed whether the selection of an appropriate strategy for maintenance could be affected by the condition of the production lines. Indeed, good maintenance means cutting the spending and reducing the time needed to ensure the reliability of the implemented maintenance. Ireland & Dale, (2001); Environment Agency, (2005); Tourki, (2010)

and Shafeek, (2012) argue that the application of maintenance without a planned strategy will inevitably lead to failure. Production systems in cement plants in Libya need to be at a high level of reliability, so as to ensure the continuation of production so that they can meet domestic demand and then access foreign markets. In other words, the components of the production systems, in particular, those which have a direct impact on production, must be highly reliable. At least one interviewee in each case believed that the success of the maintenance currently in place can be ensured in accordance with the current situation of many components of the production lines. Other interviewees, about one from each plant, looked at this issue from a different angle and said that the amount of production in their factory is limited because of the low efficiency of many production lines. The view of the general supervisor of maintenance of plant B was different; he thought the lack of needed spare parts was the main obstacle to the success of maintenance. He went so far as to claim that adopting a proper strategy of maintenance is directly linked to the conditions of the production line components which in turn maybe influenced by the unavailability of spare parts.

7.3.6.3 The level of managerial performance with regard maintenance

Overall, all the participants from B and C and some from A believed that the level of maintenance output is minimal. The lack of motivation in the workers has a significant influence on the ability of most of them to do the assigned tasks as required. These participants went on to comment that the wage systems needed some improvement to make salaries commensurate with the volume of work achieved. Although none of the respondents in the four plants could recognise the influence of managerial performance on choosing the appropriate strategies of maintenance, many of them linked the low maintenance output to the low efficiency of many of the shop floor staff. Essmui et al. (2013) found, in their examination of the performance of 207 Libyan industrial organisations, that more than 83% of them were unable to achieve the minimum amount of targeted production because they suffer from a weak managerial performance. Despite this, many interviewees did not realise that top management can play a significant role in increasing the chance of successful maintenance through providing their employees with a suitable work environment. One aspect of this, as other interviews in factories A and B acknowledged, is to introduce what called a rewards system. The interviewees were sure that this

programme would make a big difference to the workers' motivation to carry out the assigned tasks better. However, the employees could be encouraged either by providing sufficient financial support in developing or by introducing plans to create or improve strategies of maintenance in these factories. The managers of firms A and B and the general supervisor of plant B believed that the lack of proper training can be traced systemically to the failure of the top management to take an interest in it. The lack of skilled staff frequently causes accumulations of maintenance work which in turn lead to a breakdown of one or more of the production lines components and thence to interruptions or stoppages. Some interviewees from firms A and D added that the unavailability of spare parts is another reason for the maintenance backlogs which are also due to the inability of the management to provide such things in good time. However, suitable plans for improvement need to be created by the top management. These strategies should consider every aspect that could affect or be affected by maintenance. These factors are reflected in the level of efficiency of the shop floor staff, the condition of the production systems and the targeted amounts of production. In other words, the objectives of these factories need to be clearly identified. This says in other words what Azizul Baten et al. (2006) mean in their claim that the efficiency of the organisation reflects the success of the management in leading the institution. Although the general supervisor of maintenance of firm D alleged that no clear programme was in place to facilitate communication between the plant's departments and top management, the others underlined the possibility of benefiting from the good relationship between their departments and senior management to develop improvement programmes. Competitiveness is an indicator of the strength of organisation performance; therefore the successful administration of any industrial organisation looks for ways to increase the efficiency of the company and tries to avoid or deal with any obstacles to it (Ogajl & Probert, 2006 and Essmui et al., 2013).

From the above analysis, there was obviously no noticeable difference between the cases in terms of results. The similarities in the analysis maybe due to the similarity of the regulations adopted by the top management in the four factories. This can be confirmed from the literature review and the interviews analysis, which confirmed that these plants are subject to government regulations. Therefore, they have no absolute right to control such areas of managerial as choice of employees or the use of all their

factory's revenues. Social norms may be another factor, as all the targeted factories recognise. This means that the culture of most of the respondents is almost identical, with the same social customs and traditions. Accordingly, it can be said that there is no remarkable difference in their views and behaviours. Their lifestyle is almost the same. Thus, similar situations could be expected in other industrial organisations in Libya; this may facilitate the generalisation process.

Chapter summary

The aim of this chapter was to describe the results of the quantitative and qualitative dimensions of the study separately before converging these results to discuss the findings of the study. The first section presented, as its main source, the results gathered from analysing the answers to the questionnaire in the four cement factories. This research considered the shop floor responses to get a clear view of current maintenance practices and any obstacles to the success of maintenance implementation in these firms. The second section of the chapter focused upon the results of the semi-structured interviews that targeted the middle managers in the four case studies. This part proposed to cover any details missed in the survey and to get more in-depth understanding of the administrative problems that face the adoption of proper maintenance from the perspective of those experts. The position of this group of participants suggested that they would have practical experience on the shop floor in addition to their knowledge of the administrative aspects that may be hidden from workers. Direct observations were used in the data gathering exercise in order to enhance the internal validity of this research.

The outcomes of this chapter identified some factors which have a significant impact on the success of maintenance. In the analysis process, these issues were put under sub factors as follows: 1. current maintenance practices, 2. the barriers that may have an impact on maintenance and 3. the level of managerial performance with regard to maintenance. This structure aimed to facilitate the discussion of the findings. An understanding of these influences would contribute to adopting a proper strategy of maintenance through which the maximum level of reliability of the production lines could be achieved thus ensuring continued productivity. The both quantitative and qualitative analytical findings are aligned with the literature review in Chapters 2, 3 and 4.

The next chapter presents a comprehensive discussion of these findings. The argument, based on matching the analysis results of the quantitative and qualitative approaches, aims to develop a conceptual model of a proposed strategy of maintenance

CHAPTER 8: Discussion and Model Development

Introduction

The previous two chapters presented the results from the survey questionnaire and multiple case studies in the four targeted Libyan cement factories regarding the status of their maintenance their practice of maintenance.

The survey was conducted with the shop floor staff, engineers, technicians and technicians' assistants. Its aim was to identify, from the point of view of the participants, any obstacles to implementation of proper maintenance. The qualitative findings were produced from face-to-face semi-structured interviews targeting middle managers. In-case analysis and cross-case analysis were undertaken to get an in-depth understanding of the current situation of maintenance and its practices and determine the similarities and differences between the case firms.

The main aim of this chapter is to bring together and organise the evidence that emerged and the key findings of the analysis results, with a view to identifying the main factors that would have a significant impact on maintenance practices in the cement plants in Libya. The conceptual model is also built on the basis of the discussion outcomes and its purpose is investigating RCM implementation in Libyan cement factories.

It was vital to highlight and discuss the analysis findings of this study in relation to the literature review. The research results discussed the level of the current practices of maintenance and the related issues that impacted on maintenance efficiency. The research outcomes have been re-identified for this further task as follows:

8.1 Current Maintenance Practices

From the statistical analysis of the data gathered from 112 participants representing the shop floor staff in the four cement factories, it is clear that the level of maintenance output is very low. The analysis suggested that maintenance has not been successfully implemented. The level of workers' awareness regarding the equipment that they are about to fix is limited, since most of these workers have no ability

to run or maintain sophisticated devices efficiently. There is a clear problem when they have to deal with the operation and maintenance manuals. According to the survey findings, such manuals are available to some extent, especially for important devices, such as the main ventilation fans.

Despite this, some of the interviewees affirmed that many of the shop floor staff in the four firms could not benefit from these records. The manager of the raw materials department in factory C mentioned that the operation and maintenance manuals are very important in determining the technical design and the security operating method of the machine; they sometimes include information about the recommended methods and times of maintenance. The most often encountered problem is that all the available manuals are written in English which almost none of the maintenance and production staff understands. The evidence of this appears in the frequent stoppage of production lines in the production process, as both the quantitative and qualitative data confirmed. In addition to the occurrence of unwanted maintenance backlogs at times. The qualitative findings show that the four factories often ask for outside specialists to finish maintenance related activities.

The managers of maintenance in the firms A, B and C affirmed that more money is paid to outsource maintenance and avoid delays in finishing the work. The results of the survey analysis are supported since most workers have difficulty in identifying failures of the production lines quickly enough. Tourki (2010) states that to meet the growing demand for cement system performance needs to be improved overall to raise productivity. In other words, the reliability of the production lines should be as high as possible so as to produce enough goods. This could be done by maximising the available resources, in this case making the workforce more efficient.

Although the qualitative analysis showed that maintenance work is sometimes adopted according to specific and known schedules in firms B, C and D, other findings, from both the quantitative and qualitative surveys, confirmed that the reactive maintenance or run to failure approach is the most frequently adopted strategy in the four cases, but such a huge industry this method is inadequate. As a result, the achieved maintenance does not meet its objectives. But a good maintenance strategy can play a significant role in ensuring the success of such work. The maintenance managers of factories A and

B discussed the need to improve the current strategy of maintenance, along with improving its efficiency, in order to spend less time and money. The maintenance department manager of firm A suggested introducing an integrated system for maintenance to avoid waste. Al-Muhaisen & Santarisi (2002) and Graisa (2011) state that an effective strategy for maintenance needs to be applied in Libyan cement plants to avoid interruptions in production caused by adopting the traditional approach to maintenance. The cement manufacturing sector in Libya should introduce plans for maintenance rather than following a reactive strategy which usually gives unreliable outcomes (Ogajl & Probert, 2006).

“We rely on the received reports from the production department about the occurrence of a fault in any of the production line components. Based on these reports a team from the maintenance department is commissioned to preview and determine the volume of the error and then take the needed action to maintain the faulty device” MDM-D.

The reliability of production lines was shown to be low; the cement plants in Libya cannot provide the targeted amount of cement which would enable them to compete even locally with the huge quantities of imported cement. The main reason is that they apply no maintenance strategies at all which leads to unreliable production systems.

Based on the analysis of the case factories, although attempts had been made in them to adopt maintenance by means of a particular strategy, only a few workers could correctly identify one strategy of maintenance or more. Experience is the main source of the methods adopted. The quantitative analysis affirmed the absence of an adequate strategy of maintenance which would ensure success. However, it was surprising to find out that some of the shop floor staff had heard, maybe indirectly, about the strategy of reliability centered maintenance which would raise the maintenance level and give continuous productivity. This may be a good sign of possible future improvements in maintenance. Moreover, the desire of most workers to increase their knowledge and skills regarding maintenance would help in setting up training programmes where the selection and application of appropriate strategies for maintenance could be taught.

A more surprising result is the acknowledgment of some respondents of attempts to implement RCM in their firms. This contrasts with other findings of the survey, which say that most of the shop floor

staff use their experience as the main source to implement maintenance work. Some managers from firms B and C discussed the need to improve the skills of individuals to facilitate the application of advanced strategies for maintenance. This would mean that the shop floor staff would need to understand clearly the principles of maintenance and related issues such as its practices, its types and its requirements. Stepelberg (2009) and Chen (2012) state that maintenance is an ongoing and necessary task which requires knowledge for its purpose to be attained.

In spite of the availability of monitoring devices to control machines and the components of production lines in all the firms, according to the quantitative results, it is evident that these systems urgently need improvement and calibration to avoid unplanned breakdowns. It is very important to emphasise the reliability of the control and monitoring devices to avoid errors in the diagnoses of warning indicators that badly affect productivity (Graisa, 2011). This claim that monitoring devices exist finding is inconsistent with what the manager of the production department in factory A maintained: that observations of the production lines is assigned to a group called the supervisory team. Those workers monitor the machines as they operate. His description is more in line with the evidence; the survey results suggest that a great many shop floor workers have difficulty in dealing with advanced machines which need daily monitoring. The evidence, as illustrated above, can be seen in the frequent unplanned breakdowns of the production systems. It can be concluded that a monitoring system would be very helpful in determining faults before they occurred. If such a system existed there would not be so many breakdowns. The maintenance manager in firm B added that the overhead costs such as undesirable additional maintenance costs due to unplanned failure could be reduced by introducing effective monitoring devices.

8.2 The Barriers and Obstacles that may have an Impact on Maintenance

This research has illuminated some topics that can affect or be affected by maintenance activities including, of course, the main principles of the quality of the maintenance applied and the efficiency level of the shop floor staff. However, it is indisputable that understanding and knowledge are keystones in any successful project. The analysis of the research findings has shown that it is not possible for these

shop floor workers to implement the maintenance work as required. This is, for example, because of their lack of clear understanding of maintenance and its practices. Most of the workers in the four targeted cement factories rely on their experience alone when undertaking maintenance. According to the quantitative findings, a good number of workers held irrelevant maintenance certificates or had an educational level of secondary school or below. As a result, they find it difficult to deal with the proper maintenance of the production lines. These employees know too little about the machines or devices they are called on to fix. This is consistent with most of the interviewees' opinions, who related the weakness of performance level of many workers to their low educational level.

“The background of many workers regarding maintenance activities is very limited. Therefore, those employees are useless” MDM-A.

Ogajl & Probert, (2006) and Graisa & Al-Habaibeh (2010) stress the need to increase the knowledge level of workers to ensure the application of proper maintenance. In the maintenance area, lack of knowledge is one of the local factors leading most clearly to maintenance error. Although both quantitative and qualitative results shown adequate levels of communication between the factories' departments, some interviewees, such as the maintenance managers in factories A and B, recognised that the confusion in the workplace is highly likely if a breakdown occurs in one or more pieces of production equipment. This chaos is due to the limitations of the skilled and qualified staff who are unable to maintain the machinery properly and also to the lack of active communication between the top management and the departments, because the senior administration failed to coordinate with them and distribute the tasks responsibly. Applying an advanced strategy of maintenance such as RCM would help both the top management and the shop floor staff to organise the available human and financial resources and thus get the full benefit from them in terms of increased the reliability of the production lines. With regard to the summary in Chapter 2, several faults can be found in choosing the current strategy of maintenance which show up in delays in completing maintenance jobs. This sometimes causes unexpected accumulations in maintenance, as the quantitative results affirm. Some authors, such as Nakajima, (1988) and Reason & Hobbs, (2003), mention that the knowledge and awareness are essential factors in increasing the capacity of maintenance members to do their work correctly. The

approach of maintenance workers to dealing with a machine or a device is significantly influenced by their awareness level of it. The survey results clarified that the cement factories find it hard to improve their current maintenance standards. This conclusion shows that there is a shortage of studies that evaluate the quality of maintenance applied, which is considered one of the most critical requirements for improving it. This finding is not reported in the literature review but is limited to the present research; it means that too little attention has been paid to increasing the reliability of production lines through improving maintenance.

According to the questionnaire results, the awareness level amongst the shop floor staff regarding the maintenance influence on the productivity was very high. This was a surprising finding since the cement factories under investigating face fluctuation of stop in production in many times as a result of inability of many of the maintenance workers to perform maintenance as should. This outcome is inconsistent with the result from the interviews: that improvement plans such as training courses are needed to make the maintenance staff more familiar with the importance of maintenance. Moreover, the survey results themselves show that more specialists are needed to increase the efficiency level of maintenance practices and also the maintenance outcomes. Looking at this issue from another angle, it was clearly admitted by the survey sample that they lacked expertise in the maintenance field. Many of the interviewees referred to their limited knowledge of maintenance, its practices and its importance in their plants. This can be seen, as discussed earlier, in the inability of the four factories to identify any proper maintenance strategy through which they could increase the performance efficiency of the production lines. The analysis of authors such as Nagi & Cheng (1997) and Oakland (2003) is consistent with the above discussion in stating that the existence of experts and skilled staff in maintenance was essential to ensure the success of an organisation. It is well established also that the quality of maintenance is proportional to the level of knowledge and skills of the maintenance workers.

Poorly designed procedures are a common cause of maintenance failure. Smith & Hinchcliffe (2004) recommend setting out a plan before starting maintenance, such as determining the time it should take and defining the responsibilities and tasks for the technicians as well as the spare parts and tools required

to implement the plan. The questionnaire results indicate that the system for recording maintenance needs to be improved. The top managers of the four firms are not keen to follow any procedure for maintenance, whether before, during or afterwards. Recording the work steps usually relies on the awareness of the staff, including managers and shop floor workers, of the importance of documentation. The findings on this matter were not surprising since many members of the maintenance staff are not familiar with the importance of recording maintenance activities. Moreover, senior management, as noted, does not take this task seriously; the vast majority of the survey respondents who acknowledged the existence of documentation stated that all maintenance activities are manually documented. The direct observations in factories A and B revealed that maintenance activities are not fully recorded. Some interviewees confirmed that it is difficult to subject maintenance work to any standardised procedures. The rationale for this belief was the low awareness of maintenance practices, as mentioned earlier. This suggests that the level of maintenance staff commitment to documentation is very low. Authors such as Reason & Hobbs, (2003) and Mostafa, (2004) state that documentation programmes could play a significant role in improving maintenance in any industrial institution.

“There is, sometimes, a frequent confusion over finishing maintenance work as a result of the lack of required information regarding maintenance and production processes. This initially resulted from the lack of proper documentation” **MRMD –C.**

Indeed, introducing an effective programme of documentation would have a great positive impact on the effectiveness of maintenance activities given the availability of good communication between the top management and the departments. In this respect, it is not easy to make any improvement in the current level of maintenance without setting up a system for recording; all the information related to maintaining the production line components is badly needed. This does not exist in any of the case plants under investigation, as nearly all the questionnaire respondents acknowledged. In other words, commitment to the requirements of continuous improvement is one of the key elements in the possibility of adopting a proper strategy of maintenance.

It was very surprising to find that some of the shop floor members, as the quantitative results showed, believed that there was no need to document maintenance activities in their firm. This indicates how

low the awareness level of such employees in this regard is low as the recording of maintenance activities is an essential task to ensure the success of maintenance. Through documentation, the status of a machine can be known, and the need for future action can be determined. However, according to these results, it is quite challenging to show any improvement without clear documentation of past, current and future maintenance work.

The quantitative results illustrate that the four plants have no scheduled maintenance in place. This explains the incapacity of these firms to adopt an effective strategy for maintenance. It was clear that no appropriate maintenance for achieving a positive outcome such as a reliable production system had been recognised. These findings are consistent with the view of some of the managers, at least one from each case, who in their interviews advocated filling the gaps in a correct implementation of maintenance by increasing the skill level of the shop floor staff and providing the needed spare parts. What was meant by this is that maintenance was carried out at random and not chosen by an accurate system. Researchers such as Kelly, (1989) and Mostafa (2004), mention the importance of the procedures of maintenance selection and documentation in the preservation of the available assets and the improvement of efficiency. It can be inferred from this that the reliability of production systems cannot be assured without adopting proper maintenance, causing either a fluctuation or interruption in the production process.

The shortage of maintenance tools is another obstacle to the success of maintenance. This is, according to many of the shop floor workers, due to the lack of communication between the firm's departments and their senior management, who do not create orders to provide the needed tools promptly. Some of the interviewees, such as the general supervisor of maintenance of firm B and the raw materials department manager of factory C affirmed that the complicated procedures are the main barrier to getting the tools when they are needed. The general supervisor of maintenance in plant D related this shortage to the inability of top management to provide the needed funds to cover such requirements as the current production levels demand. This is somewhat illogical, however, since none of the case factories can make full use of its revenues, as the qualitative findings illustrated. Despite this shortage,

some tools are usually kept safe and clean. This gives the workers a chance to reach them easily these tools, as confirmed by nearly all of them. The maintenance managers of firms A and C believe that a system of technical reporting is needed for all the factories to help keeping everyone up to date with the maintenance related issues, such as determining the needed resources for implementing maintenance correctly. In this regard, such complex regulation has been found to have a negative impact on providing the needed spare parts in time. The maintenance manager of factory A and the general supervisors of firms B and D wanted senior management to pay more attention to providing spare parts without delay, since such delay surely reduces the chance of adequate maintenance. It often forces the maintenance staff to follow the strategy of “run to failure”. It also increases the possibility of more delays in production which in turn reduce the chance of becoming competitive whether locally or globally. This result is consistent with Tamimi and Sebastianelli (1998) who say that several factors work against the implementation of an effective maintenance, one of the most important of them being the lack of adequate resources such as spare parts.

The views of the shop floor workers were sought about their organisations’ objectives, as this would guide the actions they took to achieve them. According to the results of the survey, it is clear that none of the case factories had any clear vision and the mission, needs and costs of maintenance were not fully understood. This surely would prevent the workers from understanding the importance of the tasks they were set. The current mission of the maintenance in place was as far as possible to avoid frequent unplanned breakdowns. This policy narrowed the chance of raising maintenance standards. This shortcoming, as the questionnaire results say, is one of the factors with the most significant influence on choosing an effective of maintenance strategy through which the objectives of maintenance could be achieved. The manager of the maintenance department and the general supervisor of factory B repeated that senior management has no absolute right over every aspect of management, because they were mostly subjected to the state regulations. Therefore, the firm’s strategic direction was much obscured, which has a negative impact on maintenance practices. Al-Ghwell (2013) recommends that Libyan organisations should put together a vision and plans for what they want to be in the future.

Hoffman (2002) and Mostafa (2004) have advocated making maintenance strategy very clear for every staff member in order to make sound improvements to any institution. The interview findings showed the marked absence of suitable strategies of maintenance in the targeted cement factories due to their unclear overall strategy. In this research, the lack of clear objectives may be related to the low level of qualified staff and the inability of the top management to identify the firm's direction under a centralised government. This can be seen, as Elmagri (2013) explains, in the weakness of the cement factories' performance, shown in their low productivity.

The influence of socio-cultural norms on the quality of the implemented work, as this research reveals, is very widespread. Hedert (1981, p.3) cited in Grifa (2006, p.80) infers a close relationship between the social environment and the overall performance of an industrial institution. Sheban (1986) concludes that the social structure of Libyan society are based on a hierarchy starting from the individual and extending through the family, the clan and finally the tribe. This determines the attitude to the environment and its effect on maintenance and the other operational processes of the organisation overall.

The questionnaire results confirmed the impact of socio-cultural factors on the cement factory's performance; as a good number of the respondents believed that some employees are privileged because of the top management's favouritism. As public sector bodies, the four cement firms are subjected to state policies which are directly affected by social assumptions. In other words, the public sector is driven by socio-political norms. In Libya, the tribal structure has exerted and still exerts, significant influence even on issues such as running a manufacturing organisation (Mogherbi, 1998 cited in Mohamed 2005, p. 184). All of the interviewees agreed that a good number of employees are appointed by either by the Minister of Industry or the Ministry of Manpower; Libya's public organisations themselves have no absolute right to make decisions about recruitment. In other words, it is the government that forces businesses to absorb a huge number of unqualified and unskilled workers and this social approach has to be appreciated as an effect of the Libyan culture. In his study, Elabedy (1995) found that 32 percent of the people who responded to his research were appointed through their strong

social and personal relationships. This means that the staff often did not comply with the firm's employment standards. As a result, many inactive workers find a place on the shop floor, so the poor performance of the plants is scarcely surprising.

The negative impact of the social structure can be seen, as some of the interviews in the four firms affirmed, in the hours of unproductive employment for some workers; they are allowed to leave the worksite in working hours to attend to other activities such as visiting relatives or friends or doing their shopping. It was observed in the course of interviewing that some of the employees come to the department manager's office simply to chat about non-work subjects. It was more surprising to find that a member of the shop floor staff was trying to involve himself in the conversation by answering some of the interview questions without permission in one of the formal interviews. This gives a clear sign of the effects of the social and political climate on managerial performance. This, indeed, might bring great loss to the factories, but their own top management cannot control such behaviour. Mohamed (2005) discovered that some workers are not committed to doing their assigned work properly. Despite this, their supervisors or managers do not like to take action against them or complain about their behaviour to the senior management. They were convinced that no action would be taken to punish offenders, for reasons of social custom.

What must be inferred is that the existence of such issues in the cement factories would certainly hinder management in these organisations from taking control and exercising its functions effectively. This factor could also get in the way of securing effective outcomes from maintenance. In such a large and vital sector, it is essential that the technical and professional work should not be subjugated to other considerations, whether political or social. People who work in this area must be highly-skilled and professionally and technically qualified.

8.3 Training

According to the International Labour Organisation (ILO) (2003), training is essential for enhancing people's capacity to do their jobs better. Haniffa & Cooke (2002) and Mackety (2007) believe that the impact of training on staff's confidence level to implement the assigned work in turn influences the

outcomes of the job. Despite the recognition by some shop floor staff that training courses to raise the workers' skills regarding maintenance and its implementation methods are available, the training programmes were still in their infancy, as can be seen from the poor maintenance practices and outcomes. More than one reason for this is apparent. For example, many maintenance workers have no background in the subject, which is bound up with their not meeting the employment criteria. This makes it very difficult to improve their skills in short training courses. At least one interviewee from factories A, B and D stated that intensive training was needed for many of the shop floor workers to make up for their lack of awareness regarding maintenance and its practices. According to Graisa & Al-Habaibeh (2010), the low efficiency of workers in the Libyan cement industry is due to the absence of effective training programmes. The unavailability of development programmes, directly linked to the lack of senior management interest, is a second major obstacle to the introduction of proper training (Mohamed, 2005).

In his research on Libyan manufacturing organisations, Mohamed (2005) found that none of the Libyan industrial institutions analyses training needs, although this is essential for any improvement process. The current skills level of the maintenance staff should be evaluated so as to set up suitable courses for training them all. At the same time, the organisation's training needs should be determined. Some managers in the four factories acknowledged that there is a significant need to evaluate every aspect of the cement factories, including training, before planning any improvements. However, such programmes lack funding, representative of the insufficient attention paid to them. The blurry objectives of the factories overall, which in turn comes from the lack of clarity of the maintenance goals themselves, exposes the poor administrative performance. Some managers in the four firms emphasised the significance of the senior management's role in introducing proper programmes for increasing the skills of the employees, such as training.

"The senior management should pay more attention to providing the employees with some facilities such as the needed training and rewards to improve their skills and motivate them to do work better"
HOD-A.

In this research, it was found possible to benefit fully from the offered training courses if they were well planned, because nearly all the shop floor workers have a great desire to improve their work knowledge and skills. However, it was noted that the availability of training was mostly subject to offers from the top management to fund it. As the interviews made clear, the four factories have no absolute right to spend even part of their revenue on such programmes, as this would contravene the state's regulations.

All the maintenance in the targeted firms relied on the staff's experience. As a result, fluctuations or even interruption in production sometimes occurred. But even if training was given, it would be insufficient: the quantitative results showed that most training courses are inertial which are considered low. This reflects the lack of planned programmes for training. This more or less consistent with Culley et al. (2003) who say that insufficient training would make no marked difference to the trainees' performance. This supports the earlier conclusion that training needs analysis should be mandatory for every organisation. To clarify, the findings of the research confirmed that the knowledge of many shop floor workers is poor. Therefore, they need intensive courses given by experts in maintenance. Moreover, the skills and knowledge of the workers should be updated with new developments in the field by giving them the chance to visit developed cement plants. From the above, it can be concluded that the four cement firms need to pay more attention to training programmes, for the sake of continuing productivity and of keeping pace with developments in maintenance. This is why training in skills was seen by most of the questionnaire and interview respondents as a very important task. Taylor and Christensen (1998) affirm that the members of maintenance staff could possess high technical skills if these are in focus during training.

As discussed above, in the cement factories under investigation, experience was relied on for maintenance in preference to improving the workers' skills. This resulted in minimising the level of maintenance outcomes. In the interviews, most respondents remarked that a great many maintenance and production workers were considered ineffective. They needed good training in maintenance and operation processes and practices. In the same context, it is suggested that the four factories should conduct a comprehensive training needs analysis of all their current employees. Training the

maintenance staff would raise their awareness level along with increasing their skills and allow them to do their tasks efficiently. Many authors, such as Adebajo & Kehoe (1998); Sayle (1994) and Oakland (2003) support the findings of this research; they all insist on the urgent need of any business or any industrial institution to install training programmes and stress that the lack of proper training courses has an adverse impact on the quality of overall business performance. Those experts also agreed that the weakness or lack of training programmes is the main obstacle to improvement for any organisation. The maintenance field is greatly concerned with training issues. The anxiety is due to its classification as a "technical function", unlike other tasks. Consequently, employees in the area of maintenance need to be well trained.

To adopt any new programme means more effort should be made through teamwork. This calls for more responsibility and a greater level of skill and knowledge from the workforce but these can be achieved through appropriate and systematic training. Depending on the needs of each institution, training should be provided to all staff members as part of an ongoing process to ensure that the organisational objectives are attained. In this research, a significant proportion of Libyan society consists of young people, who would have many opportunities, if they were well educated and trained in some field of work to use their potential to make developments across the country. Once employees have basic skills, they need to apply them in the workplace. As they become more familiar with the concepts in the field and their applications, they can use their skills to make the needed improvements and share the new knowledge and understanding with their colleagues. By this means, an improvement process is phased into an entire institution (Kelly, 1989 and Bakejan, 1994). It can be summarised that cement firms have to change the condition of their workers as they improving conditions in the entire work environment, including the performance of the production systems; they should be treating errors as an expected and foreseeable part of maintenance work.

8.4 Management Performance

The success of any organisation reflects the level of its managerial performance. It shows the ability of the senior management to deal with external and internal events and issues related to the running

requirements of the business. Efficient leadership means that the administrators have sufficient talent to lead an institution to success. Nagi & Cheng (1997) and Amar & Mohd (2002) show that the leadership can have a significant effect on any organisation's performance. The senior staff can lead the organisation to success or failure, depending on their capacity to lead and manage their organisations in continuously variable conditions. Hence, continuous improvement is mostly subject to leadership performance. However, asking the middle managers of the four case factories to evaluate the leadership qualities of senior management was a sensitive question. This may be due to career disclosure-related matters, because all the respondents were trying to relate most of the problems experienced by their seniors to structure of the Libyan government. Despite this, the interviewees were willing to give answers whenever they could.

The above justification is to some extent acceptable, according to Elmagri (2013) and Essmui et al. (2013) who all agreed that political factors are the greatest challenge facing Libyan industrial organisations. Fundamentally, the major decisions always come from outside the factories. Autonomy in the Libyan institutions varies from one organisation to another, depending on the manager's standing and his informal personal relationships with governmental bodies. This analysis is consistent with the quantitative and qualitative findings of unqualified staff being recruited. More than half of the interviewees in the four factories, at least one from each, affirmed that the senior management cannot control the decision-making process on this; the state mostly prevails.

Graisa & Al-Habaibeh (2010) believe that the weakness of both managers and other staff in the cement factories is due to the failure to apply specific standards for choosing directors and employing workers, resulting in many unsuitable appointments. The main disadvantage of this situation is that it puts at risk the supply of the targeted amount of cement. A major managerial issue in the case firms was that, from the perspective of most participants, managers should pay more attention to supporting maintenance activities. For example, the managers of the maintenance department in plants A and D and the general maintenance supervisor in factory B mentioned that there was always a delay in providing the needed spare parts due to the complicated ordering procedures set up by the senior management. As a result,

they said, the production process in these factories is restricted by the resources allocated for maintenance, which obliged the maintenance workers to concentrate on breakdowns; they could never move on to applying a suitable maintenance strategy for ensuring the optimum operation of the production systems. They suggested that more authority should be given to individual departments, for instance, allowing direct contracting for the purchase of spare parts. The shortage of spare parts could also be linked to the lack of technical reports about maintenance requirements, which is blamed in the survey for the shortage of needed maintenance tools. Two possible reasons may account for this scarcity. The first is the lack of senior management attention either due to the inability to make the right decision on time, as presented earlier, or the failure to provide sufficient funds for such things. The second shows up in the absence of clear documentation for maintenance and its related activities which may result from the low efficiency of the shop floor staff as a good number of them have too little understanding of maintenance, its practices and its importance.

The above discussion is consistent with what Masters (1996) and Tamimi and Sebastianelli (1998) who contend in their research, that inadequate resources are among the main factors that work against the successful implementation of maintenance. However, both scenarios were implied: the lack of provision and the lack of skill to manage the resourcing of maintenance. Despite this, it was observed on the shop floor that the available maintenance resources are properly stored, which reflects the interest of the middle managers and the shop floor staff in maintaining the assets of their factories.

The quantitative findings reveal the weakness of management performance in several places. Although a good number of the shop floor staff showed considerable enthusiasm over engaging in any improvement processes, their managers ignore most suggestions and opinions regarding maintenance practices and improvements, as the survey results showed. In contrast, certain workers may receive exceptional support from their top managements and are usually involved in the decision-making process. This may result from the power of their tribe. None of the interviewees referred to this point, seeing it as a sensitive issue, like having unqualified employees. For example, the production department manager of factory B perceptively commented that there was no distinction between

workers; all of them received the same support. He may have been someone who was favoured by the top management. However, the earlier findings do not agree with this statement; these cement factories face some production problems, such as unplanned stoppages and maintenance backlogs.

Coordination and cooperation are the factors that could most facilitate the success of an organisation. Overall, Human relations or dealing with people, individuals or groups, is seen as the most challenging area by senior maintenance mechanics (Robbins & Alvy, 2003; and Kahn, 2014). It was believed that measuring the level of cooperation among the shop floor workers and their management and between the shop floor members themselves was critical for adjusting the capacity of the top management to lead these important factories. However, according to the questionnaire results, the relations between the shop floor members, engineers, technicians and technicians' assistants are all cordial according to most of the maintenance and production staff in the four cement factories. In contrast, the workers were not satisfied by their relations with the senior staff alleging that they have no direct connection with management.

It can be concluded from the above finding that although the workers have good relations with each other, the top management seems not to be interested in communicating with its employees, either directly or through their departments. Many of the four factories' interviewees see that the quality of senior management communication does not raise the volume of work that their firms need. Some of them, such as the general supervisor of the production department in B and the general supervisor of maintenance in D proposed the introduction of programmes to communicate with the top administration, such as the direct exchange of work reports using electronic communication. Such programmes would increase the chance of successful maintenance through, for example, shortening the time required to obtain spare parts for it. The lack of interest of the senior managers in connecting with their employees is clear from the inability of the researcher to contact them despite continuing attempts during the data collection period. In the quantitative findings, it was noted that the engineers were more likely to be contacted by the top administration. This is consistent with the findings of Bait-Elmal

(2000), which affirm the existence of a bias towards engineers in the culture of the industrial sector in Libya.

The quantitative analysis also shows that co-ordination and co-operation between the maintenance and production departments is high. This contrasts with what Mohamed (2005) found in his study of some Libyan manufacturing organisations: that current organisational policy distinguished maintenance workers from operators. This researcher went so far as to claim that the production department workers are more appreciated by senior management than maintenance staff were. Such a result was not borne out in the present research, either in the quantitative or the qualitative findings. The only problem, as stated above, is the poor quality of coordination and cooperation between the top management and its departments.

The senior management does not seem keen to improve its relations with the factory's departments. The general supervisor of firm D believed that the lack of overall strategy of the plant is one of the greatest obstacles to an effective programme for communication. Despite this logical clarification, the manager of the production department in the same factory confirmed that a scheduled meeting with the senior management is held every two weeks. This information may have been given because manager in question may be getting support for some reason; all the other participants agreed that they and the top management disagree about the existence of a communication process. However, Reason and Hobbs (2003) mention that coordination and cooperation are very important for increase the possibility of continuous improvement, as they enhance the confidence level between the top management and the departments and also between the factory's departments themselves. The discrepancy suggests that coordination and cooperation between the departments and their top administration in the four case firms were not seriously addressed and were still below the required level. This matter has a significant influence on the effectiveness and efficiency of the maintenance adopted, in the view of Campbell and Reyes-Picknell (2015).

From the preceding discussion, it can be said that the coordination and cooperation between the top administration and its departments should be vigorously activated to make maintenance as effective and

efficient as it should be. Mohamed (2005) suggests that the Libyan industrial organisations should contain modules which can provide these institutions with the information needed for decision support and decision-making related to maintenance. For instance, computerisation of the maintenance activities could improve the quality of maintenance; it would improve the working condition of the production systems and increase the chance of the improvements' succeeding. This is confirmed by Reason & Hobbs (2003) who say that effective and regular communications are essential for all stages of improvement and change processes. In this research, the maintenance operation was affected negatively by the lack of a good communication and information system. This can be seen, for example, as illustrated earlier in this chapter, in the delays in providing needed spare parts when wanted and the lack of clarity of maintenance instructions.

Regarding the satisfaction of the shop floor staff, the four cement factories were far from earning it. According to the quantitative findings, the work conditions were poor. Generally, most of the shop floor workers are unsatisfied with senior management's attitudes and behaviour towards them. Wages were low in comparison with the volume of the work to be done and with the cost of living in the country as a whole. This is why nearly half of the workers took on extra work to supplement their income. Many of the workers considered that the top management does not pay any attention to their views thoughts. Moreover, the senior management shows favouritism to some employees regardless of how little they do to complete the assigned work. The dissatisfaction can also can be seen in the desire of a good many employees to move to another job, because they are not happy with their present situation. It is apparent from the survey findings that these plants do not provide their employees with sufficient work-related incentives and they are hardly ever given certificates of excellence in appreciation of a piece of work done.

Consequently, most of the workers were not motivated to finish the assigned tasks properly; the reasons may be summarised as follows: Inadequate treatment, low salaries, inequality between workers, lack of recognition and rewards and uncertainty about their future work. The interviewees could substantiate this.

The above quantitative findings are in many ways consistent with the qualitative results. The views of the interviewees regarding work conditions are on the same lines. They claim that the work situation is somewhat unsuited to accomplishing the assigned tasks properly and safely. According to the interview participants, this can be seen in failing to providing employees with such amenities as availability of transportation, air-conditioned halls for relaxing and eating and even safety and security requirements. Although they acknowledge that incentives and bonuses are given to the workers from time to time, they are low compared to the volume of work required of them. Therefore, according to at least one interviewee from each firm, the rewards system needs to be improved. The general supervisor of plant B suggested that the rewards system should include a programme to treat workers according to the amount of effort they put in. Although many of the interview respondents linked the lack of this critical system to the lack of interest on the part of the top administration, others perceived that it is the government's edicts that prevent management from making any improvements. This matter has resulted in the creation of unmotivated employees, which in turn has an adverse effect on maintenance, thus undermining the reliability of the production line components.

Some managers of factories A and C saw an urgent need to rebuild the wages system. They believed that many of the shop floor staff lack any desire to complete the assigned work as they should. These workers think that they work hard and are paid very little. Adebajo and Kehoe (1998), in their study of the implementation of TQM in some of the UK's industrial organisations, found that there was no systematic approach to evaluating a worker's performance and capability and as a result salary adjustments are often not commensurate with job functions. It appears to be the same in Libyan factories.

Moreover, these critical factors made the employees less loyal to their organisation. From this low loyalty, two main features were generated from both quantitative and qualitative findings. The first one is that most of the workers have a feeling of nonchalance. This can be seen from the maintenance backlog or the unplanned system breakdowns as a result of the low efficiency of the maintenance workers. Second, the shop floor staff lacked enthusiasm as a result of very low spirits. Apparently the

morale of the middle managers was low too, since they thought that the senior management was not as keen to support its departments as it should have been.

Despite the factories' failure to satisfy their employees, in the longer view, this failure should not be seen in isolation from the wider political social and economic context. Many factors beyond the firms' control have caused it. This is the main reason for the desire of many of the workers to move to a different job. Reason & Hobbs (2003) discussed such concomitants to maintenance failures, such as delays in providing spare parts, the unavailability of the requisite tools and unreasonable pressures, which could all combine to cloud judgment with emotion.

8.5 Production Line Improvements and their Association with Maintenance Practices

It is natural for people to resist change, at work or home, in everyday situations especially if they are not well informed about it (Mohamed, 2005). Despite this, nearly all the survey respondents, as the questionnaire results show, agreed with the statement that making improvements in maintenance could increase the reliability of the production systems. However, to call the improvements in maintenance successful, the efficiency level of the production lines would have to meet or be compatible with this improvement. In this regard, all the interviewees in this research agreed that continuous improvement would be needed to ensure the reliability of the production system was maximised and that the associated tasks such as maintenance easy to apply. The managers of maintenance and production from factory A stated that it was essential to improve the components of the production lines before making any improvement to the current maintenance. These managers meant that improving the condition of the production lines would facilitate the choice of a proper strategy for maintenance and increase the chance of its success.

Although some attempts had been made to improving the production systems in the four targeted cement factories, some of the interviewees acknowledged that many of these initiatives failed for good reasons. The head of the operation division of firm A, for example, believed that the lack of interest from senior management which can be seen in the lack of funding is the biggest obstacle to creating these programmes. Tourki (2010) notes that the executive directors in senior management in some Libyan

manufacturing institutions do not pay sufficient attention to supporting new projects especially those related to improvements.

The manager of the maintenance department in factory B and the production department director of plant D revealed that the skills and knowledge of many workers could not meet the improvement requirements. This director added there was a lack of managerial commitment to the provision of an infrastructure for improvement such as sufficient funding and the training of individuals to engage in such programmes effectively. He meant by this that firms must embrace the idea of change and it is important to present as much as possible clearly to all staff the members who will be involved in the change. Mohamed (2005, p.188), in his study of some Libyan industrial organisations, summed up what change needs as follows: “the commitment of both employees and managers to any change processes could be active only with full understanding of the mission and objectives of that change”. This suggests that the success of maintenance can be determined by the condition of the production lines, either positively or negatively. Therefore, sufficient attention should be given to ensuring the effectiveness of these systems when their components undergo to maintenance.

8.6 Development of the conceptual model

In order to enhance the ability to compete in the local market and to become globally competitive, the Libyan cement industry needs to shift from a traditional production method to one which has clear and effective strategies for improvement. Its approaches should focus on ways through which the reliability of production lines can be ensured to meet the requirements of competition. Correctly maintaining such critical production assets is the only method to ensure that they are operating as they should. Therefore, adopting efficient strategies for maintenance is essential for achieving reliability of this kind. In other words, the continuity of production is considered one of the critical factors for success. The main elements that are involved in a study topic and their relationship with each other are usually represented in the form of a diagram called the conceptual model. (Robson, 2002). Easterby-Smith et al. (2008) maintain that developing a model will help to guide the researcher and keep the investigation focusing on the particular subject. Robson, (2002) adds that creating a conceptual model is required, to properly

understand and answer the questions of a research study. It should reflect the relationship between the variables and factors that should be focused on in the study. According to Kanji (2000 and Dale et al. (2001), a systematic approach to proposing a model or roadmap is necessary and through it a suggested strategy of maintenance can be successfully implemented.

In the initial model, which has been presented in a published conference paper by two researchers (see Appendix 10 for the full text), many key elements of maintenance practices and related issues are discussed. They are divided into two main groups; human factors which are generated from staff training, motivation and satisfaction and factors of production which are generated from both internal factors, such as the maintenance strategy currently in place, management commitment and resource availability and the external factors, such as the marketplace and the availability of raw materials. In this case, the building of the conceptual model in the study period was essential, in order to identify a solid and unified conceptual model for Libyan cement plants to apply. The comparison between the findings that were based on a review of the recent literature on maintenance and related issues, the initial model and the findings from the empirical research showed significant consistency. However, further problems related to maintenance practices were revealed in the discussion of the research findings. Therefore, to match the reliability of the production systems and its relationship with the maintenance activities in the four Libyan cement firms and the barriers to successfully implemented maintenance, the suggested model has to be revised and improved. The improved conceptual model is presented in Figure 8.1 to give a deeper understanding and broad view of the implementation of the conceptual model and its integration with the studied factors.

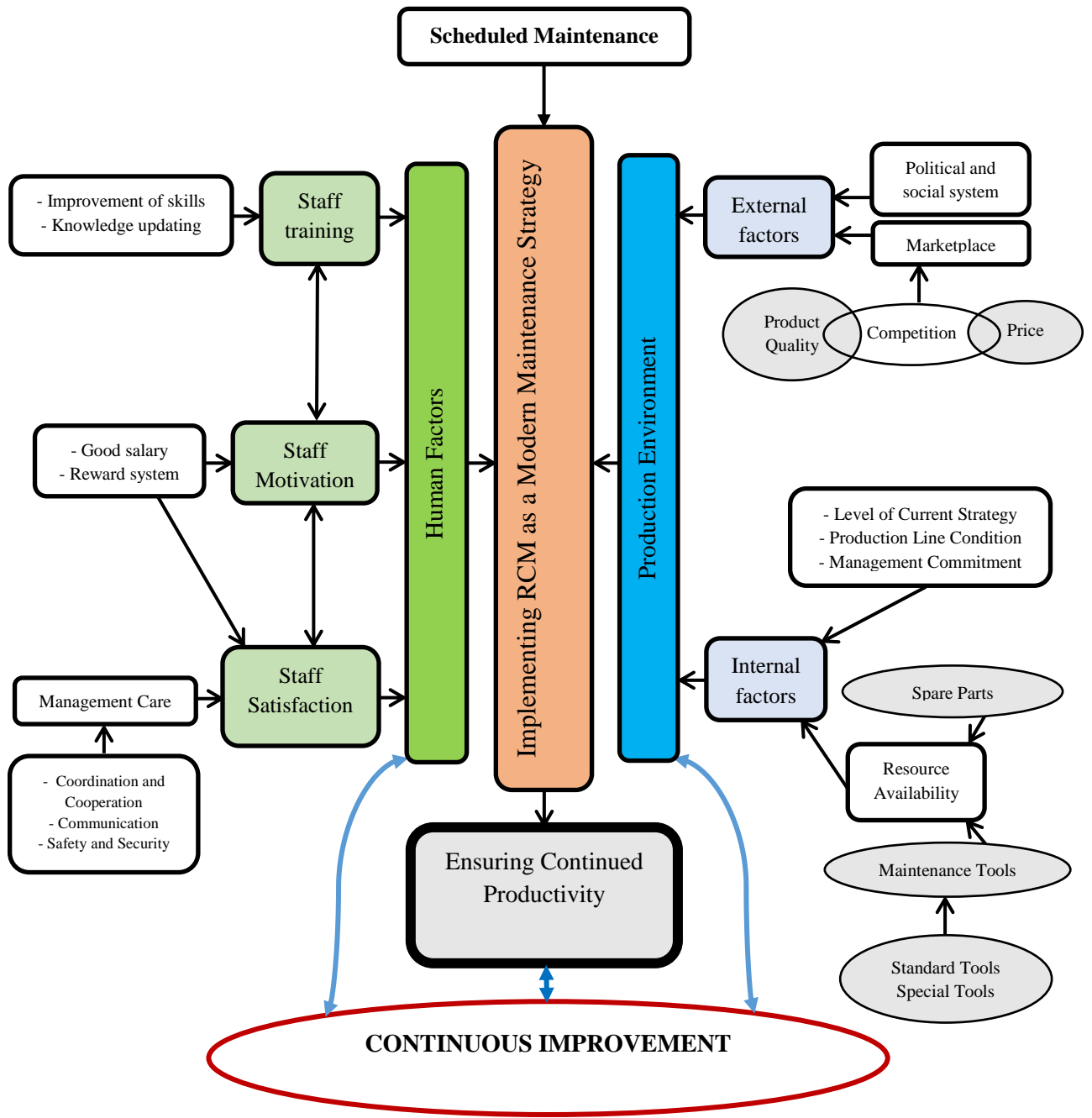


Figure 8.1: The conceptual model to overcome the problems and barriers to the improvement of maintenance in the targeted cement factories (Source: author).

The above revised model has two main phases that can affect and be affected by maintenance practices and their related issues. The first one is named human factors and second is the production environment. The conceptual model also identified the sub-factors that influence maintenance and its practices in the environment of the cement factories in Libya. These two most important factors and sub-factors are addressed below.

8.6.1 Human Factors

In this research, the sub-factors that are listed under the heading of human aspects have been considered as the main issues in improving the standards of maintenance; they were widely debated with reference to maintenance and its related activities in the four targeted cement firms. Such principles concern the performance capacity of the shop floor staff and their ability to deal with maintenance and related issues. According to the research findings, maintenance and related matters can be converted into human factors, as follows.

8.6.2 Training of the Maintenance Staff

According to Graisa (2011), in the 1960s major industrial companies set up training departments which gradually grew into independent units, since workers' skills cannot be improved and the knowledge gap cannot be filled without proper training (McIntosh et al., 1996; and Culley et al., 2003). The research findings clarified that there were no clear programmes for training to put proper maintenance procedures in place and improve current practices. The cement factories in question lack any systematic audit of the training needs or approaches required. Leslie (1988) states that training courses could bring together a group of workers who could debate mutual difficulties and problems, learn as a group and share ideas and methods. They could also practise their theoretical skills on each other. Sloman (1999) mentions that programmes and activities for training personnel could contribute to an organisation in different ways, for example, enhancing self-motivation through appraisal or performance review. They can also contribute by giving workers the ability to perform the assigned tasks efficiently and creating an appropriate framework for cooperation and interaction between the senior management and its employees. Two conclusions follow from the current level of training in the four factories:

. Improvement of staff skills; many of the shop floor workers lack sufficient skills as they are enabled, in many cases, to perform maintenance job as required. The staff weaknesses can be seen, for instance, in the periodic accumulations of maintenance work and the unplanned breakdowns of one or more of the production lines during production. This is due to the lack of maintenance experts who could

determine faults before they arose. Graisa & Al-Habaibeh (2010) state that the individual skills of workers in Libyan cement firms need to be improved to meet their work requirements. Staff with high skills would mean successful maintenance.

. *Knowledge updating*; highly efficient workers would have a wide knowledge of maintenance practices. The shop floor staff lack lack this knowledge and do not understand its importance. This reduces the chance of success in carrying out maintenance tasks. More attention should be given to the ways of increasing the knowledge of the workers regarding maintenance and its practices. In the case of the cement plants under investigation, intensive training should be offered to the maintenance workers to fill the gaps in the maintenance related qualifications. Tourki (2010) found that intensive training is needed for a great many cement factory workers in Libya whose education level is low, as can be seen from their inability to participate in improvement programmes. This improvement would help such employees to choose what to maintain and determine what was required in each case.

8.6.3 Staff Motivation

The study results have confirmed that most of the shop floor staff are not motivated enough to do the assigned tasks as they should. The first proposal regarding this issue, the study found, is that the senior management should treat its staff according to their efforts rather than favouring some workers because of personal or tribal ties. To be more active in the workplace, maintenance workers should be involved in the decision making process (Swanson, 2001). Gary (1979) states that one motivation theory holds that employees are normally motivated to receive a valuable and equitable reward for working hard. According to Graisa (2001), rewards or bonuses are two basic requirements for motivating people. Employees feel that great efforts should lead to a bonus or reward. Conversely, job dissatisfaction arises from offering staff insufficient wages in relation to the volume of work required of them. The industrial organisation should have clear plans to enhance the desire of its workers to do maintenance jobs better (Elmagri, 2013). The salaries offered should meet the basic needs of a worker and should balance the volume of the achieved tasks. Low wages make it seem burdensome to stress productivity; the research

results confirm that many of the shop floor staff must take on extra work to supplement their income. Regarding staff motivation, two critical points need to be reconsidered, namely:

Good salary; the satisfaction of employees with their received wages means that they are keener to complete their work efficiently. The study results showed that the low salaries now paid simply increase the desire of the shop floor staff to switch to another job. As stated above, low wages make workers concentrate less on work, which in turn leads to low maintenance outcomes. According to Porter & Chairman (2006), low salaries are among the main reasons for the failure of the Libyan industrial sector to help the country's economy. It shows up in the unwillingness of workers to finish the required work properly.

Reward system; in this research, it has been found that the top management is not keen to improve the rewards system so as to take full advantage of staff effort. It should make bonuses and incentives available for every member of staff in line with the volume and quality of the work they do. Indeed, this would encourage the workers to concentrate more on the job and make the outcomes more reliable. Introducing bonuses and incentives would make the staff work more efficiently, in the belief that rewards are given only to hard-working employees. The quality of adopted maintenance could be increased by developing a good rewards system which inevitably would make the workers focus on completing their jobs perfectly (Alghadafi & Latif, 2010). The incentives are essential to strengthening the competitive spirit among the workers and making them ambitious to develop their individual skills (Graisa & Al-Habaibeh, 2010).

8.6.4 Staff Satisfaction

One of the biggest obstacles to maintenance success is the favouritism towards certain employees which has an adverse effect on all other employees' performance in the Libyan cement industry (Elmagri, 2013). Different ways of treating the staff members in the workplace for no good reason makes workers frustrated. This creates what is called job dissatisfaction, which lessens workers' desire to do their assigned job and, therefore, lessens their benefit to the firm. Most Libyan industrial organisations suffered from management's inability to pay sufficient attention to their employees and make them as

satisfied as possible with their work conditions. Their dissatisfaction inevitably affects their performance, preventing the organisation from attaining its overall goals (Aagnaia, 1997). The Libyan cement factories urgently need to look at ways of increasing the level of career satisfaction among maintenance workers. This would allow these firms to benefit fully from the maintenance and related activities performed by these employees.

Marr (2012) states that the satisfaction of a worker is a powerful leading indicator of profit; satisfied employees are more productive (Ford et al., 2011). The satisfaction of the workers can be influenced by training they receive and their motivation level, as noted above. Coordination and cooperation, together with safety and security are two other areas which management care factor should develop. The logical reason for this is that the senior management is fully responsible for such issues. The following points may be added:

. *Coordination and Cooperation*; Proper coordination and cooperation are needed, whether among the employees in the department or between the departments itself and the top management. Mohamed (2005) found in his research on Libyan manufacturing institutions that conflict among the shop floor staff is highly likely to ensue when coordination is poor, since two or more workers or groups find themselves doing the same task or working in the same place. According to the research results, however, coordination and cooperation between the factories' departments are at a good level. In contrast, there is clear evidence of the failure of top management to communicate with its departments in the interests of efficiency. Consequently, if the job descriptions and functions are not sufficiently clear, the work is impaired. Thus, the outcomes of maintenance are poor (Bait-Elmal, 2000). The lack of coordination and cooperation inevitably lead to departments and individuals misunderstanding each other. As a result, the effectiveness and efficiency of maintenance operations decline (Reason and Hobbs, 2003).

. *Communication*; relations between the sections and the senior management form one of the greatest barriers to the implementation of maintenance (Nagi & Cheng, 1997 and Oakland, 2003). The communication may mean the exchange of information between departments. This practice would be

more effective if top management took the initiative to improve communication by the provision of an information system, for example, for reporting maintenance activities and production parameters as quickly as possible (Riis, et al., 1997 and Raouf, 1994). Workers can be persuaded that their existence in the workplace is important if they can share their ideas and suggestions with top management. This would indeed enhance their self-confidence (Mohamed, 2005). From the study findings, it is clear that the communication process in the four cases was not addressed well and is still below standard. None of the four cement plants has an internet service, which is a contributory factor in the low level of maintenance achieved. Riis, et al. (1997) and Mostafa (2004) state that an information system is essential if all the tasks of maintenance are to be done as well as possible. Reason & Hobbs (2003) mention that effective and regular communication is needed to know when to adopt or improve maintenance.

. *Safety and Security*; providing the work environment with such important facilities would increase the staff's confidence in the workplace, making them feel safer in their work. The outcomes of both the quantitative and qualitative research confirmed that a good system of safety and security is available in the four factories. This is a good sign of the interest of top management in taking full care of their staff as well as protecting the environment. To be successful, maintenance should fulfil other requirements such as personal and environmental safety, advice Ajukumar and Gandhi (2013). Consideration of safety and health is an essential part of planned maintenance (Aspinwall & Elgharib, 2013).

8.6.5 Production Environment

It is generally accepted that understanding and awareness of a production environment is the most important part of the success of any project. According to the model shown in Figure 8.1 the surroundings of the production process can be divided into two sub-factors, the internal and the external, to cover all the issues that may have an effect on the production process. These two sub-factors are discussed below:

8.6.6 The Three Internal Factors

. *Level of Current Strategy:* according to the findings of the study, the four cement factories still face some obstacles to maintenance. For example, there is a continuous accumulation of maintenance jobs, resulting in the frequent stoppage in one or more of the lines in the production process. To avoid any interruption in production, the Libyan cement factories should introduce an effective strategy of maintenance (Al-Muhaisen & Santarisi, 2002 and Graisa, 2011). Tourki (2010) mentions that poor maintenance means more failures in the production system components, making maintenance backlogs even more likely to occur. As a result, additional money is paid for outsourcing the work and more time is wasted, owing to the inability of the maintenance workers to implement maintenance properly. The research by Graisa & Al-Habaibeh (2010) and Chen (2012) confirms that the success of adopted maintenance can be ensured only if the maintenance staff have sufficient knowledge and understanding of maintenance and its practices. Mohamed (2005) and Graisa & Al-Habaibeh (2010) claim that inadequate knowledge and understanding of maintenance, its importance and its practices may work as obstacles to the maintenance carried out in the Libyan cement factories.

The results of this study found no clear strategy of maintenance through which to ensure the success of the work. In other words, the shop floor staff are still not aware of strategies of maintenance and their influence on ensuring continuous production. In addition, the top management did not pay sufficient attention to supporting plans to improve this critical deficiency. From the research, it was found that all the four cement firms adopt reactive maintenance, a very traditional approach which cannot be effective in this critical industry. Nagi & Cheng (1997) and Amar & Mohd (2002) agree that the level of adopted maintenance is directly influenced by the level of awareness and understanding of the maintenance workers in this field. Graisa, 2011 affirmed that the lack of staff awareness of maintenance issues is one of the local factors reducing the efficiency of maintenance in the Libyan cement industry. Maintenance work should be implemented according to a pre-planned strategy to ensure the continuity of production. Indeed, scheduled and well-planned maintenance would increase the reliability of the components of the production system, according to Tourki (2010) and Shafeek (2012).

Condition of the Production Line: the reliability of the production system can play a great role in ensuring continuous production when needed (Tourki 2010). The research findings confirmed that the efficiency level of many of the production lines is substandard. Therefore, improving the production system is an essential step in applying any strategies of maintenance in the cement factories being studied. This is consistent with the report by Mohamed (2005); that maintenance missions are usually effected by evaluating the conditions of the production system components. In other words, renewing or upgrading some production line components would help in choosing suitable maintenance which in turn would increase the chances of successful maintenance. According to Hayes & Pisano (1996), only successful manufacturing organisations recognise the value of upgrading production systems for in increasing the chances of successful maintenance. Graisa (2011) found that the Libyan cement industry lacks reliable monitoring devices. The documentation is insufficient, which very much impairs the capacity for improvement. Such systems would help to adjust the condition of the production line components by detecting and diagnosing any problems, leading to the necessary maintenance work. In general, the research results illustrate that there was a lack of thoughtful planning for system improvement in the four factories, indirectly affecting production in the end.

. *Management Commitment;* the interest of senior management in fulfilling the running requirements of an organisation can be measured by the organisation's overall performance level. In the maintenance area, the commitment of top managements should be to provide every facility for ensuring the success of maintenance can be ensured. If it is, it is reflected in the reliability of the production system to carry out continuous production as needed. In this research, there is a kind of lack of commitment from senior management towards supporting maintenance. For example, as stated above, more attention should be given by top management to setting up training programmes. Other aspects equally need improvement, notably the rewards system and wages. However, managerial performance in such matters is weak, part of the administrative responsibility is directly linked to the powers senior management which are often subject to national laws and procedures, as the employment of unqualified employees shows; none of these factories, according to the study findings, could fully comply with their own employment

standards. The findings are consistent with what has been found by authors such as Dale (1994) and Amer & Mohd Zain (2002). They state that the power of the leadership in dealing and managing its organisation in different situations leads to success or failure for the institution. Therefore, the top management in these factories should be skilled enough in controlling their plants to take legal advantage of the state's regulations and policies. In the broad sense, inefficient leadership works as a barrier to improvement. Mohamed (2005) affirms that an unstable management structure is one reason for the lack of senior management commitment. Therefore, the leadership in the Libyan cement firms should be transparent with all its departments and especially when dealing with maintenance issues in order to overcome any obstacles resulting from the restrictions on management.

8.6.7 Resource Availability

Maintenance activities require resources. Finishing maintenance promptly and as needed depends on allocating resources to maintenance activities. Therefore, it can be said that one of the main factors with a critical impact on the success of maintenance is the availability of such resources as maintenance tools and spare parts. The following discussion highlights the impact of these resources on maintenance work.

According to the research findings, a shortage of some resources related to maintenance work is more or less evident, as shown by the frequent shortages of spare parts and maintenance tools. The main reason behind this is the lack of sufficient concern from senior management to facilitate the activities associated with maintenance, which in turn reflects the lack of clarity of maintenance targets and the overall vision of the firms. For instance, the complex regulations and procedures adopted by top management often delays the purchase of spare parts more than it should. This delay causes an unplanned delay in finishing maintenance which directly influences the production process because the machine or device that is undergoing maintenance has stopped operating. Therefore, it could be said that the needed resources for effective maintenance are inadequately managed. Campbell (1995); Reason & Hobbs (2003) believe that the availability of resources such as maintenance tools and spare parts is an essential factor in improving maintenance work in an industrial institution.

8.6.8 External factors

From the research findings, it can be inferred that the power and right of these factories to make their own decisions by limited by law. Any decision-making takes a while because all managerial issues have to be approved by government bodies, such as the Ministry of Industry which is already under the external control of the state, by definition. It should be mentioned here that top administration is obliged to communicate with governmental authorities to discuss all decisions before they are adopted. As a result, decisions take a long time to be approved. This issue causes a frequent critical delay in maintenance, which in turn affects the production process. In maintenance a little delay can sometimes have serious consequences, such as damaging the components of the main kiln which cannot easily be addressed. Therefore, many issues have to be sorted out immediately to avoid possible risks. The social structure also plays a significant role in driving an organisation in Libya. The tribe's support, according to the study results, is essential for anyone who wants to be employed or be promoted at work. The relationship between colleagues in the workplace is likely to be influenced by the social system, which may lead to poor teamwork.

Thus, it can be said that managerial performance in these factories is substandard. This eventually has significant effects on the maintenance function and the whole factory's performance as well. Political and social factors usually influence the operation and function of industrial organisations (Bait-Elmal, Even more to the point, the Libyan industrial organisations are subject to the Ministry of Industry which determines the production targets and controls the budget according to the country's overall plan. Therefore, as the study results show, maintenance has not received the adequate care because of the limited budget allocated to it. The widespread strategy of "if there is a problem fix it" rather than any other such as TPM or RCM corroborates this. Without sufficient funding, it is very difficult to make any improvements in maintenance. Some authors, such as Kelly, (1997) and Cholasuke, et al. (2004) refer to the indirect adverse effect of budget shortages for maintenance activities, in support of this view.

This model could be developed into a series of guidance documents that could be used to conduct a study within a Libyan cement plant to determine the effectiveness of the different recommendations from this particular project that captured in the framework.

Chapter Summary

The research findings in this chapter concerned the four case factories selected from the cement industry. The objective of the research was to build a suitable model for improving maintenance aiming to ensure the maximum reliability of production systems in the targeted firms. The results of this research helped to improve the conceptual model for identifying the factors through which maintenance could be improved so as to ensure the continuity of production, as required.

To sum up, the conceptual model is a novel approach to optimise the maintenance practices and increase the reliability of production lines in Libya's cement factories. The next chapter concludes the research outcomes; it also presents the study's contributions to knowledge, together with the research limitations and some future research directions.

CHAPTER 9: Conclusions and Recommendations for Further Work

Introduction

The main findings of the research have been discussed in the previous chapter. The adopted methodology in this study was a mixed method, quantitative and qualitative, that employed a case study approach. The conceptual model was developed and discussed in the preceding chapter based on the findings from the four case plants and aims to help improving the maintenance practices within the Libyan cement industry. This chapter brings together the study results in order to draw some research conclusions. The contributions of the research to knowledge are summarised and presented and the limitations of the research are discussed. The present chapter also outlines a number of recommendations for future research based on the research findings. Finally, the conclusions of the research are stated.

9.1 Meeting the aim and objectives of the research

The Libyan cement industry is essential to the growth of the country as it is an indispensable part of infrastructure developing process. One of the challenges in this industry has been the lack of clear strategies for maintenance in achieving the maximum level of reliability of the production systems through which the continuity of production can be ensured. In exploring this, the following research questions were asked:

- 1- What maintenance strategy currently in place in the four cement factories?
- 2- What is the awareness level of related maintenance staff in terms of maintenance, its practices and its importance?
- 3- What are the barriers and difficulties affecting maintenance within the targeted factories?
- 4- What factors are likely to affect productivity from a maintenance perspective?
- 5- To what extent the level of adopted maintenance can be effected by the managerial performance?

The research questions were answered through achieving the objectives of the study. Ultimately, the research aim has been achieved successfully by addressing the specific objectives of the research, as follows:

The first objective was to identify maintenance and understand its theoretical basis, history, types, strategies and its applications in industry. A survey of the literature was conducted to achieve the first objective. An overview of maintenance including its history and definition, a classification of the forms of maintenance including preventive maintenance (PM), corrective maintenance (CM) and total productive maintenance (TPM) were presented. Definitions of maintenance strategies, the classification of their forms and their importance were discussed under the heading of maintenance strategies, with special reference to reliability-centred maintenance (RCM).

The second objective was to investigate as case studies the obstacles and difficulties affecting maintenance in four Libyan cement factories. In order to achieve this second objective, an overview of the Libyan background to the study was provided, including Libya's geographical features and population; its historical and political background; its social structure and economic system. In this research, there was a broad discussion on issues related to maintenance practices in the Libyan cement industry and the cement industry in general; the Libyan cement industry; its importance in Libya; its current situation and management issues for the four targeted Libyan cement factories.

The third objective was to investigate the impact of the managerial performance on the level of maintenance practices. In this mixed methods research, both quantitative and qualitative approaches were taken to widen the understanding of the obstacles to maintenance practices in the case study factories. Hence, a total of 132 questionnaires was distributed in the four targeted cement factories, 33 in each. 112 usable responses were obtained. In addition, 12 face-to-face semi-structured interviews were held with the managers of maintenance and production departments and other relevant figures in the four firms. The collected data were described, interpreted and then analysed, using in-case and cross-case analysis.

The fourth objective was to study the factors which should be included when improving the current maintenance. In this research, most of the common obstacles that affect maintenance activities and were found by many writers were presented. Regarding the level of maintenance practices in the four cement factories, this study discovered that the four cement firms generally shared the same characteristics. Hence, the four case factories, according to the empirical findings, faced almost the same problems in respect of maintenance practices and activities as had previously been identified in the literature review. Accordingly, it can be said that the obstacles to the practices and activities of maintenance in the case study firms were successfully investigated.

The fifth objective was to develop an appropriate model to improve maintenance for the company's factories, taking into account the possibility of circulating this model to other industries that have similar operating conditions. To meet this objective, the research findings were widely discussed under the heading of future improvements to maintenance and compared with the findings in the literature review with the aim of comparing and combining the factors affecting maintenance practices and activities found in the four cement plants. Therefore, the initial model for the study was revised, developed and then finalised in the light of the final research findings. By meeting the five objectives of the research and presenting the final model so as to improve maintenance in the four Libyan cement firms, the research aim was achieved and the five research questions were answered.

9.2 Contributions to Knowledge

The primary emphasis of the present research has been to investigate the level of current practices of maintenance and its effect on the reliability of the production systems. This reliability needed to be at as high a level as possible to ensure continuous production. Therefore, the main contribution of the present study is the conceptual model, which should help to put the four Libyan cement firms in a position to implement the strategy of the reliability-centred maintenance. This strategy is considered a solution for ensuring the reliability of their production systems at the highest level and thus increase operational efficiency, which ensures continuity and increases production. However, this research

includes several other contributions to the existing knowledge of maintenance and related issues. The study contributions are divided into theoretical and empirical, as detailed below:

Theoretically; the importance and significance of this study are clear from the following aspects:

- The study contribution to the existing knowledge representative in making terminology related to maintenance such as maintenance concepts, types, practices, strategies and importance very clear for the potential readers and researchers which will increase understanding and knowledge in this field.
- This study helps the Libyan cement industry to improve maintenance by identifying the obstacles and barriers that hinder successfully implementing maintenance.
- The research would benefit other researchers who seek to improve the state of the Libyan industrial sector in particular and perhaps other regions also, especially in the developing countries through identification of the key factors for the success of maintenance.

Choosing the Libyan context gives an opportunity to researchers even outside the engineering field to benefit from discovering and learning many of the issues that relate to geographical, historical, political, social and economic aspects of Libya.

Empirically, the importance of effective maintenance activities in practice and the need to increase the knowledge of maintenance and its practices in Libya's industrial organisations in general and cement industry in particular suggests that expanding the existing knowledge and awareness of the maintenance management literature in such a critical sector is a big contribution. However, importance and significant of the study are clear for the following reasons:

- There is a significant lack, it must be admitted, of empirical studies on obstacles to the introduction of effective strategies for implementing maintenance in Libya, as well as other countries all over the world, the developing countries above all. Therefore, this study contributes to the maintenance field by adding to the limited number of studies that are available. In this research, many of the results obtained were consistent with those found in other studies with different national backgrounds. Consequently, it can be said that this study reinforces the results of those studies.

- This research, in fact, is the first research in Libya’s industrial sector to focus on maximising the reliability of maintenance as one of the essential pillars supporting the highest reliability of production systems. Reliable maintenance ensures the continuity of production.
- The findings of this research will allow the shop floor staff of maintenance and production and their managers in the industrial sector to verify that improving maintenance has a significant positive impact on the reliability of production systems and in turn on increasing productivity. This could be done by identifying the improvements that are needed before the Libyan cement factories can compete, whether locally or globally.
- Some unique obstacles and barriers as summarised in Table 9, have been identified by this research, though they were not reported in the review of the literature.

Figure 9.1: The unique obstacles and barriers that affect the practices of maintenance in the four Libyan cement plants (source: author).

Technical barriers and obstacles	Managerial and organisational obstacles and barriers	Social-cultural and environmental obstacles and barriers
No programme for maintenance documentation	Some workers held unrelated maintenance certificates	Lack of commitment among Workers to perform the assigned tasks as they should
Low wages compared to the volume of achieved work	Low level of communication between senior management and its departments	The presence of inactive workers on the staff due to their tribal or personal power
Frequent maintenance backlog	No clear distribution of maintenance tasks	Lack of rewards and bonuses
Difficulty of getting spare parts in a timely manner	Too little attention from top management to maintenance requirements	Lack of motivation in many workers, due to the failure to take strict action against the uncommitted workers
No programme in place to evaluate the conducted maintenance	Exceptional support from top management to some employees regardless of their insufficient efforts	
The inability of many of the shop floor staff to absorb the relationship between continuity of production and the quality of maintenance	Influence on the decision-making process in the cement firms from multiple national bodies (Ministries of Industry and Labour)	
No clear programmes for training		
No cross factory cooperation		
No internet access		
No reliable manuals		

9.3 Limitations of the research

According to Yin (2009), all research is limited by the constraints placed upon the researcher. This study is like all the others in this respect. However, every effort was made to overcome limitations in order to ensure that this study was conducted smoothly. Despite this great endeavour, it was not possible to control all the influences that were likely to affect its quality of the study. These limitations are summarised as follows:

- The documents related to maintenance activities in the four cement factories are scarce. This has reduced the ability to confirm or refute some of the results obtained from both the survey questionnaire and the interviews. Data were further curtailed by the inability to take photographs when engaged in direct observation, which affects the clarity of description of the situations observed.
- Another limitation concerns the researcher's inability to contact the top managers due to unknown reasons. This may mean that some information regarding financial aspects and the ability of senior management to support maintenance activities is missing.
- In reflecting on the questionnaire and the results that have been achieved in this research, the researcher has realised that the use of words such as strong, medium, weak, sufficient, etc., there is a degree of ambiguity in the way to which the people responded.
- Given that Arabic was the only language spoken by most of the participants, both interviews and questionnaires were conducted in Arabic language and then translated into English. Although every effort was made to ensure the accuracy of the translation, there may be some minor differences between the two languages that affect the transfer of technical information.
- The developed model could have been applied in one of the four cement factories. However, due to time limitations and the ongoing political events affecting Libya, the idea was abandoned as too difficult for the present time, but it is still open to future researchers to consider it.

9.4 Recommendations for further research

This study has brought up many interesting questions that could be explored in further research regarding maintenance, its practices and its importance in the industrial field. This study represents a beginning rather than an end to the chance to explore further research focusing on maintenance as a way of increasing the reliability of production systems in Libyan industrial organisations and similar states. Through achieving maximum reliability, continuous production would be ensured and thus profitability would go up, which would increase the opportunity to remain competitive. Hence, in view of the research findings, the following recommendations are made in relation to maintenance practices:

- Applying the same conceptual model of the research to other industrial institutions seems to be the major direction for further research. This is because it would extend the current study and increase the chance of discovering the results of optimum improvement of maintenance in a rigorous way.
- Replicating this study with similar organisations in other countries in order to conduct a wider comparative analysis and thus develop greater understanding of maintenance and related issues than the present study allows. The similarities and dissimilarities of internal and environmental factors would allow further exploration of the ways in which the characteristics of industrial organisations in other countries work. The benefit of such an investigation in the context of similar manufacturing enterprises in different regions would help to assess the validity of the findings and conclusion reached by the conducted research.
- Although this research was conceived as an initial investigation into the field of maintenance in Libyan industrial organisations, it is clear that it could not possibly deal with all the issues related to maintenance. Therefore, further studies could be conducted to investigate in depth other maintenance aspects such as its cost, its continuous improvement and the organisation of a maintenance structure.
- Given that the main barriers to maintenance practices in the four cement factories have been identified in this study, it would be interesting and beneficial to highlight further how these problems could be

overcome elsewhere by introducing an appropriate model based on the results of this research. It could start by using the conceptual model which has already been developed in this study.

- Finally, the present study suggested RCM as a strategy for ensuring the success of maintenance. For this reason, it would be very useful to explore the methods of implementing and evaluating this strategy if it were introduced in the Libyan cement industry, by conducting a detailed study of the way in which this strategy worked in practice.

Chapter Summary

The conclusions in this final chapter are drawn from the research findings concerning the research questions. Overall, this thesis is believed to have made a significant contribution in the area of maintenance and its influence on the reliability of the production systems in the industrial organisations. Therefore this study can claim to have successfully achieved its aim and objectives and to have made clear recommendations and suggestions for future improvements. Some issues for future research have also been raised in the light of the research findings. The thesis provides a holistic review of maintenance improvement in the cement industry in Libya through a comprehensive literature review and empirical study. It has identified the obstacles to maintenance practice as discussed in the conceptual model. In such a critical industry it is necessary for maintenance to be planned from the very outset. The key to this success lies in implementing RCM to maximise the reliability of the production lines and thus ensure the continuity of production as it should. This work has shown that these four Libyan cement factories must be helped in many ways to improve the overall image of Libyan industry. The conceptual model of reliable maintenance which is the main outcome of the study has been developed for improving and assessing these plants and will help to add value to the improved forms of maintenance that they practise.

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Appendices

Appendix 1: Confirmation Letter



Appendix 2: Letter for asking the firms to participate in the research



Appendix 3: Data collection letter



Appendix 4: Participant information leaflet & consent form

Appendix 4.1: Participant information



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PARTICIPANT INFORMATION LEAFLET & CONSENT FORM

This interview is a part of a PhD study in engineering management by Khalid Albarkoly, School of Engineering and Applied Science, Aston University, Birmingham, UK. This doctoral program is currently funded by Libyan Higher Education Ministry. It studies the reduced efficiency of production systems in the cement industry in Libya, due to the problems and barriers facing the implementation of maintenance. This study looks for ways to implement a strategy of Reliability Central Maintenance which would ensure the reliability of the production system in a factory and thus increase its productivity. This study has been approved by School of Engineering And Applied Science Ethics Committee Aston University, Birmingham, UK.

Before you decide whether or not to take part, it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and feel free to ask the researcher if you would like more information or if there is anything that is not clear for you.

Title of the study

Studying the Need to Implement a Strategy of Reliability Centred Maintenance (RCM) in Libya's Cement Industry.

Purpose of the study

The aim of this study is to investigate the possibility of implementing a Reliability Centred Maintenance strategy (RCM) in Libya's ACC factories as part of a maintenance development program to make the factories' production systems as reliable as they should be. This study focuses on exploring staff (managers, engineers and workers perception as a way of assessing current maintenance and to what extent need to be improved. It touches in particular on academic staff who deal directly or indirectly with maintenance. The expected result from this study will reflect on the development of maintenance programmes and will be generalised among Libyan industrial sectors through journalism, workshop and conference.

Why have I been invited to participate?

You have been identified as someone who has a great deal to share about your experiences in maintenance in your factory.

Do I have to take part?

Taking part in the study is entirely voluntary. It is up to you to decide whether or not to take part. If you do decide to take part then I will describe the whole study to you. You will be given this information sheet to keep and be asked to give your formal consent to start the interview. If you agree to take part and later change your mind, you are free to withdraw from the study at any time and without giving a reason. Your **PERSONAL DETAILS WILL NOT BE USED** in the study.

What is involved if I decide to take part?

If you decide to take part in this study, Interviews will be conducted to gain an understanding of the barriers and difficulties that facing maintenance implementation in your factory, and your opinion to overcome such these problems, e.g. experience in using current maintenance strategy, the efficiency of current maintenance programmes as well as management support. The interview will last around 45 minutes

Will I be recorded, and how will the recorded media be used?

Yes, and a full transcript will be made of your comments. If you would like to review the transcript please let the researcher know and a copy will be sent to you.

Will what I say in this study be kept confidential?

All the data will be fully anonymised and your personal and organisational details kept confidential at all times. No such details will be shared outside of the immediate research team (the research and two academic supervisors)

For further information:

My supervisor will be glad to answer your questions about this study at any time. You may contact him at:



Thank you for your time!

Appendix 4.2: Consent form

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CONSENT FORM FOR IN-DEPTH INTERVIEW

Title of the Project: Studying the Need to Implement a Strategy of Reliability Centred Maintenance (RCM) in Libya's Cement Industry.



Please put a check mark (✓) in the boxes:

- I have read and understood the attached information sheet giving details of the study.
- I have had the opportunity to ask the researcher my questions that I had about the study and my involvement in it and understand my role in the study.
- I understand that my participation in this study is voluntary and I will not be paid for my participation. I am free to withdraw and discontinue participation at any time without giving any reason.
- I understand that taking part in this study will include being interviewed and audio recorded. If I don't want to be taped, then notes will be taken during the interview.
- I understand the data gathered in this study may form the basis of a doctoral dissertation to other form of academic publication or presentation.
- I understand that the data I provide will be treated as confidential, my anonymity will be protected and the researcher will not identify me or my firm by name in any reports, publication or presentation using information obtained from this interview.

Participant's Signature:
Participant's Name (BLOCK CAPITALS):

Date:

Researcher's signature:
CONSENT FORM FOR IN-DEPTH INTERVIEW

Date:

Title of the Project: Studying the Need to Implement a Strategy of Reliability Centred Maintenance (RCM) in Libya's Cement Industry.

Appendix 5: Survey introduction and questions

Survey on improving maintenance strategies in the Libyan cement industry:

A case study of Reliability Centred Maintenance Strategy as Implemented in the Factories of the Alahlia Cement Company

1. Introduction

This survey is a part of a PhD study in engineering management by Khalid Albarkoly, School of Engineering and Applied Science, Aston University, Birmingham, UK. It studies the reduced efficiency of production systems in the cement industry in Libya, due to the problems and barriers facing the implementation of maintenance. This study looks for ways to implement a strategy of Reliability Central Maintenance which would ensure the reliability of the production system in a factory and thus increase its productivity.

2. Benefits of the study to your company

The intention of this research is to determine how far the Libyan cement industry needs to improve the maintenance programmes in its factories. The results obtained will apply to your company and many other industrial companies within the research framework, and therefore, will help to review the performance your company's factories.

3. Confidentiality

Your reply will be kept completely confidential and anonymous and will be used for academic purposes only. Your participation in this study is completely voluntary, so if responding feels uncomfortable at any point, you can withdraw immediately from taking part.

4. Filling in the questionnaire

I would be very grateful if you could spare a few minutes of your valuable time to complete the attached questionnaire. To make it as clear and quick to complete as possible, most of the questions are in the form of questions followed by a set of optional responses. Please choose the answers which best indicates the current situation in your factory.

5. Contact information

If you have any question/s about this survey or you need any further information, you may contact the researcher in the following ways:



May I thank you very much for taking part in this study.

Section A: Respondent's background

In this section is a set of questions about you, such as your experience, qualifications and official position.

(Please tick the answer which applies to you)

RB.1. Gender

1	Male	<input type="checkbox"/>
2	Female	<input type="checkbox"/>

RB.2. What is your age?

1	Under 21	<input type="checkbox"/>
2	21-29	<input type="checkbox"/>
3	30-39	<input type="checkbox"/>
4	40-49	<input type="checkbox"/>
5	50-59	<input type="checkbox"/>
6	60-65	<input type="checkbox"/>
7	Over 65	<input type="checkbox"/>

RB.3. What is your educational level?

1	Below primary school	<input type="checkbox"/>
2	Below secondary school	<input type="checkbox"/>
3	Secondary school	<input type="checkbox"/>
4	Diploma	<input type="checkbox"/>
5	Bachelor	<input type="checkbox"/>
6	Master	<input type="checkbox"/>
7	PhD	<input type="checkbox"/>

RB.4. What is your qualification for working in maintenance?

1	Professional	<input type="checkbox"/>
2	Technical	<input type="checkbox"/>
3	Experience	<input type="checkbox"/>
4	Not relevant to maintenance	<input type="checkbox"/>

RB.5. What is your job title?

1	Manager	<input type="checkbox"/>
2	Engineer	<input type="checkbox"/>
3	Technician	<input type="checkbox"/>
4	Helper	<input type="checkbox"/>
5	Other (please specify)	<input type="checkbox"/>

RB.6. How long you have been with this factory?

1	Less than 5 years	<input type="checkbox"/>
2	5-10 years	<input type="checkbox"/>
3	11-20 years	<input type="checkbox"/>
4	21-30 years	<input type="checkbox"/>
5	More than 30 years	<input type="checkbox"/>

RB.7.How long you have been working in the field of maintenance?

1	Less than 5 years	
2	5-10 years	
3	11-20 years	
4	21-30 years	
5	More than 30 years	

Section B: Maintenance practices

In this section is a set of questions about the maintenance activities in your factory.

(Please tick all answers that apply to your situation)

MB.1.Do you deal with equipment?

1	Yes	
2	No	

MB.2.What type of equipment do you deal with?

1	Complex	
2	Simple	

MB.3.Are operation and maintenance manuals available for all items of equipment?

1	Yes	
2	No	
3	Not all (only critical ones)	
4	Not all (only expensive ones)	

MB.4.Has the production system ever stopped due to a technical failure?

1	Yes	
2	No	

MB.5.If yes, how many times has it stopped (an approximate average number)?

1	0-2 stops per month	
2	More 2 stops per month	

MB.6.Could you easily identify the fault(s)?

1	Yes	
2	No	

MB.7.What percentage of faults could be determined before they occurred?

1	Less than 25%	
2	25-50%	
3	51-75%	
4	More than 75%	

MB.8.Does your factory outsource its maintenance activities?

1	Yes	
2	No	

MB.9.If no, is the equipment maintained according to a specific and known schedule?

1	Yes	
2	No	

MB.10.As you are one of the maintenance team, do you have full information about the equipment that you are about to fix?

1	Yes	
2	No	

MB.11.Do you know of any maintenance strategies?

1	Yes	
2	No	

If no, go to MB.12.

If yes, go to MB.13.

MB.12.Do you want to learn about maintenance strategies?

1	Yes	
2	No	

MB.13.Which maintenance strategies (ies) are you aware of? (Please tick all that apply)

1	Reactive	
2	Proactive (Predictive/Preventive)	
3	Aggressive(Total Productive Maintenance)	
4	Reliability Centred Maintenance	
5	Other (please specify)	

MB.14.Does your factory apply one or more of these strategies?

1	Yes	
2	No	
3	Not know	

If no, go to MB.15.

If yes, go to MB.16.

What in your opinion are the reason(s) for not using maintenance strategies? (Please tick all that apply)

1	Lack of financial support	
2	Lack of senior management interest	
3	No needed for maintenance strategies	
4	Employees are not familiar with maintenance and its importance	
5	Other (please specify)	

MB.16.Which strategy is used in your factory?

1	Reactive	
2	Proactive (Predictive/Preventive)	
3	Aggressive(Total Productive Maintenance)	
4	Reliability Centred Maintenance	

MB.17. On what basis was this strategy chosen?

1	scientific study	
2	Experience	
3	Random	

MB.18. Do you think maintenance strategy currently used by your factory is appropriate?

1	Yes	
2	No	
3	Not know	

MB.19. What problems have you encountered when carrying out maintenance? (Please tick all that apply)

1	Financial	
2	Technical	
3	Managerial	

MB.20. Do you have a clear understanding of the importance of maintenance?

1	Yes	
2	No	

MB.21. Are there any plans to develop maintenance at your factory?

1	Yes	
2	No	

MB.22. How far do you agree that the targeted amount of production can be achieved by increasing the reliability of production systems?

1	Strongly agree	
2	Agree	
3	Neither agree Nor disagree	
4	Disagree	
5	Strongly disagree	

MB.23. Have you heard about Reliability Centred Maintenance as a strategy through which the reliability of production systems and hence continuity of production can be ensured?

1	Yes	
2	No	

MB.24. Do you think that there is a need to apply such a strategy in your factory as a part of the maintenance development programme?

1	Yes	
2	No	

MB.25. Has there been any previous attempt to use this strategy in your factory?

1	Yes	
2	No	

MB.26. At your factory are there any devices or system to monitor equipment?

1	Yes	
2	No	

MB.27.If yes, is there programme to calibrate these devices?

1	Yes	
2	No	

Section C: Management issues

In this section is a set of questions about the management issues that related to maintenance in your factory.

(Please tick all answers that apply to your situation)

MI.1.Do you receive any support from the management when you carry out maintenance?

1	Yes	
2	No	
3	When I ask	
4	If there is a big problem	

MI.2.Is there any cooperation between the maintenance and production departments?

1	Always	
2	Sometimes	
3	Rarely	
4	Never	

MI.3.What is the relationship between following employees in your factory?

		Strong	Medium	Weak	No relation
1	Engineers and technicians				
2	Engineers and Managers				
3	Managers and technicians				

MI.4.Is there any maintenance backlog in your factory?

1	Always	
2	Sometimes	
3	Rarely	
4	Never	

MI.5.Are there enough maintenance engineers and workers in your factory?

1	Yes	
2	No	
3	Don't no	

MI.6.If yes, what percentage of them, in your opinion, are qualified?

1	Less than 25%	
2	25-50%	
3	51-75%	
4	More than 75%	

MI.7.Are maintenance tools available?

1	Always	
2	Sometimes	
3	Rarely	
4	Not available	

MI.8.Are these tools stored properly?

1	Yes	
2	No	

MI.9.Can these tools be reached easily when needed?

1	Yes	
2	No	

MI.10.Are records kept of the maintenance tasks completed?

1	Yes	
2	No	
3	Sometimes	

If yes, go to MI.11.

If no, go to MI.12.

MI.11.How is the records documented?

1	Manually	
2	Electronically	

MI.12.In your opinion, why are no records kept? (Please tick all that apply)

1	Lack of senior management interest	
2	No need for documentation	
3	Lack of employee awareness of the importance of documentation	

MI.13.Is there any programme to evaluate the effectiveness of the maintenance carried out?

1	Yes	
2	No	

MI.14.Are you involved in the decision-making with regard to maintenance issues?

1	Always	
2	Sometimes	
3	Rarely	
4	No	

MI.15.Are your opinions and suggestions regarding maintenance of interest to senior management?

1	Yes	
2	No	

MI.16.Do you agree that maintenance tasks can be re-distributed to give better results?

1	Strongly agree	
2	agree	
3	Neither agree Nor disagree	
4	Disagree	
5	Strongly disagree	

MI.17.Are the factory's objectives clear to you?

1	Yes	
2	No	

MI.18.Are the tasks that are assigned to you clear?

1	Yes	
2	No	

MI.19. Are there privileged employees in your factory?

1	Yes	
2	No	

MI.20.If yes, what makes them privileged?

1	Receive special support from the administration	
2	They have a desire to be creative	
3	They have other goals	

MI.21.In your experience of the production systems of your factory, do you think they could run efficiently if they were well maintained?

1	Yes	
2	No	

MI.22.Did you attend any training courses in the past?

1	Yes	
2	No	

If yes, go to MI.23.

If no, go to MI.24.

MI.23.What kind of training did you receive?

1	Internal	
2	External	

MI.24.In your opinion, what was the reason for the lack of training?

1	Lack of senior management interest	
2	Lack of funds	
3	Lack of desire in training	

MI.25.Do you think that training programmes are important for improving your skills and doing your job better?

1	Yes	
2	No	

MI.26.Does your salary meet your basic needs?

1	Yes	
2	No	

MI.27.If no, do you do other work to supplement your income?

1	Yes	
2	No	

MI.28.Are you treated well by senior management?

1	Yes	
2	No	
3	sometimes	

MI.29.Does your salary include a performance related incentive?

1	Yes	
2	sometimes	
3	No	

MI.30.Have you ever received a certificate of appreciation from your employers?

1	Yes	
2	No	

MI.31.Do you want to find another job because you are dissatisfied with your present position?

1	Yes	
2	No	

MI.32.Does your factory organise any recreational programmes/trips?

1	Yes	
2	No	
3	sometimes	

MI.33.If you were ever injured or involved in an accident at work, did you receive adequate care?

1	Yes	
2	sometimes	
3	No	

MI.34.Does your factory have standards for security and safety?

1	Yes	
2	No	

MI.35.Do workers comply with these standards?

1	Yes	
2	No	
3	sometimes	

MI.36.Does your factory has an emergency system on standby in case of fire or other incidents?

1	Yes	
2	No	

MI.37.Have you ever received any kind of training for an emergency situation?

1	Yes	
2	No	

MI.38.Are the pollutants resulting from your factory's manufacturing operations measured?

1	Yes	
2	No	
3	sometimes	

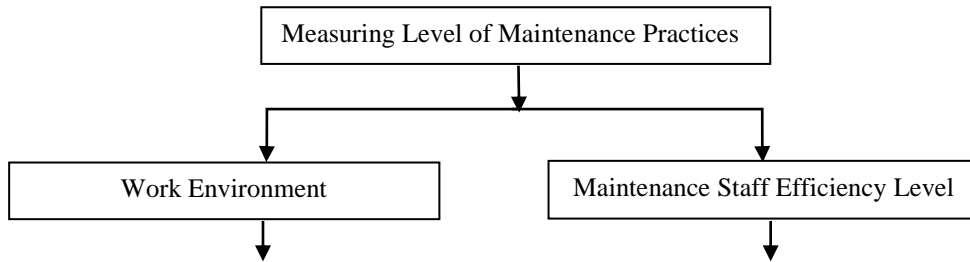
MI.39.Is waste (e.g. lubrication, oil) used and disposed of in an environmentally appropriate manner?

1	Always	
2	often	
3	Sometimes	
4	Rarely	
5	No	

Appendix 6: Interview questions

- Q1-** What is your position in the factory?
- Q2-** What is your qualification?
- Q3-** How long you have been with this factory?
- Q4-** How many workers in your organisation?
- Q5-** How many of them work with maintenance department?
- Q6-** What is the percentage of Engineers?
- Q7-** What is the percentage of them, engineers and technicians in total, are qualified in the field of maintenance?
- Q8-** How many of them have sufficient experience in the field of maintenance, 10 years or more?
- Q9-** How would you rate or evaluate their educational level?
- Q10-** Does your factory apply any kind of standards for employment?
- Q11-** As a maintenance department director, do you see that the current conditions of the firm's production systems can meet the production requirements?
- Q12-** Does your factory apply any strategy when performing maintenance?
- Q13-** From your perspective, how you would evaluate the level of adopted maintenance strategies?
- Q14-** On what basis was the current strategy chosen?
- Q15-** Are the maintenance staff, engineers and technicians, able to create or develop plans or programmes to improve the current maintenance strategy?
- Q16-** Is the surrounding environment appropriate for maintenance staff to do their jobs properly?
- Q17-** Does your factory face any problems when carrying out maintenance?
- Q18-** How do you evaluate the level of communication between the maintenance department and other departments such as production or top management?
- Q19-** From your point of view, what can be done to improve the firm's performance in general and in particular the Department of maintenance?
- Q20-** Are training programmes available for maintenance staff?
- Q21-** Any addition or comment?

Appendix 7: Observation check sheet



	Y	N	TSW		Y	N	TSW
- Performing maintenance based on				- Conducting meeting before maintenance work.			
- Scheduled plan.				- The ability to dismantle, replace and assemble the components of the production lines efficiency.			
- The sufficiently numbers of workers on the shop floor.				- Staff use the available tools and equipment correctly when performing maintenance.			
- Communications system.				- Give sufficient effort to achieve the required job properly.			
- The availability of maintenance tools.				- Work as a team.			
- Maintenance tools storage.				- Apply principles of occupational of health and safety.			
- Maintenance documentations.							
- The availability of spare parts.							
- The availability of safety and security System (equipment and devices).				- Conducting maintenance after maintenance work.			
Additional comments:							

Y = Yes; N = No; TSW = To Somewhat

Appendix 8: Transcribed interviews

Appendix 8.1: Transcribed interview (A – 1)

Interviewer: What is your position in the factory?

Interviewee: Manager of Maintenance Department.

Interviewer: What are your qualifications?

Interviewee: Bachelor of Electrical & Electronic Engineering.

Interviewer: How long you have been with this factory?

Interviewee: About 20 years in total and about 6 years of them in the maintenance department.

Interviewer: How many workers in your organisation, in total?

Interviewee: 596.

Interviewer: How many of them work with maintenance department?

Interviewee: About 55.

Interviewer: What is the number or the percentage of Engineers?

Interviewee: 20%.

Interviewer: What is the percentage of them, maintenance staff in total, are qualified in the field of maintenance?

Interviewee: About 50%.

Interviewer: How many of them has sufficient experience in the field of maintenance, 10 years or more?

Interviewee: Nearly 90% of them have been working in the maintenance department for more than 10 years and some of them have been working for almost 30 years.

Interviewer: How would you rate or evaluate the maintenance staff educational level?

Interviewee: About 50% of them held intermediate certificates or above.

Interviewer: Does your factory has any kind of standards for employment?

Interviewee: In fact, there are strict criteria for recruitment. There is a committee called the employment committee. The mission of this committee is to review applications of work seekers. The acceptance of these applications is based on the needs of the factory and according to the standards set by the factory such as education level, experience, curriculum vitae and courses attended in the field of maintenance. But the issue is that are not taken to comply with these standards often because the factory's management does not have absolute power in employment. There are many workers have been recruited from outside the firm. I'd like to say here that the factory follows the national sector, public sector. Therefore, it is subjected to the stated laws.

Interviewer: As a maintenance management director, do you agree with that the conditions of the current production systems can meet the production requirements or there is a need to improve these systems?

Interviewee: Actually the current efficiency of the production lines does not exceed 70% of the overall efficiency in the good conditions. There is an urgent need to update or replace some of the production lines such as operating pumps of production systems and central control system. These

lines become old, its lifetime ended and have no spare parts. We spend a lot when maintaining such these devices. As I said some of the production components become very old hence it is very hard to make it operate at the required level even if they undergo good maintenance. In other words, it is very difficult to increase the efficiency of the production under current conditions of the production systems. This has a direct negative effect as it causes fluctuation in productivity and stops production in some cases.

Interviewer: Which maintenance strategy is currently in place in your factory?

Interviewee: We still apply very traditional strategy called reactive maintenance or unplanned maintenance. This strategy is adopting on the theory of fix a machine or a device after stop or breakdown. Therefore, the costs and time of such strategy can't be controlled. In other words, using this strategy leads to a significant loss in time spent on maintenance work and thus loss of production. The unexpected interruptions for production systems need more time to be overcome which causes additional costs whether due to stoppage of production or increase spending on the unplanned maintenance as the failure cannot easily be recognised.

Interviewer: Do you mean that maintenance strategies currently in place need to be improved?

Interviewee: Yes, there is an urgent need to improve the current strategy and develop an integrated maintenance system. In the current time, it's not possible to adjust the effective of the current maintenance strategy as maintenance work is adopted randomly. We benefit from the staff members familiarity with the production lines components. Consequently, we rely on the senses of workers in identifying failures, as well as maintenance to be carried out. The proposed maintenance system will have significant costs at the beginning (high centre cost), but in the future, it will be very effective and will save more time and the maintenance cost will be decreased through adopting the effective strategy.

Interviewer: What is the integrated maintenance system?

Interviewee: Integrated maintenance system is a set of procedure or actions that need to be done or followed up to make the maintenance efficiency as high as possible. This with consideration of reducing time and costs. Adopting the system should start from identifying the plant objectives then studying or evaluating the current conditions of the production systems in terms of the possibility of increase its efficiency whether through better maintenance or replace some of its components. According to this, the optimal strategy can be chosen. Through the selected strategy the higher level of efficiency can be achieved with low cost and time.

As I mentioned earlier, the current strategy called reactive strategy or can be named run to failure. In some cases, preventive maintenance is applied. It adopted randomly and through maintenance staff experience with no specific study. It is applied, in sometimes, when maintaining the main kiln.

Interviewer: On what basis was the current strategy chosen?

Interviewee: As I said the preventive maintenance is applied in some time with the kiln by replacing the refractory bricks.

This strategy was adopted only based on the experience gained from dealing with production systems. The problem we face is that most of the maintenance staff are not aware of the maintenance strategies and some of them have no knowledge of the importance of maintenance improvement. In addition to that, the improvement programme cost a lot of money and the top management is not able to spend on such of these programmes. This is because it has no absolute right to use factory's revenues. This is really a big problem that we have been facing, as a result, hinder make any improvements. In addition to that, there is a shortage in operation and maintenance documents. The

available documents are written in English and most of the maintenance staff are not familiar with English. Therefore, the specifications of the production systems components are unknown for the most of the maintenance staff.

Interviewer: Is there were any previous attempts to translate the available documents to the Arabic language?

Interviewee: No, because it needs engineers who are they expertise in translation and familiar with the factory's production systems at the same time. Nobody from the firm's staff can do this.

Interviewer: Are the maintenance staff, engineers and technicians, able to create or develop plans or programmes to improve the current maintenance strategy?

Interviewee: Some of them can do that, but the rest of others need intensive training to introduce them to the importance of maintenance and the extent of development in this field. However, the lack of skilled staff forces the factory to contract with institutes who are specialised in the field of preparation and development of maintenance programmes. These programmes or plans should start from studying of the current conditions of the productions systems in terms of its efficiency, the possibility of improvement, the production requirement and the performance level of the staff on the shop floor. After that chosen of the appropriate strategy by which the maintenance time and cost can determine. In addition to the mechanism of implementation and its requirements such as the availability of spare parts and rehabilitation of staff to be familiar with the proposed strategy. The next step would be implementation stage through which the maintenance time is determined. Lastly, preparing the final report which would be a part of documentation program. Copies of this report should be sent to the relevant departments such as production department and top management. As I mentioned before the most of the current staff are not ready to create integrated programmes of maintenance. Experts are needed in this respect. In the same time, There is a big need for them as they can help in providing data and evaluating of production system conditions. This can help the contracted organisation in the preparation of the improvement programmes. Here I'd like to explain that this plan or program cannot be applied in the near future because the top management inability to fulfil financial requirements as such these programmes need to be authorised by the higher authorities.

Interviewer: Is the surrounding environment appropriate for maintenance staff to do their jobs properly?

Interviewee: I believe that, as maintenance department manager, more attention should be given to encourage maintenance staff to do their work better. These actions can be can be placed at several points:

- There is no strategy (programmes) through which the workers' demands can be viewed.
- There is no mechanism to evaluate the worker's performance.
- Employment system is very weak. This weakness usually causes the presence of workers who are unable to perform their work properly.
- Wages is low compared with tasks volume (achieved work) and the factory's revenues. Although our attempts with the senior management to reconsider the wages system, it's clear that the top management has no authority to rebuild the wages system. Because, as I mentioned earlier, this is the prerogative of the supreme state authorities as the factory follows public sector. This usually causes frustration for many employees and force them to do other jobs to improve their incomes. As a result, some workers lose concentration when performing their jobs as should.
- Social culture that imposes itself (social relations inherited) such as visiting relatives during work times or going out during work times to do or finish other activities such as shopping or visiting

patients. These factors and others have a negative consequence on the maintenance staff performance and on the whole factory employees as it causes confusion in the workflow.

- Some employees receive special support from the top management for some reasons such as their strong influence on the factory's management through dealing with outside parties which have authority on the firm's decisions. This resulted in presence of some non-desirable workers "unqualified in doing maintenance jobs". In other words, the number of maintenance workers is sufficient in total but the effective number is less than 50%.
- The low level of educational attainment, for example, there is some employees held diploma certificates in the mechanical field, but their knowledge level is much less than a diploma. This is, as I said earlier, due to the non-application of the strict standards when employment.

Interviewer: Does your firm face any problems when carrying out maintenance?

Interviewee: Yes, there are some problems, but most of them related to the state's laws. These policies restrict the factory's management in many aspects such as the delay in implementation of contracts for supply spare parts directly from its sources, standards of employing workers, the mechanism of payment of salaries and incentives, as well as non-eligibility of the factory in benefiting from its revenues.

This is because the factory follows public sector and therefore, its powers is very limited. This is completely different for private sector companies where senior management and other departments such as maintenance have stronger and wider power in the enactment of laws and legislation. If the firm converted to the private sector, I'm sure that this will contribute to raising the efficiency of these departments and thereby increase the efficiency of the factory as a whole.

Interviewer: Is there any communication between the maintenance department and other departments such as production?

Interviewee: Yes, we have a good relationship with all sections, especially production. There are regular meetings between our department and the production department. As well as the use of the other available methods of communication such as telephones.

Interviewer: From your point of view, what can be done to improve the factory's performance in general and in particular the department of maintenance?

Interviewee: I believe that there is an urgent need to privatise the public sector to avoid dealing with the state's policies and regulations. Thus, increase the opportunity to keep up with development in this area which inevitably will lead to the possibility of competition in both domestically and globally. In the private sector employees are rewarded based on their ability in doing jobs better or the volume of achieved work. This will create a great competition among employees.

Interviewer: Are training programmes available for maintenance staff?

Interviewee: Training programs are widely available to all. Top management spends large sums of money on training programs either internal or external.

- Unfortunately, the benefit from these programs is limited. I would say about 25% to 30% in its entirety. This decline is due to several factors which can be summarised as follows:
- The background of a good number of workers is not related to maintenance field. I mean that the background of many workers regarding maintenance activities is very limited. Therefore, those employees are useless. Thus, it's not easy to rehabilitate them and increase their efficiency through training programs. In other words, training programs are often ineffective. This brings us back to the first square which is the social structure of the community that depends on the support of the tribe in employment. Therefore, the maintenance management and even senior management does not have the authority to exclude or dismiss them.

- Many workers lack the desire for training as a result of lack of management support in many aspects such as rewards. This leads to the qualified workers will do the hardest part of the work because the others are incapable of performing the assigned work as required. Hence, they will be a heavy burden on the plant in terms giving them salaries or providing them with other facilities without any payoff.

Interviewer: Do you have any comment or addition?

Interviewee: No.

Appendix 8.2: Transcribed interview (A – 2)

Interviewer: What is your position in the factory?

Interviewee: Head of Operation Division (one of the production department bodies).

Interviewer: What are your qualifications?

Interviewee: Bachelor of Electronic Engineering.

Interviewer: What is your experience in the field of production?

Interviewee: More than 27 years in the field of electronic and worked about 15 years in the maintenance department. Five of them as the head of the maintenance department.

Interviewer: How many workers including engineering and technicians in your department?

Interviewee: The total number is more than 100 and most of them are technicians and workers.

Interviewer: Is the number of production staff sufficient?

Interviewee: The number in total are very sufficient but the active staff are less than this number. This is because of some reasons such as not comply with the employment requirements or standards. This generated the existence of disqualified or incompetent in the field of production. Comply with social issues which have direct negative effect on workers behaviour. This can be seen in getting out during the work time to do other activities such as visiting patient or shopping in addition to using personal phones for the purposes unrelated to work. These leads to what we called nonproduction hours. In other meaning, the benefit of a worker is zero percent in sometimes.

Interviewer: As you have worked with the maintenance department for a long time, and regarding what you mentioned, is the maintenance departments influenced by such these?

Interviewee: All the factory's departments are affected not only production or maintenance. Such this matter, in sometimes, forced maintenance department to outsource maintenance to finish some accumulated work. This causes additional costs to the production process which can be avoided if more attention could be given by the workers when performing maintenance.

Interviewer: How many percentages of maintenance staff are qualified to do their jobs well?

Interviewee: There is a big shortage in training especially for maintenance and production staff. Most of the staff members rely on their experience in doing the assigned work which they got through their work in the factory.

Interviewer: How would you rate the scientific qualifications?

Interviewee: Most of them held certificates from medium institutes or below. The real problem is that the qualifications of a good number of workers are not related to the production or maintenance. For example, some of them have secondary school certificate.

Interviewer: On what basis are labour recruitment?

Interviewee: Currently there is no employment because of the current situation of the state. In the past. There are no strict criteria for selection of professionals in the required fields. We apply just some basic requirements such as the knowledge of how to operate pumps or maintain simple machines. There is a need to set employment standards in the future so the factory can get a full benefit of its workers. This is very difficult now, considering that the plant is directly under the control of the Ministry of Industry which limit the factory's power in this aspect. Many of workers in the factory have been employed by this ministry or other bodies such as the ministry of manpower.

Interviewer: As you directly dealing with the production systems in the factory, do you think that these systems are operating as should or some improvements are needed to increase its efficiency?

Interviewee: Surely there is a big need to do some improvements. Although there are attempts to make an improvement on some production lines, we still use our experience to do this. For example, the staff could replace the cooling fans of some major production components such as ventilation fans and replace some of the main kiln heaters. These improvements show the increase in the level of this equipment efficiency and this could give us a big sign for the need to improve the whole system. Unfortunately, the improvement of such old systems needs a very big effort. I mean a sufficient attention need to be paid by the top management through support and encourage the factory's department to improve the overall firm's efficiency each according to its respective field.

Interviewer: Through your position as the manager of the production department, do you see that the maintenance programs currently in place are appropriate?

Interviewee: In fact maintain the machines or equipment is adopted based on our report of occurrences of a fault. I mean that the maintenance work is done after the failure occurs. As a result, the maintenance outputs are not successful in sometimes. This can be observed in sudden stoppages of some production lines component. This breakdown, in sometimes, affects the whole production lines. Adopting ineffective maintenance lead to the inability of maintenance staff to perform their jobs in a proper way as they have no clear plan for the maintenance job need to be done. This cause accumulating in maintenance. This gives me a clear evidence of that they use the non-appropriate strategy of maintenance. Some employees need to be trained or retraining to be able to choose the proper strategy of maintenance. From our side as a production staff, it's clear that some of the production systems became old therefore become unreliable and cannot meet the production requirements even they undergo good maintenance. This forces the maintenance staff to give a special attention to these systems to ensure the minimum level of its required efficiency. In other meaning, the level of achieved maintenance cannot be as good as should according to the current conditions of the production lines. This can be seen in the breakdown of production for long hours and in sometimes for a day or more. This can be avoided if what has the provision been of appropriate conditions such as spare parts, skilled workers and implement an appropriate maintenance strategy.

Interviewer: Do you believe that the improvement of maintenance will have a positive effect on the efficiency of production systems thus increase the production amount?

Interviewee: Yes, and through my knowledge of these systems, I think that many of the production lines can operate more efficiently and the level of its reliability can be increased if some improvement could be made and adopted a suitable strategy of maintenance. As I said early the

surrounding environment such as training programmes need more attention to support the workers skills.

Interviewer: What are the aspects that you think it should be concentrated on more when improving maintenance?

Interviewee: There are many points. For example, improvement of workers capabilities through providing good and appropriate training courses which can contribute to raising their efficiency. This will give a big opportunity for workers to improve their ability in recognising a failure more quickly. This is exactly what the maintenance department are suffering from when we report them about the existence of a failure or a problem in a production line or an equipment. The speed of discovering failures depends on the efficiency worker (engineer or technician) as well as on the adoption of appropriate strategy which can predict the location and type of failure in a manner time. The possibility of dealing with machines is better for the people who specialise in maintenance.

Interviewer: Is there any cooperation between production and maintenance departments with respect to maintenance issues?

Interviewee: Yes, there is continuous communicates on this side. We do regular meetings called technical meetings. These meetings focus on the maintenance actions that should be done according to our reports to the maintenance department. In these meetings, we could observe that the maintenance staff are motivated to make some improvement for maintenance. I believe that this is not an easy task as the production systems need some improvements.

Interviewer: Do you agree that the work environment is suitable for workers to perform their jobs as should?

Interviewee: It's fairly good. The workers requirements usually taking into account such as their social commitments which sometimes force them to leave the work site during the production times. Such these matters usually acceptable as long as there is an alternative worker to cover the shortfall caused by someone absence. In addition to that, we give the workers the opportunity to choose duty hours that suit their circumstances. We aim to make the employee relax as much as possible so he can perform his job as required.

Interviewer: Are there programs to motivate workers such as reward?

Interviewee: In sometimes, the workers are given rewards for their overtime or when they assigned other tasks out of their work scope or responsibilities. The factory gives such these rewards based on the available budget or resources. In many times, this cannot make the employees satisfied as much as should which can be evidenced through the low efficiency of their performance.

Interviewer: As the production department, do you face any kind of problems that resulted from the lack of giving enough attention and at the right time by the maintenance department staff?

Interviewee: Honestly, the maintenance department team is making major efforts in the completion of maintenance work as required. As I said before, there is no clear program through which maintenance jobs can be performed properly and in a timely manner.

Interviewer: Are there any obstacles or problems facing the production department during the work times?

Interviewee: From the workers performance side, the social issues is the biggest obstacles that encountering the production process. For example, many employees come late to the work in

sometimes. Moreover, they do other activities during the work time such as using their mobile phones. According to the state regulations, we have no control on this as only the higher authorities have the full right to employ or dismissal of staff.

Interviewer: Are there any stoppages in the production caused by maintenance staff because of the failure in the fulfilment of their duties?

Interviewee: This can happen in some cases. The reason of that is the inability to identify the failure properly and in a timely manner. In sometimes, one or more of production lines will breakdown. As a result, there will be a maintenance backlog which can lead to the breakdown of the whole system. Here I'd like to say that, although the top management gives a full support to the maintenance department in providing maintenance tools and spare parts, there are no good programmes to encourage the employees by providing them with some facilities such as incentives and promotions, trips etc. We always ask the senior management to pay more attention to provide the employees with some facilities such as the needed training and rewards to increase their skills and motivate them to do work better.

Interviewer: Are there any cooperation among maintenance and production department and top management?

Interviewee: The cooperation level is excellent, For example, as a production department, when we notify the maintenance department of the existence of something wrong their response usually quick and they try to do their best to solve the problem or failure.

Interviewer: Do you have any comment or addition?

Interviewee: No.

Appendix 8.3: Transcribed interview (A – 3)

Interviewer: What is your position in the firm?

Interviewer: Manager of Packing Department (In charge of Production Department in this period).

Interviewer: What are your qualifications?

Interviewer: Bachelor of mechanical engineering.

Interviewer: The period of work experience?

Interviewer: More than 22 years in the factory, I've worked for 16 years as the head of the maintenance department and about 6 years in the current position.

Interviewer: What is your qualification in the field of maintenance?

Interviewer: I gained good experience through my work for a long time as manager of maintenance management.

Interviewer: How many workers, including engineering and technicians, in the production department?

Interviewer: The total number is about 75 employees most of them are technicians. Although there is some difference in the assigned tasks for the engineers and other staff, all of them are under the name of operators.

Interviewer: Is this number sufficient to the job as should?

Interviewer: The number in total is sufficient but some of them are old now hence their abilities became limited. In another word, their efficiencies are very low. This caused what we are called unused or inactive members, as a result, the total percentage of effective members is about 50% to 65%. For this, I believe that there is a big need to rebuild the current staff with taking into consideration the application of appropriate employment standards.

- Here I'd like to mention to that most of the active staff use their experience around 70%.

Interviewer: As you was the maintenance manager for a good period of time, do you noticed the same issue with the maintenance department or they are different?

Interviewer: Maintenance department suffices more other in the respect of the extent of inactive workers. According to my experience as a manager of the department, staff with very high skills should be available on the shop floor when needed to ensure the success of maintenance. As you may know the efficiency of production lines in such this critical institution is directly affected by adopted maintenance.

Interviewer: Do you mean that the factory does not apply standards when employment?

Interviewer: In fact, there are good standards for employment but not comply with these standards.

Interviewer: As you are the head of the production department as well has a good experience working with the department of maintenance, do you believe that the improvement of the current production systems can increase its efficiency?

Interviewer: Yes, we are late in this field. Many of production lines or at least some of its components need to be improved. In addition to that, some of these lines or some of its components need to be replaced due to its old age. They cannot meet the production requirements such as speed in production and meet the safety and security standards such as main ventilation filters. Moreover, it cost to maintain them properly. There is a need for smart or computerised machines which can be electronically controlled with observation devices such as sensors and cameras. This system would help in reducing the unexpected failures of the operated machines and devices. Many of maintenance members are surprised of the improvement offers provided by some specialities companies. These offers contain advanced systems in the field of cement industry.

Interviewer: Is your factory apply any strategy for maintenance?

Interviewer: We use our experience in dealing with devices and adopting the suitable maintenance work. The maintenance work is done only if there is a fault. Some devices have scheduled maintenance such as the main kiln. The production and the maintenance departments are not able to make any improvement on maintenance due to the lack of some important requirements such as skilled staff who can propose or create plans for improvement.

Interviewer: Do you believe that this type of maintenance is appropriate or need to be improved?

Interviewer: The improvement is constantly needed. In our firm and compared to the current conditions of the production systems, the maintenance strategy currently in place cannot be easily improved. We can observe that maintenance cost is higher than should as this strategy depends only on the staff experience and, in many cases, the maintenance output itself is minimum as we adopt no pre-planned maintenance. Making any improvements on the current production lines means that the current strategy needs to be updated so to meet the new conditions of the improved lines. However, production department has been facing problems regarding operating the production lines

as sudden stoppage of any of component of these lines is likely to be accrued due to the lack of scheduled maintenance.

Interviewer: Is there any training courses for staff?

Interviewer: Yes, the courses are available but not as required. Most of the training programmes are represented in visiting other industrial institutions, some internal and others exertional. I mean the offered training are considered non-intensive and cannot meet its purposes. Therefore, the benefits of such programmes are very limited.

Interviewer: Is the surrounding environment appropriate for maintenance staff to do their jobs properly?

Interviewer: In fact, the salaries are insufficient and do not meet the daily needs of the employees. We suffer from the unjustified support given by the top management to some workers who their efficiencies below the minimum. This usually makes others disappointed especially skilled people as they believe that they work hard and the support given to inactive workers.

- There is a mismanagement in respect of allocation of rewards and Incentives. For example, we find in our factory that it's possible for non-maintenance or non-production staff to receive what we called technician reward because of their close relation to the senior management. This makes the maintenance and production staff disappointed and not motivated enough as they believe that they work hard and get a little. Some of them wanted to move to or looking for other jobs. We need the top management to work with us as a team to overcome such these obstacles.
- In my opinion, there should be a distinction between workers each according to his effort. For instance, it cannot be equality among workers who are making a big effort on the work site and others who just sit behind their offices. This matter usually causes some frustration for some employees. As a result, some of them wanted to move to other jobs which it is the loss of the plant.

Interviewer: Do you mean that you have been facing some difficulties in dealing with the top management?

Interviewer: Although of the limitation of active workers, they do not receive an adequate attention from senior management. For example, we forced, as maintenance and production departments, by the top management to complete maintenance at a particular time despite the lack of the necessary requirements such as maintenance tools or spare parts.

- There is no sufficient support to improve maintenance strategies so it can meet the production requirements. Despite the availability of some engineers who could help in creating plans for improvements.

Interviewer: What is the cooperation level between the factory's departments?

- Most of the factory's sections have an excellent relationship with each other. There is a big cooperation among the departments and according to the available potentials.
- There is, for example, a quick response from maintenance staff when we inform them of an existence of any failure of a problem in a production line.

Interviewer: As manager of the production department, do you think that maintenance currently in place is effective?

Interviewer: The biggest problem that we encounter is a non-distribution of tasks properly. This is due to non-application of appropriate strategies for implementation of maintenance which take into account all the surrounding circumstance such as the efficiency of maintenance staff, the availability of spare parts and the required financial support to fund the maintenance process. The evidence of this can be seen in maintenance backlog which caused, in sometimes, failure of one or more of the

production lines. As a consequence, fluctuation or stoppage of production. As I said this originally results from the lack of clarity of maintenance tasks and in some cases low efficiency of the employee who is in charge regarding his understanding of the mission that assigned to him. The maintenance departments have been trying to solve such issue by applying what we call the job description. According to this, the maintenance staff is divided into two teams. The first team named the supervisory maintenance staff. This team has to monitor the machines and the devices during their operation times. The other staff, the maintenance team, is specialised in doing maintenance works. Despite this, and in many cases, the supervisors have no clear plans for monitoring and observation. There is a confusion in performing tasks among these categories in performing the assigned tasks. Poor distribution resulted in an inability to punish the workers for their mistakes. The top management inability to punish workers is another reason that led to the lack of interest of employees to perform their work as required.

Interviewer: Any addition?

Interviewee: No.

Appendix 8.4: Transcribed interview (B – 1)

Interviewer: What is your position in the factory?

Interviewee: Manager of Maintenance Department.

Interviewer: What is your qualification?

Interviewee: Bachelor of electric engineering.

Interviewer: How long have you been worked in maintenance field?

Interviewee: 19 years in the factory and 15 of them in the maintenance.

Interviewer: How many workers including engineers in the maintenance department?

Interviewee: The total number is about 50 and about 25% of them are engineers.

Interviewer: Do you think this number is sufficient?

Interviewee: In fact this number is insufficient. There is a need for nearly other 50 workers. This need because there is a continuous need for maintenance as many of the production lines aged 30 years old or more. Therefore, faults or breakdowns in one or more of the production lines are highly likely to occur. I mean more effort is needed to control the repeated failures. Production lines Improvement is needed to reduce such unplanned failures which cost a lot either in spending on additional maintenance or losses due to unexpected stoppage of the production.

Interviewer: Are workers qualified enough in terms of experience and qualification levels to perform the maintenance works as required?

Interviewee: The largest percentage, about 55%, rely on their experience in doing maintenance job. Some of them their qualifications are not related to maintenance. For example, there are some workers held a welding certificates. The main reason for the existence of such class of employees in the firm because we do not have the right to reject them. The appointment is only by to either industrial Ministry or the Ministry of Manpower.

Interviewer: Does this mean you rely on training programmes to raise the workers' efficiency and skills in the field of maintenance?

Interviewee: Although the training is very important to improve the staff skills and increase their abilities to do the work as should, we do just internal training courses which are inadequate. The shortage in such programmes because of that the factory's management has to have permission from the higher authorities in adopting these plans. In my opinion, the level of external courses is much higher than internal. It gives the staff opportunities to join specialised institutes in the field of maintenance. As I said some of the maintenance staff held unrelated maintenance certificates and some others their educational levels are low. This means that intensive training is needed to increase their performance efficiency. Therefore, the top management cannot cover the significant financial cost of such these courses.

Interviewer: Does your mean that the lack of employment standards is considered as the main cause of the lack of qualified and skilled workers?

Interviewee: In fact, we do have a good recruitments programmes. The factory management does comply with these standards. As I mentioned the firm has no full control on such these programmes. We have to have a permission from the industry ministry before the final acceptance of any new employee. Therefore, do not be surprised if you met a wrong employee in the right place. I mean, in some cases, the employment of a person rely on his ability to contact people who they have sufficient power for employing regardless the applicant qualification, experience and skills as well the institution need for him.

Interviewer: Do you believe that there is a need to improve the current production systems along with the improvement of training programmes?

Interviewee: Surely, there is a permanent need for improvement. For the current systems, we are trying to increase its efficiency as much as we can. Our systems are very old compared to developed cement factories. Most machines are manually operated. From the maintenance side, we have been suffering from the constant accumulation of maintenance work due to the frequent and unexpected failures of the machines during the production process. Workers, in some cases, are not able to finish maintenance work as required under the current poor conditions of the production lines. In addition to the lack of clarity of the factory's objectives and based on which plans for maintenance can be created. This usually leads to fluctuation in production and, in sometimes, full stoppage in production. However, the improvements programmes will help us in several aspects. For instance, increase the reliability of the production lines, reduce maintenance costs to the lowest level. Improvement of the production lines will allow us to choose the appropriate strategy for maintenance through which the reliability of the production lines can be ensured during the production process. Furthermore, it gives us a good chance to redistribute the maintenance tasks properly.

Interviewer: Do you apply any strategy of maintenance?

Interviewee: The most common strategy is reactive maintenance or what is called breakdown maintenance. This maintenance is chosen based on the current situation of the production systems. In sometimes, preventive maintenance is performed for the whole system when the main kiln is stopped for regular maintenance. The stoppage of the main kiln is done according to what is called the annual productivity plan. This plan is prepared along with the beginning of every production year where the stops number for the main kiln are determined.

Interviewer: On what basis are chosen this strategy?

Interviewee: We do have no ready programmes or plans for adopting the current strategy. In fact, some workers held unrelated maintenance qualifications and some others need to be trained. Despite this, many of them are experienced in maintenance as they have been working in the factory for a long time. There are some steps, as I said, needed to be taken before chosen or improving the current strategy of maintenance. For example, good training is needed for most of the maintenance staff members as their knowledge regarding maintenance practices, importance and strategies are low. Now the factory has started with this by establishing, as the first step of improvement, an office called documentation section. The main aim of this section is to evaluate the current situation of the production systems and its components. I believe that this attempt will be a good starter, and through which the other needed steps for this improvements can be achieved more easily.

Interviewer: To what extent do you believe that the adopted strategy is appropriated?

Interviewee: As I mentioned before, the current strategy is chosen upon the experience of maintenance staff. Therefore, there is a big need for improvement to decrease, for example, the number of unplanned stoppages which usually causes fluctuation in production. This needs a comprehensive study of the current condition of the systems and its need for improvement or replacement. In addition to evaluating the efficiency of workers and then provide them with the appropriate training to update their knowledge and improve their skills so they can meet the improvement process. Therefore, it can be said that expertise is needed to help the staff in creating suitable plans for improvement. Moreover, there is a shortage of monitoring devices through which the machines can be controlled during their operating process. I believe this would be very helpful in decreasing the maintenance costs through reducing the unplanned or sudden failures as well as documentation will also help in the success of maintenance work. The documentation is kind of monitoring but we still do it manually. Back to your question, it is not easy to assess the current strategy in the absence of these requirements that I have mentioned. We do our best for the success of maintenance.

Interviewer: Is it possible for the current staff to make any improvements on maintenance?

Interviewee: As I said, there is a need for specialists in maintenance. The current staff need special training so they can determine the requirements for the improvement of maintenance properly. But at the same time, there is a big need for them as they familiar with the production systems. This is very important when preparing of the improving programmes. It is possible to fully benefit from their working experience in providing many data about the production machines and devices as the majority of them has been working in the factory for long times.

Interviewer: Do you face any problems when performing maintenance work?

Interviewee: The spare parts are the most needed at this time. Many of these parts are locally available, but the problem lies in our inability to provide these parts in a timely manner due to complicated administrative procedures. To get a spare part we have to follow a long managerial cycle. This may cause a delay in finishing maintenance on time which in turn leads to stop production in some cases. The unplanned breakdowns which make maintenance process more complex and not easy, and cannot be achieved in a timely manner is another obstacle we face during the production process.

Interviewer: Is the surrounding environment appropriate for maintenance staff to perform their jobs properly?

Interviewee: In general, yes the factory gives incentives and bonuses for the employees when they are available. There is still need to re-organise such these programmes so that they are available for everyone. The workers requirements are usually taken into account by senior management. For example, transportation from and to work is available for everyone. Healthcare is available in the event of work-related injuries and accident. We really do our best to make the work environment as good as should.

Interviewer: In your opinion, is it possible to increase the efficiency of production systems through improving maintenance strategies?

Interviewee: Surely yes, but the overall efficiency cannot reach even to 80% in the good conditions. Some of the production lines operate with slow speed due to its old age. We forced to turn off some of the production lines from time to time because if they run for long period of time causes a high temperature. As I said it is not an easy task to improve maintenance or apply new strategies for maintenance before making an improvement on the production systems. I mean it is worthless to make changes on the current maintenance under the current conditions of the production lines and the lack of another requirement such as improve the efficiency of the maintenance workers.

Interviewer: Is there any communication between the maintenance department and other departments especially the production department?

Interviewee: We do our best to contact all departments and update them with any news regarding maintenance. In fact, everyone is collaborators and have a desire to improve production conditions. This is what we notice through our meetings with other departments. The availability modern communications channels such as the internet would improve the overall performance of the plant thus the possibility of overcoming any obstacles such as the delay in providing the needed spare parts in a timely manner.

Interviewer: Do you have any comment or addition?

Interviewee: No.

Appendix 8.5: Transcribed interview (B – 2)

Interviewer: What is your current position?

Interviewee: General supervisor of Operating and Production.

Interviewer: What is your qualification?

Interviewee: Diploma in mechanics with some internal and external courses in the field of production

Interviewer: How long have you been working in this field?

Interviewee: 23 years in the production field. I'm familiar with maintenance and always processions for maintenance work.

Interviewer: Do you have any idea of the number of workers in the departments of production and/or maintenance?

Interviewee: The total number in the production department is 65. All of them work as shifts.

Interviewer: Do you think that this number is sufficient in the department?

Interviewee: No, it's not enough. In the past, the number was bigger than this, about 100. Some of them retired and some others have moved to another company. They are looking for better positions.

Interviewer: To what extent those workers are qualified?

Interviewee: There is a good number of qualified staff, but many of them rely on their experience when performing the jobs, about 75%. If we combine the people who are qualified and have experience, it can be said that the total percentage of active staff can reach to 70%.

Interviewer: Do you apply any standards for employment?

Interviewee: There is a committee called employment committee. But they do not comply with these standards in many cases. The factory has no absolute right in elopement. We have to take orders from the higher authorities. Honestly, some of the workers have been employed by the ministry of industrial. They were not subjected to any test. Moreover, some of them held unrelated work field certificates.

Interviewer: Is there any programmes to raise the efficiency of workers, such as training courses?

Interviewee: Yes, especially the internal training. Some of the employees need intensive courses as their backgrounds are not related to maintenance or production field. Some others their knowledge need to be updated so they can engage in the improvement process in a better way.

Interviewer: As you already mentioned to that you are familiar with maintenance, does the maintenance department apply any strategies for maintenance?

Interviewee: The maintenance staff are performing maintenance work when they informed the existence of a failure of a device or one of the productions lines. In some cases, they adopting preventive maintenance, especially when the main kiln undergo to periodic maintenance work. Even in such cases, the maintenance is performing upon the device or machine condition. For example, we only maintain machines that run for long period. There is no clear plan for maintenance and the adopted strategies mostly generated from the staff experience.

Interviewer: In your opinion, do you believe that the current production systems could work at sufficient efficiency or need to be improved?

Interviewee: In general, the current efficiency of these systems is sufficient compared with their ages. On the other hand, I believe that the improvement is needed from time to time to ensure the maximum reliability of the production lines during the production process. Many benefits can be gained by this improvement such as update workers with the advanced technology regarding chosen and implementation of maintenance properly. The chance of competitive in the cement industry either locally or globally can be increased through ensuring the maximum of production.

Interviewer: Do you have any idea or knowledge about the adopted procedure for selection of the current strategy of maintenance?

Interviewee: I think there is no specific plan for the current strategies. The maintenance department tries to adopt these strategies according to what called the productivity plan. This plan is built according to the targeted amount of production for each year. This is usually along with determining the expected obstacles such as the shortage of spare parts. Therefore, maintenance is done based on our reports about the existence of a failure of a problem.

In addition to this, the comments or feedback received from both departments, maintenance and production are taken into account when creating the annual productivity plan.

Interviewer: Do you believe that the maintenance strategies currently in place are appropriated and effective?

Interviewee: It's appropriate to somewhat and compared to the available resources and to the current conditions of the production lines. This can be observed through the number of stoppages that occur during the production times which is few. But the idea is that to keep up to date with the developments in this field, the efficiency of the production systems need to be increased. This can be done through improving the components of these systems. The next step is the improvement of the current maintenance strategy to meet the new conditions of the improved systems. The maintenance improvement processes include increasing the staff skills. Most of the employees have strong desire to improve their skills which increase the opportunity for improvement success. We need a strong support from the senior management in this regard.

Interviewer: Do you mean that there are some steps need to be taken before improving maintenance?

Interviewee: Yes, as I mentioned previously the first step is looking at the ways of how to improve the conditions of the factory's assets. Then determining the requirements of maintenance strategy improvement. This includes training of the employees, improve the shop floor conditions and introduce monitoring programmes. Before these steps, we need to improve the documentation system as all of the factory's departments still do it manually. Using the appropriate documentation we can make the right decision to determine which components or lines need to be improved or replaced.

Interviewer: You already said that there is a need to raise the staff skills. Do you mean that this staff cannot make this improvement?

Interviewee: Yes, But this does not mean that the staff members are not qualified enough to improve the current maintenance strategies. I mean here that the skills and the knowledge of the workers need to be improved if some improvement could be made on the production systems so they can meet the new conditions of the production lines. Therefore, it is better to engage experts who specialise in this field.

Interviewer: Are there any obstacles preventing you from achieving the target amount of production?

Interviewee: Most of the problems encountering the production process are that some of the production lines are old thus its efficiency are very low. They are costly in two aspects. The first one is that they are likely to stop working at the unexpected time. Therefore, more time is needed and extra money paid to maintain these components. Unexpected failure means that that the stoppage period of a production line is likely to be longer than should which result in the loss of production.

Interviewer: Is the work environment suitable for workers to perform their tasks better?

Interviewee: Most of the employees receive an adequate support from senior management. For example, they receive a proper care in case of exposure to accident or if they injured during the work time. The only aspect that needs more attention as I said before is the incentives and awards programmes.

Interviewer: Do you believe that improving maintenance can lead to raising the efficiency of the production systems thus achieve the targeted amount of production?

Interviewee: Any improvements of maintenance would be very helpful. But the issue is that some of the components need to be replaced. This is mean that some of the production lines need to be replaced as a whole to achieve the required efficiency and make the process of maintenance improvement easy as much as possible.

Interviewer: How do you evaluate the cooperation and the relationship between the departments of the firm?

Interviewee: We do have excellent communications with the other departments regarding information exchange. There is a great cooperation in providing the necessary tools and information to help in achieving work as should. There is a full commitment of all departments to meet the production requirements.

Interviewer: Any addition?

Interviewee: No.

Appendix 8.6: Transcribed interview (B – 3)

Interviewer: What is your position in the factory?

Interviewee: General Supervisor of Maintenance.

Interviewer: What is your qualification?

Interviewee: Bachelor of Mechanical Engineering.

Interviewer: What is your experience in this field?

Interviewee: 10 years in the maintenance field.

Interviewer: How long you have been with this factory?

Interviewee: 10 years, all of them with the maintenance department.

Interviewer: Do you agree that the number of maintenance staff is sufficient to perform maintenance work as should?

Interviewee: we have about 50 to 55 workers including engineers. The number in total is more than enough, but the efficiency of some of them are considered the minimum. We are subjected, as a public sector, to the state's laws which are not consistent with the factory's objectives in many cases. Therefore, it is not possible to comply with employment criteria as should when employment. Moreover, the factory's top management cannot update these standards to meet the objectives of the firm. As a result, we encounter many problems related this issue. In the maintenance department, for example, the percentage of members who are qualified in maintenance cannot reach even to 40%. This is a very low percentage in such big and important industrial institution. These low efficiencies make rehabilitation programs not an easy task. Most of the staff members rely on their experience in doing maintenance jobs. Some of them have been working in this institute for more than 30 years. This forces the firm outsourcing to perform maintenance work in many times to avoid the accumulating in maintenance, especially with significant failures, which increases the maintenance costs.

Interviewer: With respect to the employment standards, did you mean that the employment standards are adopted by the higher authorities or specialised bodies authorised to do so?

Interviewee: In fact, there are strict standards which developed by a team from the factory authorised to do so, but not comply with in many cases. As I said, we follow the public sector. As a result, nearly 90% of the factory staff are employed either by the Ministry of Industry, or what is known as the Ministry of Manpower (Ministry of Employment). Although such these matters are considered very critical which can play a significant role in the success of the firm, we have to take orders in such these issue from the higher authorities. We cannot hide that although these bodies have standards for employment, they are not meet the employment criteria of the factory most often.

Interviewer: How would you rate the efficiency of the current production systems?

Interviewee: There is a continuous need for development. We deal with old systems thus it is not easy to achieve the required amount of production which can meet the flow of this item whether from domestic or external sources. It is not possible to raise the efficiency of the production lines as should in accordance with their current conditions. We suffer from the sudden stoppages due, for example, to the high temperature of some of these lines components during the production processes. Such these failures or breakdowns require more time to be overcome. In addition to that, maintenance costs are very high. If we want to compete with other firms, especially with the huge influx of imported cement, it is essential to improve these systems. We have some lines need to be replaced as a whole. Through this improvement, the maintenance programmes would be more effective and can be adopted more easily through introducing the appropriate strategies thus the possibility of controlling the maintenance time and costs.

Interviewer: Does the factory currently apply any strategy for maintenance?

Interviewee: Yes, we adopt what is called reactive strategy. As you may know, this strategy relies on the fixing the machine after failure or breakdown. In sometimes we do maintain some devices when the main kiln is undergoing to the regular maintenance.

Interviewer: On what basis is chosen this strategy?

Interviewee: The reason for chosen this strategy is the unplanned stoppages of some production lines components. There is no choice in changing or improving this strategy. We are suffered from obstacles in this context. The first one, as I mentioned, is the centralised government which hinder the power of the factory to make any improvement on its overall strategy and thus the possibility to update the production lines and improve maintenance so it can meet the new conditions of these lines. In addition to that, the interest of senior management to take serious actions to support any improvement programmes or plans. However, we benefit from the staff experience in this aspect. Many of maintenance members are familiar with the production systems and its components. Some of them use their feeling to identify failures before they occur

Interviewer: In your opinion, to what extent the adopted strategy is appropriate?

Interviewee: The implemented strategy is appropriate compared to the current conditions of the systems. But in view of progress in this industry, this strategy is inappropriate and need to be improved. The competition with others requires that the reliability of the production systems should be at the highest level. This is only can be achieved through the application of suitable and effective strategies for maintenance. Unfortunately, and due to the current situation of these systems. It's not possible to make any improvement of maintenance. The only we can do is to observe the components of the production lines during the production processes in trying to reduce the possibility of unplanned failures as much as we can. Many of the components of the production systems need to

be updated. The condition of many of these components need be improved and many others should be replaced. In addition to that, there is a need to evaluate the conditions of the surrounding environment such as production requirements, the possibility of staff rehabilitation to raise their skills and the availability of spare parts and maintenance tools. I believe that through giving sufficient attention to such these issues and others, the maintenance can be easily improved and hence increase the reliability of the production systems which would lead to ensure the flow of the production as needed.

Interviewer: Is this mean that it is possible to increase the efficiency of the current systems through improving the strategy of maintenance?

Interviewee: As I said earlier, we cannot achieve the required level of efficiency with the current circumstances of the production systems. This due to the issues that we already talked about. Despite this, the staff make a great effort to maintain the current level of efficiency.

Interviewer: If we assume that some improvements have been made on the production systems. Do you believe that the current staff has the ability to improve the current strategy of maintenance of introducing new strategy?

Interviewee: Although the availability of some workers who have high efficiency in maintenance, they are unable to develop such these programmes. Training is needed to update their knowledge and skills thus would increase the possibility of developing improvements plans or at least dealing with the improved systems. I suggest that, as a first stage, it is better to ask specialised organisations in the field of maintenance to help in developing improvements programmes. We will benefit of this in two directions. Improving maintenance would be the first aspect. Secondly, improve the staff skills which could be as internal training and thereby reduce spending on external courses.

Interviewer: Do you mean that training is compulsory for every maintenance staff member?

Interviewee: As I mentioned earlier, in current time the efficiencies of the staff are good to deal with the production systems. But if some improvement has been made on these systems then the training is urgently needed for every staff members. The training of workers in order to make the improvements of maintenance is very costly. Therefore, the best way is outsourcing in making any improvements.

Interviewer: In your opinion, what are the biggest obstacles that encounter achieving the targeted amount of production?

Interviewee: The first one is that the low efficiencies of the current production systems as I said. In addition to that, the surrounding environment is not suitable in sometimes. For example, there is a fluctuation in the electric with no ready standby generator. Some workers go out during the production times to do other activities such as go shopping. Senior management should pay more attention in controlling the worker's behaviour through, for example, reward workers who are committed to doing the assigned tasks as should.

Interviewer: You said that the surrounding environment is not suitable in sometimes, do you mean that the maintenance staff face problems or obstacles when they perform maintenance?

Interviewee: To somewhat. In general, the work environment is appropriate. The most important point in this aspect is that there is a big need to discriminate between the main departments such as maintenance and production and other departments (Assistance departments). For instance and despite the efforts given by the maintenance workers, they receive the same amount of rewards that

given to other staff in other departments such as administrative. The factory adopts what is called functional class or functional classification. This classification is right for every employee in the factory. The classification would be on the period spent by the employee in the factory regardless his effort. This makes some workers disappointed. We need to have a full control so we can develop such these programmes.

Interviewer: What about the other circumstances, for example, providing facilities while conducting maintenance such as good ventilation and work clothes, the availability of spare parts at the proper time and the readiness of the emergency systems to be operated when needed?

Interviewee: Generally, it is good. We try our best by asking senior management to provide all the job requirements in a timely manner. We do a periodic inspection for the assistance devices such as ventilation system, ambulances and other systems. This is to ensure the readiness of these systems at the needed time. The only thing that we suffer is the top management does not provide the needed spare parts in a timely manner. This problem originally results because of the complex administrative procedures when the requesting of the spare parts. This process usually takes time more than should. As a result, we face a delay in maintenance which in turn leads to maintenance backlogs in sometimes.

Interviewer: How do you evaluate the level of the relationship between you and the other departments?

Interviewee: The relation among most of the departments in the factory is good. There is an excellent cooperation between the department's members. For example, we do a regular meeting with other departments such as production to discuss issues that related to maintenance or production. Like any other public organisation, we need some advanced tool to facilitate the communication process between all the factory's departments such as the Internet and centralised documentation system.

Interviewer: Do you have any comment or addition?

Interviewee: No.

Appendix 8.7: Transcribed interview (C – 1)

Interviewer: What is your position in the factory?

Interviewee: Manager of the Maintenance Department.

Interviewer: What is your qualification?

Interviewee: graduated from a Higher Institute of Electricity.

Interviewer: How long have you been working in the field of maintenance?

Interviewee: I've been working with this firm for about 22 years. All of them in the maintenance field.

Interviewer: How many workers including engineers in the maintenance department?

Interviewee: The total number is about 60 and about 15 of them are engineers.

Interviewer: Is this number sufficient to perform maintenance work as should?

Interviewee: Although a good number of workers make a great effort to do maintenance as required, we cannot hide that some workers were suffering from the lack of knowledge regarding maintenance and its practices because they are not specialised in maintenance. Many of them could gain good experience during their working period in the department. Moreover, the skills of some of them have been improved through training.

Interviewer: Do you mean that they are qualified in the field of maintenance?

Interviewee: Yes, about 60% or more can be relied upon in achieving maintenance work. In some cases, we forced to outsource in finishing maintenance. The unknown failures are the main reason behind this. This only could happen with the big grinder and the main filters which require a quick maintenance to avoid serious consequences.

Interviewer: Do you apply any standards for employment?

Interviewee: In fact, we do have no good standards to followed when employment. But the employment is based on some requirement such as the qualification levels. In addition to that, the workers are put under a test for three months called the worker test period.

In sometimes, we receive a good number of new employees from the Ministry of Industry as it has the absolute right in such matter. Therefore, it is likely to meet some workers who they are not qualified or their backgrounds is not related to maintenance field. We could overcome such these issues through providing them with training programmes to raise the skills of those workers.

Interviewer: Through your long experience in working with this factory, do you think that the efficiency of the current production systems is sufficient to meet the production requirements?

Interviewee: It needs to be improved .Some of the production components become old and not able to meet the production requirements in terms of speed. In addition to that, the cost of maintenance itself is higher than should as some of the production lines components need special attention to be able to operate during the given period. The shortage of spare parts in many times is the other issue which has an adverse effect on the maintenance outcomes such as delay in production as a consequence of the delay in finishing maintenance on time. As I said the systems are old, therefore, some of its components have no ready spare parts. We have to order them from specialist resources or manufacturers. It usually takes long to receive these parts. This has negative effects on the maintenance processes .In sometimes ,we forced to stop a production line because of this reason. The imported cement invades the local market because we are unable to achieve a sufficient amount of cement in a timely manner which can cover the domestic consumption as the efficiency of our systems poor.

Interviewer: Do you, as a maintenance department, apply any strategy for maintenance?

Interviewee: Reactive strategy is mostly adopted. Some devices such as the main kiln need regular maintenance. This is because its failure (unplanned or sudden stoppage) will have serious consequences on two sides. The first one is the stoppage of the whole production systems which in turn will lead to the stop in production. Secondly, the kiln itself will be affected as some of its bricks will be damaged which is very difficult to replace them as these bricks are considered expensive and need time to be replaced correctly. In this case, a quick response is required to fix such this fault in a short time and bring back the device to its original condition. The quick response means that more cost. For this, planned maintenance is applied in some cases.

Interviewer: On what basis is chosen this strategy?

Interviewee: The use of experience through the observation the components of the production lines during the operation process is the most player in this aspect. The maintenance work is performed upon the experience of workers in dealing with the production systems components. For example, some devices should have a determined number of allowable stops during a year such as ventilation fans. In other words, these devices should undergo to maintenance works in known and determined times during the production year. Most of the staff members can realise these times using only their experience.

Interviewer: Do you believe that this strategy is appropriate?

Interviewee: Honestly, the carried out maintenance cannot meet the purpose for which it was conducted because it is only performed after a failure occurred. This is due to the lack of awareness of some maintenance workers with regard adopting the proper methods of implementing maintenance and make it successful. Therefore, the occurrences of the same fault are common and repeatedly.

Interviewer: How do you evaluate the cooperation level between you and other departments?

Interviewee: Yes, there are regular meetings between our department and relevant departments such as production and raw materials. In these meetings, we prepare what is called a production plan. This plan is adopted on the evaluation of the systems conditions and the availability of raw materials. These meetings are very helpful for us and even for other departments. The lack of good documentation is the only problem we face as we used to do it manually. Therefore, some information regarding is to be missing which makes maintenance task more difficult.

Interviewer: What about maintenance, are there any programs or methods for documentation?

Interviewee: In often the maintenance works are recorded. Although this is done manually, it's a great task. There are some attempts to develop advanced programmes for documentation. This would be through using computers and monitoring cameras (CCTV) to record data about the machines and to monitor these machines remotely during its operating process. Currently, we do have what is called the device card history through which the maintenance information for any device or machine can be found.

Interviewer: Do you think that the maintenance department members are easily able to make any improvements to the current maintenance strategy?

Interviewee: The maintenance staff can make this improvement just for the current systems. But I think these improvements would not be effective. To make the process of maintenance improvement successful, some of the production lines components need to be replaced. Therefore, I believe that there is a need either to consult experts in the field of maintenance or rehabilitation of the current staff to be able to deal with the upgraded devices and equipment which would rely on advanced technologies such as electronic systems and smart mechanical systems which operate using computers and software.

Interviewer: Do you have, as a maintenance department, any plans or suggestions for improvement?

Interviewee: Yes, there is some attempts in this area, but we encounter complex managerial regulations. These regulations prevent us from making the appropriate improvements. As you may know, such these programmes need more spending to be successful. For example, one of our plans

has been adopted since three years. The issue is that to start working on this plan, the main air filters need to be replaced. Since that time the senior management is still not able to create any purchase contract to provide the factory with these filters.

Interviewer: why?

Interviewee: it seems that senior management is not keen to make any effort in this aspect as it is related their inability to fulfil these issues to their limited power.

Interviewer: Do you believe that the work surrounding conditions that represented in some basic requirements such as rewards system and wages level are appropriate to make the employments perform their assigned tasks as should?

Interviewee: We seek to make the work environment as suitable as we can. The top management is interested in providing the employees with some facilities including rewards, transportations service and emergency service. For example, a sufficient care is given to a worker in the case of an accident during the work time. We have been seeking to develop what is called health insurance contract. Through this system, the workers have the opportunity to receive adequate care in some different specialist health care centres instead go to the public centres.

Interviewer: Do you face any management obstacles or problems when performing maintenance jobs?

Interviewee: As a maintenance department manager, I would say that the top management is given great interest in this side and I do not believe that there is a lack of attention given by senior management towards the maintenance department. However, some issues cannot be controlled such as giving the workers' salaries on time as I said the power of the senior management is limited.

Interviewer: How to evaluate the relationship between you and other departments?

Interviewee: To some extent it's good. I can rate it at 60% good. For example, the production department is responding to our requests with regard stopping a device for the maintenance work at the desired time. We adopt what is called the work orders through which the production department is contacted. This is, for example, to notify them to stop on or more of the production lines because of the existence of a problem. They usually make a quick response in dealing with such this instruction.

Interviewer: Any addition?

Interviewee: No.

Appendix 8.8: Transcribed interview (C – 2)

Interviewer: What is your position in the factory?

Interviewee: Manager of Production Department.

Interviewer: What is your qualification?

Interviewee: Higher Diploma in Electronic Engineering.

Interviewer: How long have you been working in the field of production?

Interviewee: The total period is 20 years, including nine years with another industrial institution.

Interviewer: How many workers in production department?

Interviewee: There are about 55 workers. This department is divided into operation section, packaging section and the unit of reporting and following-up the production processes. Although most of them held diplomas or below, they have a very good experience.

Interviewer: Do you think that the number of production staff is sufficient to perform their assigned jobs as required?

Interviewee: For the current conditions, this number is more than what we need because no high skills are required for this time. Most of the components of the production lines are manually operated. Hence, most of the workers can operate the production lines with high efficiency. In addition to that, a good number of them have sufficient experience in this aspect. The workers are familiar with the production component as some of those workers have been worked with the firm for more than 25 years. However, if some improvements would be made on these systems, in this case, I would say that the skills of workers need to be improved so they can deal with the improved production systems. In other words, the staff knowledge regarding operate the improved systems need to be updated. I mean that the workers will be unable to deal with the improved machines and devices if they are not trained well.

Interviewer: Does this mean that the efficiency level of workers is high and no need for training under the current conditions of the production lines?

Interviewee: No, I meant that the current systems have no advanced technology such as simulation systems and monitoring devices which depend on the use of electronic devices to be run. As I said, most of the machines are manually operated.

Interviewer: Are there any standards for employment?

Interviewee: We focus on some aspects when employing operators such as the good desire to work, academic qualification level in the field of work and the factory need for new workers. These and other requirements have been adopted by the plant management as standards. Despite this. We have no absolute right to make recruitment decisions, but we send the applications that been already approved by the factory management to the Ministry of Industry for the final approval. In sometimes the recruitment decisions come directly from the ministry, and we have no right to refuse these decisions.

Interviewer: Here I can conclude from your speech that the current production systems are old and therefore, improvement is needed?

Interviewee: Certainly there is a continuing need for improvement. For example, many of the production systems components are aged more than 30 years old. Although some improvements have been made on some components of the production lines, these improvements have occurred since a very long time. Therefore, more improvements are needed. The improvement programmes are essential to keep pace with new technologies. This could give us the opportunity to stay in the competition area either locally or globally. The improvement plans inevitably will result in rising the efficiency of the production lines components thus the targeted amount of production can be achieved. We addressed the senior management in this regard several times, but they usually say that such these programmes are very costly. Although we are agreed with them as this is a known fact for all, we still believe that this matter is critical to ensure the continuity of the production. Upon this, we have suggested that it should divide the improvements processes into more than one stage so we can control the costs and make the improvement process an easy task as well. In the current conditions of the systems, operate and maintain these systems have become very costly .For instance,

we face continually unexpected breakdowns or what is called unplanned stoppages. This causes confusion for maintenance workers in many times. Honestly, it is not easy for the maintenance staff to control such these stops or breakdowns. In addition to that, the maintenance process itself takes more time than should which force us to shut down, in some cases, a production line as a whole. As a result, stoppage or fluctuation of the production.

Interviewer: As you are close to the maintenance department, do you have any knowledge of maintenance strategies currently in place in the factory?

Interviewee: Surely yes, we widely apply the reactive approach. In addition to what is called the big maintenance which is taking place when changing the refractory bricks of the main kiln. This type of maintenance is usually scheduled. This is because the kiln must undergo maintenance work every 6 to 7 operating months. This is what called planned stoppage. In other words, the kiln needs to be stopped working twice every one year. The maintenance department benefits from this by maintaining other devices and machines. This is a kind of unplanned periodic maintenance.

Interviewer: On what basis are chosen this strategy?

Interviewee: This strategy inherited and quoted by experience only. There was no study or plans.

Interviewer: As you are in charge in the operation of production systems, do you believe that there is a need to improve the current strategy of maintenance, and to what extent this improvement would have a positive effect on the factory?

Interviewee: There is an urgent need to reconsider the strategy currently in place. A comprehensive study to evaluate the efficiency of production lines should be addressed as the first step. In addition to determining the targeted amount of production. Moreover, the improvement of the staff skills is the most important step. I'm sure that staff with high efficiencies levels of awareness regarding maintenance and its practices means that more chance in adopting the proper maintenance. Here I should point out that, it's better to introduce monitoring system along with the improvement process. This system will be very helpful in saving time and money as the discovering of the faults before they occur will be easier and faster. In addition to that, reducing the risks resulting from the availability of workers in some locations to make detection on some devices such as filters. For example, we need what is called smart thermometer. This tool will help in measuring the whole internal kiln temperatures then compare the difference between theses temperatures. Through this, the parts of the kiln that need for maintenance can be determined easily. However, we have plans for improvement but in its infancy.

Interviewer: Do you believe that the maintenance staff can make improvements of the currently adopted maintenance?

Interviewee: Although many of the current staff members have high efficiency in doing maintenance jobs, it is better, in my opinion, to use the expertise in improving the maintenance or even help the maintenance staff to do so. This is because of that the knowledge of current maintenance staff needs to be updated so they can make appropriate improvement in the same time there is a need for those workers as they are familiar with the current systems and have full information about the production systems components. Most of the workers have received adequate training to improve their skills and deal with the production systems. Here I'd like to say that the improved systems need new skills which mean that more training is needed in this case.

Interviewer: Is the surrounding environment appropriate for workers to perform their job as should?

Interviewee: To some extent yes. The training courses are available. Despite the fact that the rewards system need to be improved to meet the volume of the workload, most of the staff whether production or maintenance members could revive, in sometimes, bonus or incentives. Also, the transportation from and to the work sites is available for everyone in the factory. The only issue that needs to be reconsidered is the wages which are low compared to the work volume ant the factory revenue. Unfortunately, the factory is subjected to the public sector. Therefore we have no right to make any changes in this side. However, we usually ask top management to find out alternatives to overcome such obstacles. For example, we have asked senior management, and we still do so to improve the rewards system so the wages can be increased indirectly and legally, but no response so far.

Interviewer: Do you mean that the senior management does not pay adequate attention to some aspects through which the employees can be more motivated?

Interviewee: in fact, and according to their limited power, the senior management is given sufficient attention to its staff. The top administrators are interested in providing suitable conditions for the workers. As the factory follows the public sector, there are some issues out of control such as the delay in payment of the employees' salaries and low of the incentives and bonuses.

Interviewer: how do you evaluate the communications level between the factory's departments in particular between the maintenance and the production departments?

Interviewee: it is good in general. We do have meetings with each other from time to time. For the maintenance department, we share the production and maintenance reports. Also, we do private meetings to discuss the issues that related to the production and maintenance. These meetings are upon our request or when the maintenance department asked. In general, there a good cooperation between our department and the maintenance department.

Interviewer: Do you have any comment or addition?

Interviewee: Just I'd like to mention to that the factory is produced about 70% of its total designed capacity which seems good but in fact, it does not. Because there are additional costs to be added when carrying out maintenance to achieve this percentage of production since we adopt an unplanned strategy for maintenance. Therefore, we face unexpected stoppages or breakdowns in the production lines. This is surely uneconomical. Therefore, more attention is needed to improve the strategy of maintenance.

Interviewer: Do you like to add any comment or addition?

Interviewee: No.

Appendix 8.9: Transcribed interview (C – 3)

Interviewer: What is your position in the factory?

Interviewee: Manager of raw materials department.

Interviewer: What are the tasks of this department?

Interviewee: The department of raw material is consists of maintenance section of machinery and vehicles that are used to transfer the raw materials from its original sites to the factory and a section of operation and maintaining of crushers. This department is specialised in providing the factory with the required raw materials. This process is done by a huge fleet of machinery such as big tractors, diggers and crushers. The mission of this department is the first and essential phase of this industry.

Interviewer: What is your qualification?

Interviewee: Bachelor of geology engineering.

Interviewer: What is your experience in this field?

Interviewee: I've been working with this factory for 17 years and 4 of them are in this department.

Interviewer: How many workers, including engineering and technicians, in your department?

Interviewee: We have 100 workers. About 15 of them in maintenance centre. This number includes drivers, crushers' operators and maintenance technicians.

Interviewer: How many percentages of them are qualified to do their jobs well?

Interviewee: Although the desire of knowledge exists of many workers, maintenance work depends mostly on experience.

Interviewer: Do you have any relation with the maintenance department?

Interviewee: Surly yes, we have a great cooperation with them we share some activities with regards maintenance.

Interviewer: Is your factory adopted any standards for recruitment?

Interviewee: In fact, there are no specific standards. In most, we receive new employees according to the instructions of the ministry of industry. But in general, most of the workers are held diplomas certificates which are sufficient for our department. Through my long working experience in the factory, I would say that we have a good number of staff in the factory. Despite this, the number of engineers is insufficient as engineers usually have no strong desire to join the factory. This is because of low wages compared to the work volume and to other organisations. I believe that high salaries would increase the desire of the potential employees to join the factory.

Interviewer: You mentioned that many of the workers held diplomas certificates or below, are they able to perform the required work as should?

Interviewee: Honestly, good training is needed. The senior management realises that and tries to provide the employees with such these programmes. The problem that we encounter, either in this department or in other departments especially the maintenance and production, is that the existence of some employees who held qualification not related to their position in the factory. Therefore, it's difficult to improve their skills through training. Although the availability of many workers with good experiences in completion maintenance job, the training remains very important in giving an opportunity to an employee to improve his skills which in turn will increase chance of success of achieved work.

Interviewer: Do you apply any particular strategy for maintenance in the factory?

Interviewee: Through my dealings with the maintenance department and my knowledge regarding maintenance practices in the factory, I can observe that maintenance staff deal with the equipment

and machines according to its current status. There is no clear idea about what staff should do before and during performing maintenance job. With regard to our departments, as we have no complex devices or machines, we just fix machines that have appeared problems. We benefit from standby machines to overcome any failure or breakdown with the operated machine.

Interviewer: Do you believe that this approach, fix the machine after breakdown, is appropriate or you see there is a need to reconsider the maintenance currently in place?

Interviewee: Although there is urgent need to look to ways through which the success of maintenance can be insured, some steps need to be taken to reach this. For instance, update some of the production lines would help in chosen the appropriate maintenance and make maintenance mission as an easy task. This would increase the reliability level of production lines. However, this should start from our department as some machines and devices need to be replaced such as diggers and crushers. I believe that by doing such step, the applied maintenance would be more effective, otherwise we are only wasting our time. For example, the speeds of some crushers are very slow. Consequently, they cannot meet the basic requirements to provide the raw materials for the production. Evaluating the maintenance staff efficiencies are very essential. Through this, the plan for the needed training can be created properly to make this training more effective and reduce the gap resulted from the lack of field work related qualifications.

Interviewer: Do you have any knowledge of any plans or programs related to improving the current strategy of maintenance?

Interviewee: We could receive some reports from the departments of maintenance and production in this regard. These documents contain some suggestions with regard to the production systems improvements. Our recommendations have been added to these plans. Such these programmes would be effective if a good attention is given by factory management. However, this is not an easy task as the adopted managerial procedures are very complicated. For instance, some of the contracts such as importing spare part contracts need a long time, more than two years in some cases, to be signed.

Interviewer: Are you going to say that some improvements have already been made?

Interviewee: In fact, there are some efforts from some maintenance members, but they don't live up to the real level of improvements requirements. As you may know, the improvement needs a huge potentials including training and use of experts. This needs a great budget which I believe that the top management cannot fulfil this.

Interviewer: Do you mean that the skills of maintenance and production members don't meet the improvements requirements?

Interviewee: Honestly, most of the staff are motivated to do some improvements. But I do believe that such this task need experts in improvements processes as a full plan that should involve all improvement steps is needed. These actions starting from assessing the condition of the production lines and ends with chosen the suitable strategy for maintenance. Staff knowledge needs to be updated with respect to maintenance strategies and their importance in improving the overall efficiency of the production systems. The existing staff can play a significant role in the improvement process because the majority of them are familiar with the production systems. Therefore, the success of improvements cannot be ensured with the lack of their support.

Interviewer: You mentioned that the reactive maintenance is the only adopted strategy in the factory, on what basis are chosen this strategy?

Interviewee: Through our observation and knowledge, it's clear that the experience is the most used when adopting maintenance. Although the poor condition of many of production lines components, there was some attempts for improvements. In other words, the efficiency of maintenance output cannot be as good as should according to the current conditions of the production lines. The other issue is the lack of manuals for many of the production lines components and even the available are written in English, most of the employees are not familiar with the English language. As a result, they have insufficient about the machines or devices they are about to fix. This lack has a negative effect on maintenance as the science specification of machines or devices are important when chosen of the maintenance strategy.

Interviewer: Is the surrounding environment appropriate for maintenance staff to perform their jobs properly?

Interviewee: We have been trying to do our best to meet the basic needs of workers. As you may know, the factory followed the public sector. Hence, the top management has limited powers to provide the employees with some facilities, such as given bonuses or increase wages. The rewards and salaries are low compared to the volume of work done. However, there still some facilities could be given by the firm with no permission from the higher authorities such as transportation, the provision of air-conditioned halls for relaxing and worships areas. This is to some extent contribute in raising the morale of workers.

Interviewer: What about the training, do you think that the training programmes are sufficient?

Interviewee: As I mentioned before, training is widely available in the past. Most of the workers could receive training either internal or external. In this time, many workers need to be retrained as their knowledge and skills need to be updated. This is surely will increase the chance of maintenance success through adopting valid strategies. However, according to the current condition of the production lines, I believe that most of the employees are sufficiently trained to deal with the production systems components.

Interviewer: Do you face any management obstacles or problems when performing maintenance jobs?

Interviewee: As I mentioned earlier, we experience a complex routine, especially when ordering spare parts. This delay in dealing with such these issues caused, in sometimes, maintenance backlog. As a result, some of machines and crushers will completely stop working. This accumulation, in some cases, force us to outsource in doing big maintenance. This is good to avoid maintenance problems but some maintenance agents are incompetent in the maintenance field. As a result, the level of maintenance would be poor which forces the firm to redo maintenance. Therefore, additional costs will be added, and the number of unwanted stoppages might be increased.

Here I'd like to add an important point which is that we in urgent need to re-allocate or re-distribute tasks and responsibilities as a part of improvement and facilitate workers' evaluation processes. This should start from senior management down to the shop floor workers in addition to identifying the authorities afforded to the departments.

Interviewer: How to evaluate the cooperation level among your department and other departments?

Interviewee: In fact, we have a good relationship with the factory's departments, especially maintenance department. Our department is in delay need for the maintenance department support and help. Honestly, they are widely responsive. Through our regular meetings and based on reports we receive from other departments we can observe that the level of cooperation between departments is very good.

Interviewee: In sometimes, there is a frequent confusion in finishing maintenance work as a result of the lack of needed information regarding maintenance and production processes. This initially resulted from the lack of proper documentation.

Interviewer: Do you have any additions?

Interviewee: I hope we could get the opportunity to change to the private sector. I'm sure this will allow us to have more power and thus the possibility for good improvements and getting into the competitive world. The private sector depends on the efficiency of both the staff and the administration in achieving its objectives as should. The successful investment can be only through changing over to the private sector. As a result, the possibility of increasing the performance efficiency of the factory are limited as our power has been restricted by the state's laws. Therefore, the only way or path of successful is to change to the private sector with the emphasising on the implementation of both the environment and the industrial safety and security requirements.

Interviewer: Any addition?

Interviewee: No.

Appendix 8.10: Transcribed interview (D – 1)

Interviewer: What is your position in the factory?

Interviewee: Manager of maintenance department.

Interviewer: What is your qualification?

Interviewee: Bachelor of Mechanical Engineering.

Interviewer: How many years have you worked in the field of maintenance?

Interviewee: I've been worked with this factory for about 20 years. 7 of them as a head of the maintenance department.

Interviewer: How many workers including engineers in the maintenance department?

Interviewee: The total number is 53, about three of whom administrators and the rest of others are divided into three categories. 13 engineers, 20 technicians and the rest are general workers.

Interviewer: Do you think that this number is sufficient to cover the maintenance work as required and in a timely manner?

Interviewee: Yes, compared the volume of the current needed maintenance work, this number is enough. The problem that we are experiencing, as most public sector companies suffer from, is that there are a good number of non-active workers. Those workers are not able to perform maintenance as required due to their low educational level, as well as some of the others, held certificates unrelated to maintenance such as refrigeration or air conditioning diplomas. Therefore, it is very

difficult to train this class of employees. This is because when you train a person in the maintenance field, his background should be in the same field of training so the training would be effective.

Interviewer: What do you mean by the volume of the current needed maintenance work?

Interviewee: I meant that we are dealt with simple and old production systems. Many of these systems components are manually operated, and its structure is simple.

Interviewer: Does this mean that the training programs are available to the workers?

Interviewee: Yes, all maintenance personnel, without exception, could receive an adequate training and some of them could receive more than a course of training in the field of maintenance. As I said, we suffer from the inability of some workers to take advantage of such programmes, and this is evident from the low level of maintenance in some cases.

Interviewer: On what basis are employed workers?

Interviewee: In fact, there is a special committee called the Committee of employment. The mission of this committee is to revise the employment applications according to the standards set by the factory management. But the issue is that the factory's management has to have the final approval or acceptance of these applications from the ministry of industrial. This process usually takes a very long time, in addition to non-compliance with the firm's standards. As a result, a good number of staff has been recruited directly by the ministry of industry.

Interviewer: How would you rate the efficiency of the current production systems?

Interviewee: To some extent good, but as you know, the need for the improvement is continuous. The improvement helps to increase the efficiency of the production systems and thus avoid many of the problems during the production process, such as unexpected faults thus reducing unplanned maintenance costs. However, we deal with systems that need improvements because many of their machines are manually operated hence direct observations are continually needed to avoid the unplanned failures.

Monitoring devices such as cameras and remote control devices are needed so through which we can send and receive data. Workers suffer from their inability to overcome the unexpected faults that occur from time to time during the production process. This is because the possibility of determining a failure in some cases need time more than should. Such problem causes confusion for the maintenance workers which in turn negatively affects the functioning of the production process.

Interviewer: Do you apply a specific strategy for maintenance to overcome such problems?

Interviewee: In fact, we have been trying to apply the preventive maintenance. This strategy is adopted based on what is called the annual production plan and through identifying the targeted volume of production during the production year. During this year, the main kiln must undergo a known and scheduled maintenance. The department of maintenance exploits these stoppages (when the main kiln undergoes to periodic maintenance) to perform a comprehensive maintenance of all the components of the production lines. Therefore, you can say that preventive strategy is adopted in the factory.

Frankly, the strategy itself is good, but we were not able to take a full advantage of it. This is due to lack of technical studies of this strategy. As I mentioned earlier, we face unexpected and frequent breakdowns. These stoppages reach to four times monthly. This number is considered very high in such big institution. To avoid or reduce this number, we are forced to find quick solutions to restore a machine or a production line to work order which means more spending on maintenance. In addition to that, the low quality of maintenance output. Therefore, it is better to reconsider the current

strategies in line with the target production volume. In the lack of improvement programmes, we have to spend more on maintenance as a trying to avoid the accumulation in maintenance and thus, ensure the continuity of production. In other words, we forced to increase spending on maintenance in order to overcome some problems especially caused by unexpected failures as the adopted strategies are unclear for many of the workers.

Interviewer: Does this mean that there were no studies or plans developed to adopt strategies currently in place?

Interviewee: Actually, some improvement plans were developed. The only we need now is to conduct a comprehensive study of the current systems so that the conditions of these systems can be improved so they can meet the requirements of any developed or introduced strategy. Here I'd like to add that we already started with the improvements process through improving the ventilation system as the first stage. The improvement process, as I said, need financial support. Back to your question, maintenance currently used has been adopted based on the current status of the production systems upon which the annual production plan has been prepared with taking on the consideration the ability of maintenance departments to fulfil the maintenance requirements during the production periods.

Interviewer: According to what you already mentioned about the maintenance strategy selection procedures, do think that the adopted maintenance would be effective as should?

Interviewee: Yes, to some extent and as I said, in some cases, we suffer from the difficulty to identify the failures properly and in a timely manner which means that maintenance work usually takes time longer than should. Such issue emphasis that some workers need technical support so they can recognise faults more easily and complete the required maintenance properly and in timely manner. This is because those workers do not have sufficient technical understanding of production machines and devices.

Honestly, even if we assume that current workers' efficiency is good, still the improvements programmes are not an easy task and need to provide the workers with special training. Since workers can keep abreast of scientific developments in this area if they could receive adequate training and thus they can help in making or introducing any improvement programmes. In our case, the knowledge of the shop floor staff needs to be updated so they can properly engage in the programmes of maintenance improvement.

Interviewer: Do you have any attempts to develop maintenance under the current circumstances represented in the conditions of the production lines or the level of performance of the workers?

Interviewee: Yes, as I told you earlier we have many plans in this regard. I would like to point out here that these plans have been prepared based on the modest experiences of maintenance workers. However, there are some proactive steps should be taken before making any improvements such as providing the necessary financial support as well as the improving or replacement some of components of the production systems in line with the improved maintenance requirements.

Interviewer: How do you evaluate the suitability of the surrounding environment to workers so they can perform the assigned tasks as should?

Interviewee: As a maintenance department, we have been trying to do our best to provide workers with the needed facilities such as transport and security and safety requirements. Despite this, these are some issues that need to be given more attention by the senior management. For example but not

limited to, we need to adopt a programme through which it can distinguish between employees each according to his effort. We noticed that a many of the active workers complain of not distinguish them from others as they believe that they work harder than other workers. There are some other programmes which we do not have the power to change or improve them to meet the worker's requirements, but we do believe that they need to be given more attention as the lack of these programmes have a significant impact on the desire of employees in performing work as should. For example but not limited to, the bonuses and allowances need to be reconsidered. Such issues cause confusion in the workflow within the department. This is what can be seen through the delay or failure of maintenance, and even the achieved maintenance are considered, in sometimes, unreliable.

Interviewer: How would you rate the relationship between you and the other departments?

Interviewee: The relationship between all the firm's departments, in general, is good. We suffer mostly from the complex regulations, especially when ordering of spare parts. Regarding dealing with the other departments, I think that all of the departments should be informed of the meeting dates in a timely manner and obliging them to attend and participate in these meetings which I believe that this is one of the factory's responsibilities.

We rely on the received reports from the production department regarding the occurrence of a fault in any of the production lines components. Based on these reports a team from the maintenance department is commissioned to preview and determine the volume of the problem or the error and then take the needed action to maintain the faulty device or machine.

Appendix 8.11: Transcribed interview (D – 2)

Interviewer: What is your position in the factory?

Interviewee: General Supervisor of Maintenance.

Interviewer: What is your qualifications?

Interviewee: High diploma in industrial engineering.

Interviewer: How long you have been with this factory?

Interviewee: I've been working with this firm for 10 years all of them in the maintenance department.

Interviewer: How long you have been in the maintenance field?

Interviewee: 10 years, as I've started to work for first time with this factory.

Interviewer: Do you think that the number of maintenance staff is sufficient to perform maintenance as required?

Interviewee: Although the number of staff is sufficient in total, in sometimes, maintenance work need time more than should to be finished. Hence, delay in production as a result of stop a one or more of production line components or the whole line. More technical workers are needed to ensure completion of maintenance as should and in a timely manner. Honestly, a good number of our workers, especially non- maintenance qualified need special training programmes or retaliation so as to benefit from their energies in raising the level of maintenance outcomes.

Interviewer: Does this mean that there is a shortage of training programs?

Interviewee: In fact, there is a need for intensive training programmes so that can overcome the problems that resulted from the low education level of some workers. As I told you a good number

of employees held unrelated maintenance certificates, thus increase their skills in maintenance is not an easy task. Such programs require considerable support from the top administration.

Interviewer: Did you mean that there is a shortening of the administration in support of such programs?

Interviewee: The problem is not because of the low administration performance but in the volume of the needed financial support which is not easy to be covered under the current circumstances that are represented in declining in production levels.

Interviewer: You have mentioned to that; some workers are non-specialists in or not familiar with maintenance, does that mean you do not you apply standards when employment?

Interviewee: The employee is directly assigned by the Ministry of Industry. We have our own employment standards. But the problem is that the plant does not have the authority of the final decision in hiring, so these standards are exceeded in most cases.

Interviewer: As you are the general supervisor of maintenance, how do you assess the efficiency of the production systems of the plant?

Interviewee: Compared to the age of these systems, the efficiency is very good. But if we want to achieve the targeted amounts of production through which we can compete with others, the effectiveness of the components of these systems should be increased. In the current conditions of the production lines, the maximum efficiency we could reach to was about 60%. We are forced to stop production in some cases due to the problems that occur from time to time such as the high temperature of some equipment. These planned stoppages are considered as attempts to maintain or to the safe operation of the systems.

Interviewer: Do you adopt any strategy for maintenance in order to overcome such problems?

Interviewee: We are unable to adopt any strategy for maintenance according to the current conditions of the production lines as I told you. The only we can do in this case is observing the components of the systems, especially that are more likely to have a problem> we rely on the workers' experience in this matter. In addition to the lack of a sufficient number of specialists in the maintenance field which resulted in the existence of a good number of workers who are not familiar with no maintenance and its importance. However, the good point in this regards is that many of these workers could gain a good experience through their dealings for long periods with these systems.

Interviewer: Does this means that no particular strategy for maintenance in place?

Interviewee: No, I mean that we do not have any previous study or plans upon which the appropriate strategy for maintenance can be chosen. Maintenance work is usually done when a problem occurs or after a machine breakdown which depends on the experience of employees. Also, we try to conduct a comprehensive maintenance when turn off the production systems due to the periodic maintenance of the main kiln.

Interviewer: I understand from your words that there is a need to reconsider the current practice of maintenance?

Interviewee: Surely, as I told you earlier, we suffer from unplanned stoppages and therefore, in some components of the production lines are disrupted. In some cases, we have to stop the entire line to avoid or reduce the damage that may occur to the other components. As you know that the plant produces large quantities of cement. Therefore, such shutdowns caused significant losses in profits.

Interviewer: Are there any attempts to improve maintenance under the conditions that you already mentioned?

Interviewee: For maintenance, no, but in the context of seeking to develop production lines, yes, according to available resources. For example, we have replaced the primary ventilation filters (the filters of purification of dust resulting from the manufacturing processes) with other new and modern that match safety standards in such factories. We need more support from the top administration in this aspect through the provision of some basic requirements such as new pumps for ventilation.

Interviewer: Did you mean that the current staff is able to introduce such improvements programmes for maintenance if the needed improvements on the production systems have been made?

Interviewee: To some extent, yes, but the improvements process is not an easy task even for the people who they are specialised in the field of maintenance. Therefore, I think that there is a need to use of companies that are specialised in the improvements of maintenance programmes.

Interviewer: Is the surrounding environment appropriate for maintenance staff to do their jobs properly?

Interviewee: As a maintenance department, we are tried our best to meet the requirements of the workers according to the available resources. We have a good distribution of tasks depending on the possibilities and the qualifications of workers to make maintenance work as easy as we can for all the staff members. In addition to providing suitable places to rest. We from time to time, ask the top management to provide the workers with incentives. Although the availability of bonus, there is still no clear program through which the rewards can be fairly distributed among the workers each according to his effort.

Interviewer: How do you evaluate the relationship between you and the other departments?

In fact, we do not have a significant correlation with the other departments. But we mostly deal with the production department due to the similarity in the nature of the job. In spite of the existence of a great presence of cooperation between our department and the top management, we are suffering from the lack of the overall strategy of the plant upon which the production plans can be built.

Interviewer: Do you have any comment or addition?

Interviewee: No.

Appendix 8.12: Transcribed interview (D – 3)

Interviewer: What is your position in the factory?

Interviewee: Manager of Production Department.

Interviewer: What is your qualification?

Interviewee: Bachelor of Mechanical Engineering.

Interviewer: What is your experience in the field of production?

Interviewee: 4 years in the production field.

Interviewer: How many years have you worked with this factory?

Interviewee: I've been working with this factory for 12 years.

Interviewer: How many workers including engineers in the production department?

Interviewee: we have more than 50 workers. Nearly 70% of them are classified as machines operators.

Interviewer: In your opinion, to what extent they are qualified?

Interviewee: Frankly, they are good to some extent; we can say that some of the workers are able to perform the work as required. A good number of them are not specialised in the production or the maintenance fields. Therefore, they are not familiar with the issues that related to production or maintenance. As a result, training is needed for the majority of those employees to raise their efficiency.

Interviewer: On what basis are labour recruitment?

Interviewee: We have special employment committee. This committee adopts a predetermined criteria for employment. These standards defined based on several requirements such as the overall objectives of the factory and the conditions of the production systems as well as the market demands of cement. The big problem, if I could say, is that we are unable to communicate with the Ministry of Industry properly as it the authorised body for the final decision for appointment after the approval of the Interior Committee of the plant. Moreover, a good number of the staff were employed directly by this ministry. This obliges us to receive non-qualified workers in the workplace. Therefore, those employees need for intensive training.

Interviewer: As you are head of the production department and you have good knowledge about the production systems, could you assess the current conditions of these systems?

Interviewee: The factory is more than 30-year-old. Since that time, no remarkable improvements have been made on the systems components. Just some minor updates such as changing the main filters of the ventilation system. Therefore, it can be said that the efficiency of most of the production lines cannot meet the production requirements through which the targeted amount of cement can be produced.

Interviewer: Do you have any plans or attempts for improvements?

Interviewee: Improvements are not an easy task as many thinks. It more spending which is tough to be provided at the current time. In addition to that, the lack of skilled workers who are able to create or prepare programmes or plans for improvements which make the improvements task more difficult. But if they could receive adequate training in this regard, it is possible to rely upon. We try to get good deals with low-cost by contacting specialised companies in this area.

Interviewer: Considering that you are close to the maintenance department, is the maintenance department applies any strategy for maintenance?

Interviewee: We rely on the workers' experience in identifying faults. Some faults can be detected before they occur. But we face unplanned breakdowns that cannot be easily controlled. This is because of the lack of reliability of the production machines due to its old as I told you. We usually inform the maintenance department of the existence of a fault or a problem with the equipment. They are doing their part to take the necessary action to repair the faulty machine or device.

Interviewer: Does this mean that no strategy in place that can rely upon when performing maintenance?

Interviewee: In fact, no, because the current conditions of the systems are levied the type of applied maintenance. As I've indicated previously, we suffer from sudden stoppages or what is called unplanned stoppages. Such these breakdowns require very quick action to be overcome in a timely manner.

Interviewer: Do you see that this approach is effective?

Interviewee: Yes, it is very effective, since these is no alternative solution to overcome the unplanned faults. Sometimes we suffer from the inability to identify failure easily. This forces us, in some cases,

to shut down the entire production line. However, there is a big need to find appropriate strategies for maintenance to reduce such interruptions and increase the efficiency of the performed maintenance. I mean here that many of the workers have a good experience, but due to the lack of a clear plan for maintenance and through which the maintenance tasks can be distributed properly, and according to the capabilities of the workers, it cannot take full benefit of workers energies in this aspect.

Interviewer: If we assume that some improvements have been on the production lines, do you think that the maintenance staff are able to perform maintenance as required?

Interviewee: Yes, we have some qualified workers, and if we could work as a team, we can increase the efficiency of maintenance to the desired limit. But on the other hand, the improvements processes need trained staff so that the workers can deal with improved systems. In the same time, they would be able to introduce sufficient planes through which appropriate strategies for maintenance can be chosen.

Interviewer: Is there any attempts for improvements?

Interviewee: As I said to you, we do have some plans in this area. However, the most important thing is to provide appropriate financial support. For example, the use of experts in this field requires a great expenditure. As well as training programs are needed to increase the knowledge of the workers in this aspect.

Interviewer: Are the workers provided with appropriate conditions to help them perform the assigned job as should?

Interviewee: Yes, to some extent, transportation are available to all. The relaxing areas are equipped with air-conditioners. A large proportion of workers complains of the low level of wages they receive compared with the workload. I believe that there is a need to distinguish sections each according to the nature of their task. I mean that the workers should be rewarded according to the quality of the achieved work. By the way, such these matters are out of the top management control. This is because we are obliged to follow the laws of the state as the factory is followed the public sector.

Interviewer: How would you rate the relationship between you and the other departments?

Interviewee: There are periodical meetings between the relevant departments such as maintenance department. In addition to that, we held a meeting every two weeks with senior management. We try to take advantage of these meetings to find solutions and overcome any problems or obstacles that face the course of the production process in the factory. As the public sector, we face a shortage of communication tools such as Internet access.

Interviewer: How do you evaluate managerial performance with regard to dealing with staff?

Interviewee: Frankly, workers receive adequate support. Despite the factory's potential, which is limited, senior management tries very hard to provide its workers with a sufficient support by giving them rewards and provide health care for the all. As well as allowing workers to work overtime in order to overcome the problem of low wages.

Interviewer: Do you have any comment or addition?

Interviewee: No.

Appendix 9: Emerging main themes according to codes and sub-themes








Appendix 9.1: Main themes, factory (A – 1)

CODE	SUB- THEME	MAIN THEME
1- Not comply with employment standards 2- Employee Awareness level	Quality of employment standards	Employee Output
1- Outsourcing maintenance 2- Insufficient active workers	Management performance	
Low productivity	Old system (need for update)	Production lines Improvements
Lack of fund	Management performance	
Reactive strategy	Unplanned strategy	Quality of Maintenance Strategy
RCM is adopted	Bad sequence on the system	
Experts is used	Production lines improvements	
1- Reduce cost 2- Save time 3- Increase system efficiency	Integrated maintenance system	Maintenance Strategy Improvement
1- Experience is used 2- No manuals	Maintenance selection conditions	Maintenance selection Procedures
1- Have no awareness of the importance of maintenance 2- Not familiar with maintenance strategies	Randomly adopted	
1- Relay on experience 2- Social culture influence	Employee output	Maintenance Output
1- Lack of spare parts 2- Lack of documentation	Management performance	
Regular meeting	Department action	
Outsourcing maintenance Lack of training	unskilled workers	Management Performance
1- Lack of spare parts 2- Unable to compete	Centralised government	
Uses of available communication tools	Department action	





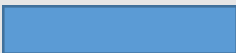


Appendix 9.2: Main themes, factory (A – 2)

CODE	SUB- THEME	MAIN THEME
1- Centralised government 2- No clear objectives	Management performance	Employee Output 
1- Not comply with employment standards 2- Comply with trip system	Quality of employment standards	
Insufficient training	Lack of skilled workers	
<hr/>		
Low efficiency	Old system (need for update)	Production lines Improvements
1- Old system 2- Non-effective maintenance	Unreliable system	
<hr/>		
1- System breakdown 2- Inability to identify the failure	Maintenance backlog	Quality of Maintenance Strategy
A big job is needed	Adopting non-effective approach	
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Increase system reliability	New strategy is needed	Maintenance Strategy Improvement 
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Lack of qualified staff	No strategy in place	Maintenance selection Procedures 
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Low workers efficiency	Non maintenance qualification	Maintenance Output 
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Regular meeting	Department action	Management performance 





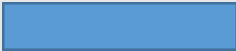


Appendix 9.3: Main themes, factory (A – 3)

CODE	SUB- THEME	MAIN THEME
Insufficient training	Lack of skilled workers	Employee Output 
1- Old workers 2- Unmotivated workers	Management performance	
<hr/>		
System are manually operated	Old system (need for update)	Production lines Improvements 
<hr/>		
Maintenance backlog	Adopting non-effective approach	Quality of Maintenance Strategy 
Relay on experience	Costly maintenance	
<hr/>		
4- Lack of fund 5- Lack of spare parts	Management performance	Maintenance Strategy Improvement 
<hr/>		
Experience is used	Maintenance selection conditions	Maintenance selection Procedures 
<hr/>		
1- old Workers 2- Management performance 3- Relay on experience	Employee output	Maintenance Output 
Adopting non-effective approach	Management Performance	
<hr/>		
1- Poor communication 2- Unmotivated workers	Management interest level	Management Performance 





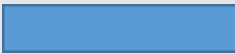

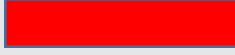
Appendix 9.4: Main themes, factory (B – 1)

CODE	SUB- THEME	MAIN THEME
Centralised government	Quality of employment standards	Employee Output 
1- Rely on experience 2- Lack of sufficient training 3- low educational level 4- Unqualified staff	Lack of skilled workers	
No rewards system	Management performance	
<hr/>		
1- System are manually operated 2- Maintenance backlog 3- Unreliable systems 4- Costly maintenance	Old system (need for update)	Production lines Improvements 
<hr/>		
1- Reactive strategy 2- Preventive maintenance	Adopting non-effective approach	Quality of Maintenance Strategy 
1- Production Fluctuation 2- No improvement plans	Unplanned breakdown	
<hr/>		
1- Decrease maintenance cost 2- Reduce unplanned breakdown	Monitoring system is needed	Maintenance Strategy Improvement 
1- Lack of documentation 2- Specialists are needed	Maintenance Output	
<hr/>		
1- Productivity plan 2- Experience is used 3- Production lines conditions	Maintenance selection conditions	Maintenance selection Procedures 
<hr/>		
1- Adopting non-effective approach 2- Unplanned breakdowns	Production lines improvements	Maintenance Output 
Non maintenance qualification	Employee output	
1- Lack of spare parts 2- Poor level of training	Management performance	
<hr/>		
Regular meeting	Department action	Management performance 
Unmotivated workers	No rewards system	





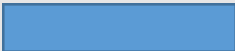

Appendix 9.5: Main themes, factory (B – 2)

CODE	SUB- THEME	MAIN THEME
1- Rely on experience 2- insufficient training 3- Unqualified workers	Lack of skilled workers	Employee Output 
Not comply with employment standards	Quality of employment standards	
<hr/>		
Low efficiency	Old system (need for update)	Production lines Improvements 
<hr/>		
1- Reactive strategy 2- Experience is used	Unplanned strategy	Quality of Maintenance Strategy 
Preventive maintenance is adopted	Bad sequence on the system	
Experts is used	Production lines improvements	
<hr/>		
Lack of training	Management performance	Maintenance Strategy Improvement 
Increase system efficiency	Production lines improvements	
Appropriate training is needed	Maintenance output	
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1- Department report 2- Productivity plan	Maintenance selection conditions	Maintenance selection Procedures 
No rewards system	Management performance	Maintenance Output 
Not familiar with maintenance	Employee output	
<hr/>		
Regular meeting	Department action	Management performance 








Appendix 9.6: Main themes, factory (B – 3)

CODE	SUB- THEME	MAIN THEME
Comply with trip system	Management performance	Employee Output 
1- Rely on experience 2- Outside workers 3- Insufficient training	Lack of skilled workers	
Not comply with employment standards	Quality of employment standards	
<hr/>		
1- Unplanned stoppages 2- Low system efficiency 3- Costly maintenance 4- More time is needed 5- Unable to compete	Old system (need for update)	Production lines Improvements 
<hr/>		
Reactive strategy	Adopting non-effective strategy	Quality of Maintenance Strategy 
Intensive training is needed	Unskilled staff	
Outside workers	Insufficient number of qualified staff	
<hr/>		
6- Reduce cost 7- Save time	New strategy is needed	Maintenance Strategy Improvement 
System reliability	Unable to compete	
System operates slowly(old system)	System efficiency	
<hr/>		
1- Experience is used 2- Unplanned breakdown 3- Training is needed 4- Experts are needed	Maintenance selection conditions	Maintenance selection Procedures 
<hr/>		
1- Lack of spare parts 2- Unmotivated workers	Management performance	Maintenance Output 
Developed system is needed	Production lines Improvements	
Production lines improvements	New strategy is needed	
<hr/>		
Regular meeting	Department action	Management Performance 







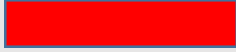
Appendix 9.7: Main themes, factory (C – 1)

CODE	SUB- THEME	MAIN THEME
Not familiar with maintenance work	Non maintenance qualification	Employee Output 
1- Under testing Workers 2- Centralised government	Quality of employment standards	
1- Low productivity 2- No ready spare part	Old system (need for update)	Production lines Improvements 
1- Reactive strategy 2- Other unplanned strategy	Adopting non-effective maintenance	Quality of Maintenance Strategy 
Bad sequence on the system	Unplanned breakdown	
Experts is used	Production lines improvements	
System need update	Production lines Improvements	Maintenance Strategy Improvement 
Complex procedures	Management performance	
Experience is used	Maintenance selection conditions	Maintenance selection Procedures 
Lack of awareness	Employee output	Maintenance Output 
1- Planned stoppage is adopted 2- Poor system efficiency	Old system	
3- Lack of spare parts 4- Lack of documentation	Management performance	
Regular meeting	Department action	





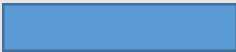

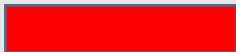
Appendix 9.8: Main themes, factory (C – 2)

CODE	SUB- THEME	MAIN THEME
Low wages	Management performance	Employee Output 
Rely on experience	Quality of employment standards	
1- System manually operated 2- More skills is needed	Old system (need for update)	Production lines Improvements 
1- Unable to compete 2- Lack of fund 3- Unskilled staff	Management performance	
1- Reactive strategy 2- Other unplanned strategy is used 3- Maintenance backlog	Adopting non-effective maintenance	Quality of Maintenance Strategy 
Lack of awareness	New strategy is needed	Maintenance Strategy Improvement 
1- Experts is used 2- Training is needed	Lack of skilled workers	
Experience is used	Maintenance selection conditions	Maintenance selection Procedures 
Rely on experience	Employee output	Maintenance Output 
5- Save time 6- Cut down spending 7- Reduce risk	Monitoring system is needed	
Unplanned stoppage	Production lines improvements	
Regular meeting	Department action	Management Performance 





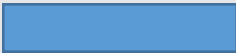


Appendix 9.9: Main themes, factory (C – 3)

CODE	SUB- THEME	MAIN THEME
Low wages	Management performance	Employee Output 
No employment standards	Quality of employment standards	
<hr/>		
System operates slowly	Old system (need for update)	Production lines Improvements 
Lack of fund	Management performance	
<hr/>		
1- No manuals 2- Reactive strategy 3- Maintenance backlog	Adopting non effective strategy	Quality of Maintenance Strategy 
No documentation	Employee output	
<hr/>		
Experts is needed	Lack of skilled workers	Maintenance Strategy Improvement 
Complex procedures	Management performance	
Poor production lines condition	Production lines Improvements	
<hr/>		
Experience is used	Maintenance selection conditions	Maintenance selection Procedures 
<hr/>		
1- Tasks distribution 2- Regular meeting	Management performance	Maintenance Output 
1- Lack of awareness 2- Intensive training is needed	Unqualified workers	
Rely on experience	Employee Output	
<hr/>		
1- System breakdown 2- Outsource 3- Unable to compete	insufficient training	Management Performance 
Improvement report	Complex administrative procedures	








Appendix 9.10: Main themes, factory (D – 1)

CODE	SUB- THEME	MAIN THEME
1- Not familiar with maintenance work 2- Intensive training is needed	Non maintenance qualification	Employee Output 
Centralised government	Quality of employment standards	
1- Reduce maintenance cost 2- System manually operated 3- Monitoring system is needed	Old system (need for update)	Production lines Improvements 
1- Unknown failure 2- Reactive strategy is used	Adopting non-effective strategy	Quality of Maintenance Strategy 
1- Preventive maintenance is adopted 2- Production system conditions	Annual productivity plan	
Lack of fund	Management performance	Maintenance Strategy Improvement 
1- Improvement plan 2- More training is needed	Production lines Improvements	
Reduce unplanned stoppages	New strategy is needed	
Some procedures is used	productivity plan	Maintenance selection Procedures 
1- Insufficient wages 2- level of training programmes	Employee output	Maintenance Output 
Poor rewards system	Employee output	Management Performance 
Lack of spare parts	Factory policies	
Communication method need to be improved	Top management interest level	





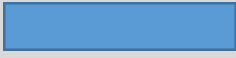


Appendix 9.11: Main themes, factory (D – 2)

CODE	SUB- THEME	MAIN THEME
1- Lack of specialised in maintenance 2- Intensive training is needed	Lack of skilled staff	Employee Output 
Centralised government	Quality of employment standards	
<hr/>		
1- The ability to compete 2- Unreliable system	Old system (need for update)	Production lines Improvements 
<hr/>		
4- Old system 5- Experience is used 6- Unplanned strategy	Adopting non-effective maintenance	Quality of Maintenance Strategy 
<hr/>		
Increase the system reliability	New strategy is needed	Maintenance Strategy Improvement 
Experts is needed	Lack of skilled staff	
<hr/>		
1- Experience is used 2- Production system conditions	Maintenance selection conditions	Maintenance selection Procedures 
<hr/>		
1- More time is needed 2- Technician is needed	Unskilled staff	Maintenance Output 
1- Distribution of tasks 2- Lack of fund	Management Performance	
<hr/>		
Lack of communication	Department action	Management Performance 
Poor rewards system	Employee output	

Appendix 9.12: Main themes, factory (D – 3)

CODE	SUB- THEME	MAIN THEME
Centralised government	Management performance	Employee Output 
1- Low wages 2- Intensive training is needed 3- Non maintenance qualification	Lack of skilled staff	
Unqualified workers	Quality of employment standards	
<hr/>		
Lack of fund	Management performance	Production lines Improvements 
1- Low efficiency of system 2- Unplanned stoppage	Old system (need for update)	
<hr/>		
4- Experience is used 5- Reactive strategy	Adopting non effective strategy	Quality of Maintenance Strategy 
Adopting non effective strategy	Production system improvement	
<hr/>		
Old system	New strategy is needed	Maintenance Strategy Improvement 
<hr/>		
1- Production system condition 2- Lack of fund 3- Experts is used	Maintenance selection conditions	Maintenance selection Procedures 
<hr/>		
Insufficient wages	Management performance	Maintenance Output 
Unskilled workers	Employee output	
<hr/>		
Regular meeting	Department action	Management Performance 

Appendix 9.13: Main themes (Total)

Main Theme	Sub-Theme	Case Factories											
		A			B			C			D		
		1	2	3	1	2	3	1	2	3	1	2	3
Employee Output 	Quality of employment standards	√	√		√	√	√	√	√	√	√	√	√
	Management performance	√	√	√	√	√	√	√	√	√			√
	Lack of skilled workers		√	√	√	√	√					√	√
	Non-maintenance qualification							√			√		
Production lines Improvements 	Old system (need for update)	√	√	√	√	√	√	√	√	√	√	√	√
	Management performance	√							√	√			√
	Unreliable system		√										
Quality of Maintenance Strategy 	Unplanned strategy	√				√							
	Bad sequence on the system	√				√							
	Unplanned breakdown				√			√					
	Production system improvement	√				√		√					√
	Maintenance backlog		√										
	Adopting non-effective approach		√	√	√	√		√	√	√	√	√	√
	Costly maintenance			√									
	Unskilled staff					√							
	Insufficient number of qualified staff					√							
	Employee output									√			
Maintenance Strategy Improvement 	Annual productivity plan										√		
	Integrated maintenance system	√											
	New strategy is needed		√			√			√		√	√	√
	Management performance			√		√		√	√	√	√		
	Monitoring system is needed				√								
	Production lines Improvements					√		√	√		√		
	Maintenance Output				√	√							
	Unable to compete					√							
Maintenance Selection Procedures 	System efficiency					√							
	Lack of skilled workers								√	√		√	
	Maintenance selection conditions	√		√	√	√	√	√	√	√	√	√	√
	Randomly adopted	√											
Maintenance Output 	No strategy in place		√										
	productivity plan										√		
	Employee output	√		√	√	√		√	√	√	√	√	√
	Unskilled staff				√	√						√	
	Management performance	√		√	√	√	√	√		√	√	√	√
	Department action	√											
	Non-maintenance qualification		√										
	Unqualified workers									√			
	Production lines improvements				√	√			√				
	New strategy is needed					√							
Management Performance 	Old system							√					
	Monitoring system is needed								√				
	insufficient training	√								√			
	Employee output										√	√	
	Centralised government	√											
	Department action	√	√		√	√	√	√	√		√	√	√
	Top management interest level			√							√		
Factory policies										√			
Complex administrative procedures							√						
	No rewards system					√							

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