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Implementing a Strategy of Reliability Centered Maintenance (RCM) in the Libyan Cement Industry

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Abstract- The substantial development of the construction industry has forced the cement industry, its major support, to focus on achieving maximum productivity to meet the growing demand for this material. This means that the reliability of a cement production system needs to be at the highest level that can be achieved by good maintenance. This paper studies the extent to which the implementation of RCM is needed as a strategy for increasing the reliability of the production systems component can be increased, thus ensuring continuous productivity. In a case study of four Libyan cement factories, 80 employees were surveyed and 12 top and middle managers interviewed. It is evident that these factories usually breakdown more often than once per month which has led to a decline in productivity. In many times they cannot achieve the minimum level of production amount. This has resulted from the poor reliability of their production systems as a result of poor or insufficient maintenance. It has been found that most of the factories' employees misunderstand maintenance and its importance. The main cause of this problem is the lack of qualified and trained staff, but in addition it has been found that most employees are not found to be motivated as a result of a lack of management support and interest. In response to these findings, it has been suggested that the RCM strategy should be implemented in the four factories. The results show the importance of the development of maintenance strategies through the implementation of RCM in these factories. The purpose of it would be to overcome the problems that could secure the reliability of the production systems. This study could be a useful source of information for academic researchers and the industrial organizations which are still experiencing problems in maintenance practices.

Keywords- *Libyan cement industry, maintenance, reliability, production, reliability centered maintenance*

I. INTRODUCTION

The recent immense development in technology has put most of the world's industrial organizations under great pressure, making the chance of survival in both the domestic and global markets 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 level of efficiency. To achieve this, the system components should be regularly maintained throughout the life cycle of the system.

Through adequate 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. Many studies and reports endorse this; for example the Department of Trade and Industry in the UK conducted a study in 1993 which revealed that the annual cost to UK industry of poor and dangerous maintenance had reached £1.3 (about $2 currently) billion [1]. Many researchers pointed out that the annual cost by poor maintenance must urgently be paid more attention because improving maintenance performance will reduce huge amount of those costs [2]-[12]. This has forced many industrial organizations to reconsider their policy regarding maintenance and seek to apply strategies such as Reliability Centered Maintenance (RCM) by which the reliability of production systems can be increased and the continuity of production ensured [13], [14]. The present study seeks to implement a reliability centered maintenance strategy (RCM) in the Libyan cement industry as one of the solutions by which it can achieve the highest level of reliability in its production systems.

II. LITERATURE REVIEW

A. Maintenance Background and Definition

Maintenance is a word derived from the verb 'to maintain'. Different uses of the word appear in different contexts – for example, 'maintain good health' and 'maintain a certain shape'. Maintenance has been practiced since antiquity; it was a simple task when people merely had to keep their hunting tools sharp and their cooking pots clean [15]. In the18th 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 [16]. After World War II, industries in Europe were in need of rebuilding. Competition in the market had begun to intensify

and the cost of labor had begun to increase, which led to further mechanization and automation. Production machinery had become lighter and quicker. As a result, the reliability of production systems declined. This led some manufacturers to recommend that the focus should change to maintaining the components of the production system and in consequence the maintenance concept changed. Many industrial organizations were forced give more attention to maintenance and to clearly understand the concept and its importance. According to [17] maintenance is "a combination of all technical, administrative and managerial actions during the life cycle of an item, intended to retain it in or restore it to, a state in which it can perform the required function".

B. Maintenance Strategies

The great industrial advances over the past few decades have led to a greater focus on developing the traditional concepts of maintenance in order not only to increase productivity but also to enhance the reliability of production systems through discovering alternatives to the traditional concepts [18]-[21]. Reference [22] states that the quality of applied maintenance is very important. This is due to its impact on the efficiency level of the equipment in performance and thus on the quality of the final product. Maintenance cannot be done without following a suitable strategy, which is a guide for undertaking maintenance. Maintenance strategies, as a system, can play a big role in meeting the organization's objectives, such as raising product quality and reducing prices and delivery times by minimizing equipment downtime. Reference [23] in his study of some UK firms cites evidence for this. In the GLASSUK Company about 41% of working hours were spent on the repair/improvement of production systems, which may be considered very high. The reason was evidently a backlog of work after demands increased, attributable to the lack or poor quality of the company's maintenance strategy. According to [24] maintenance strategy is a "management method used in order to achieve the maintenance objectives". This definition gives a clear indication of how important a maintenance strategy is, since it calls for many things to be considered at once, such as the most suitable type of maintenance, workforce, time and place for achieving the maintenance objectives. Reference [25] clearly analyzes this definition, stating that maintenance strategies mainly depend on a set of organized processes, such as search and selection, before decisions are implemented. As evidence of this, studies conducted in the UK for over 20 years have shown the need to implement maintenance policies in better ways, for at present maintaining production systems costs the industrial organizations of the UK £20 (about $31 currently) billion per year [26]. There are of course many types of maintenance strategy.

References [27]-[30] classify maintenance strategies as Reactive, Predictive or Preventive. Predictive and Preventive are both varieties of Proactive Strategy. Reactive Maintenance Strategy is carried out after failure occurs. 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. Preventive Maintenance (PM) aims to reduce or eliminate accumulated deterioration by carrying out regular maintenance activities of the equipment at pre-selected times. This increases the reliability of equipment or production systems, but is very expensive. Reference [27] summarize what [29], [30] say about Aggressive Strategy as an added part of Total Predictive Strategy (TPM). This strategy adopts the principle of improving the overall efficiency of the system by asking all employees to join together to pre-empt failure and improve the availability of the system. They claim that using this strategy can even reduce maintenance costs and increase equipment efficiency, thus improving the availability of the production system.

C. Reliability Cantered 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 are considered among the most important reasons for seeking more effective ways of maintaining production assets.

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 heavy increase in maintenance costs following the introduction of wide-body jets, which made the aviation industry uneconomical. Next, RCM moved to the armed forces, was 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 [31]-[33]. Airlines, for example, where failure can cause serious problems, noticed that the availability and reliability of their planes improved with the application of every effort to implement RCM, given that RCM was structured to balance benefits with costs, although, unlike Preventive Maintenance, it can never aim to prevent all failures. Therefore the potential consequences of each failure had to be identified and the probability of failure estimated. Accordingly, Reference [31] summarizes the concept of RCM as an improved Program 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 fulfill 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 procedure cannot be found?

According to [32]-[34], all the other strategies such as Preventive, Proactive and Reactive Strategy are integrated optimally in RCM, together with their respective advantages, in order to achieve the highest level of reliability in the equipment

and thus that in the components of the whole facility. In addition, it reduces the cost of the equipment's life-cycle, by reducing the amount spent on unnecessary maintenance programs. Fig. 1 shows how these strategies work under the heading of RCM.

Most of the definitions and descriptions of RCM are very similar, due to its widespread popularity among industrial concerns. It is clear that RCM has been seen as a modern and developed theory of maintenance, because it requires an organized maintenance program. Such programs are usually based on the needs for equipment maintenance, arranged according to their importance. RCM also organizes 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 increase 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 is often found, due to maintenance failure as a result of the accumulation of maintenance tasks.

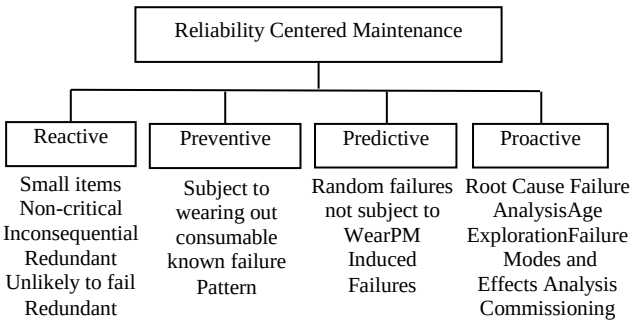

Figure 1. RCM program components [33]

D. 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 [35], [36]. In 2000 the cement plants around the world produced overall about 1.6 billion metric tons (bmt) of cement. This number rose to 4bmt in 2013 [37]because 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 [38]. Libya is not an exception. More than 97% of the construction industry depends on cement or cement-based materials such as blocks and concrete surfaces [39]. The demand for this material continues to grow: some studies estimate that the consumption of cement in Libya reached 9.6 million metric tons (mmt) in 2013 [40]. The total is so high because of the reconstruction process all over the country where, for example, in 2013 the new government allocated £18 (about $27 currently) billion to construction and infrastructure [41]. These huge investments have increased the importance of the cement industry in Libya, because it will be primarily responsible for providing the fundamental material for carrying out these projects. Therefore the cement sector should work as efficiently as possible so that it can meet these requirements [39]. This is confirmed by [42], who recommend 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.

The cement company involved in this study is the largest cement producer among three cement plants 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 mmt/yr of cement and 1.0 mmt/yr of gypsum. It is located in the north-west, near the Libyan capital, and has four cement factories. The first factory (A) was established in 1968, near Alkhumes city, 128.74km (80 miles) east of the capital. It was designed to have a production capacity of 0.33 mmt/yr. The second factory (B) lies 40.23km (25 miles) south of Tripoli. This factory was founded in 1977 with a production capacity of about 1.0 mmt/yr. The third plant (C) was built in 1979 near Alkhumes city 144.84km (90 miles) west of Tripoli with a 1.0 mmt/yr production capacity. The fourth factory (D) is located in Zliten city about 165.76km (103 miles) east of the capital with a production capacity of 1mmt/yr. It was founded in 1984 [43], [44]. All these factories adopt the so-called dry process in the manufacture of cement. Fig. 2 gives a simplified picture of the production process in the four factories.

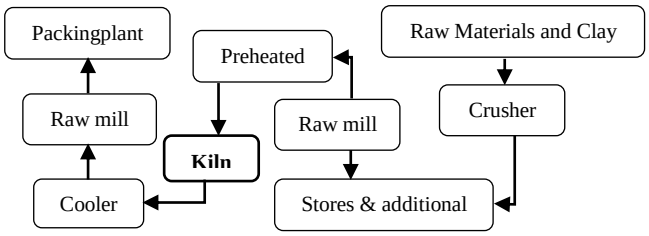

Figure 2. Outline of the main steps of cement production [43]

E. Current Issues in the Four Factories

Competitiveness is an indicator of the strength of an organization's performance, therefore the successful management of any industrial organization looks for ways to increase the efficiency of the company and tries to avoid or deal with any obstacles [45],[46].

The Libyan Cement industry, like many other Libyan industries, suffers problems in its production systems, due to missing or poor maintenance. This can be seen in the performance of many Libyan cement companies. Reference [47] found that no maintenance strategies at all were applied into cement factories and [43] highlighted that in some cement plants the only approach used at factory level was "if there is a problem, fix it". Furthermore,[48] states that the poor performance of the production systems in many cement plants results from poor applied maintenance. This is due in turn to poor management and the unfair treatment of employees. 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 as 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 [49]. This is evident from the low levels of production. According to the company's website, production declined to 1.3mmt in 2012 [44].

One of these obstacles is that the Libyan cement industry lacks technical expertise and trained personnel. This is due to the centralized management, which cannot easily meet the conditions of running production systems as efficient as possible. In other words, orders come directly from senior management, without reference to the relevant sections of authority in most cement plants see [43], [47] and [48]. Furthermore, [45] confirms that when 207 Libyan companies were examined it was found that more than 83% of them suffered from weak managerial performance. Reference [50] in their field visits to cement plants in Libya and the United Kingdom, noted a great difference between the cement industries in the two countries. For example, workers in Libyan factories lack a competitive spirit and the ambition to develop their individual skills. Behind this lies a lack of effective training programs and of incentives and encouragement. Reference [36] confirms 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. Reference [45] believes that today's competitive environment obliges industries to achieve full productivity while minimizing 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. Reference [51] agrees, believing that successful industrial organizations are the ones which recognize that effective maintenance programs are essential to the success of maintenance. These programs usually depend on the application of a 'predict and prevent' failure strategy rather than fixing what has gone wrong [52]. Reference [53] asserts 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 means planned maintenance instead of reactive maintenance which is often ineffective. Planned maintenance takes the trouble to consider the internal and external factors of the organization. Today's challenge is to improve cement production systems overall by changing from simple traditional mass production to more effective systems which increase productivity, in addition to maximizing the use of the available capacity, human and material, to meet the growing demand for cement [36].

Considering all of this evidence, it is clear that the Libyan cement industry still continues to lag behind others and faces various obstacles to its progress, for example, the failure to train current employees and accustom them to up-to-date methods so that they can work as efficiently as required. In addition, poor maintenance in itself is one of the biggest barriers to the development of the cement industry; it 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 some cement plants in Libya and explore RCM as a strategy to help ensure the operating continuity of production systems at high efficiency and thus continued productivity combined with unvarying quality.

III. Research Methodology and Results

A. Methodology

The above discussion is built upon a comprehensive literature review of the current situation of the Libyan cement industry in terms of maintenance and its practices. It was undertaken to understand and evaluate the problems and barriers which affect the implementation of maintenance in this sector. It was followed by a survey questionnaire conducted in four Libyan cement factories in order to understand in detail the factors which most affect the implementation of proper maintenance in them. In the survey, 80 employees (20 from each plant) were targeted to answer a paper questionnaire. This number was chosen out of a total of 200 employees (about 50 in each factory) who are working under the maintenance departments, as reported in the 12interviews with the maintenance and production managers in the four factories. The response rate was about 88.75% (71 respondents) in total. This indicated that most of the staff was interested in taking part in this study and helping to improve the performance of the production systems in their plants; it naturally increased the level of the reliability and consistency in the questionnaire. The questionnaire focused on the employees' knowledge of maintenance, the interest of top management in maintenance, the extent of the need to improve maintenance strategy to meet the organization's objectives and the maintenance strategy currently applied in the four factories. In addition to the questionnaire, 12 top and middle managers agreed to take part in semi structured interviews. These were carried out to enable more in-depth investigation to take place, providing more details about maintenance and its practices in the four plants.

B. Results

According to the survey results, as shown in Table I, 76.1% of the sample (54 respondents) lacked knowledge of maintenance and its strategies; as they said, the only strategy used was reactive or what is known "running to failure", which indicates a lack of specialists. This is what 7 interviewees (58.33%) confirmed; they wanted top management to contract staff specializing in maintenance so as to improve the current maintenance strategy. This is evidenced by the maintenance qualification level where44 respondents (62%) used their

experience of maintenance work as their qualification not related to maintenance this is can be supported by 36 respondents (50.7%) had been working in the field of maintenance for more than 10 years. In addition, a total of 47.9% (34 respondents) had been educated to secondary school level or below and only just 31.02% (22 respondents, 20 technical and 2 professional) held qualifications related to maintenance. Clearly, the efficiency and technical capabilities of many needed to be improved. From Table I it can be seen that 38 respondents (53.5%) had no clear understanding of maintenance and its importance. This was supported by the view of 10 interviewees (83.3%) who they maintained that most maintenance staffs were not aware of maintenance and its practices. This can be seen from the evidence about unplanned maintenance: 74.7% (53 respondents) said that there was no scheduled maintenance in place, which indicates a poor maintenance system and makes maintenance work very complex.

TABLE I. GENERAL BACKGROUND

Questions	Options	Number of Respondents	%
Maintenance strategy used	Reactive (Run to failure)	54	76.1
	Proactive (Predictive/Preventive)	15	21.1
	Aggressive (TPM)	2	2.8
	Reliability Centered Maintenance	0	0
	Total	71	100
Qualifications in maintenance work	Professional	2	2.8
	Technical	20	28.2
	Experienced	44	62
	Not relevant to maintenance	5	7
	Total	71	100
Years of experience in the field of maintenance	Less than 5 years	8	11.3
	5-10 years	27	38
	More than 10 years	36	50.7
	Total	71	100
Educational level	Secondary school or below	34	47.9
	Diploma	16	22.5
	Bachelor	21	29.6
	Master	0	0
	PhD	0	0
	Total	71	100
Clear understanding of the importance of maintenance	Yes	33	46.5
	No	38	53.5
	Total	71	100
Maintenance of equipment according to a specific and known schedule	Yes	18	25.3
	No	53	74.7
	Total	71	100

In relation to maintenance strategies, 12 engineers and technicians (16.9% of the respondents), as shown in Table II, said that they knew of some modern maintenance strategies such as TPM. In contrast, 91.5% of other staff (about 54 of 59 who said they don't know any modern strategies), as shown in Fig.3, maintained that they wanted to learn about maintenance strategies, which could be a great advantage among staff skills. Although 63.4% (45 respondents) strongly agreed that the reliability of production systems could be increased through the implementation of modern strategies, such as RCM, only 15.5% (11 respondents) of staff could define such strategies as RCM or Total Predictive Maintenance (TPM). This is related to the lack of top management interest, confirmed by the fact that 71.8% (51 respondents) thought that there was a great need to apply strategy such as RCM to improve the efficiency of the production systems in their factories. In contrast, about 97.2% (69 respondents) said that there had been no any previous attempt to use any of these strategies in their factories, even though the remainder mentioned an attempt to use TPM.

TABLE II. ASPECTS OF MAINTENANCE

Questions	Options	Number of Respondents	%
Knew of modern maintenance strategy	Aggressive(Total Predictive Maintenance)	12	16.9
	Reliability Centered Maintenance	0	0
	Not known any modern strategies	59	83.1
	Total	71	100
Believed that Improving maintenance could increase the reliability of production systems	Strongly agree	45	63.4
	Agree	15	21.1
	Neither agree Nor disagree	8	11.3
	Disagree	3	4.2
	Strongly disagree	0	0
	Total	71	100
Could define a modern strategy	Yes	11	15.5
	No	60	84.5
	Total	71	100
Felt the need to apply a modern strategy such as RCM	Yes	51	71.8
	No	20	28.2
	Total	71	100
Had previously attempt to use modern strategies such as RCM	Yes	2	2.8
	No	69	97.2
	Total	71	100

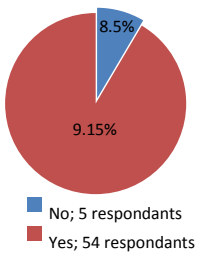

Figure 3. The desire to learn about maintenance strategies/ total respondents 59

From the standpoint of human nature and job satisfaction, it seems clear that the workers in these firms are not motivated to perform their jobs, in several respects. One of these is the low wage: 54.9% of staff (39 respondents), as shown in Table III, said that their monthly salary did not meet their basic financial needs. 31% (22 respondents) would like to move to another job and 46 out of 71 respondents (64.7%) take on extra work to raise their incomes. In addition, 20 respondents (28.1%) mentioned that they did not receive any support from the management when carrying out maintenance work while 42.3% (30 respondents) said that they could receive managerial support if there is a big problem; for example, their salary includes no performance related incentives, as 64 respondents stated (90.1%).This finding was supported by 66.7% (8 interviewees) who admitted the existence of a big gap between staff and top management, which in turn lowers the morale of the workers. At the same time, this finding indicates the lack of interest and encouragement from senior management, which has a negative impact on staff capability by reducing their performance level and thus reducing the maintenance efficiency which in turn lowers the reliability of the production systems. Here it can be said that the poor relationship between managers and other staff may be one of the factors that touches on the improvement of both staff skills and maintenance itself. This is confirmed by 69% of employees (49 respondents) who would describe the relations between managers and technicians as inadequate, and also by 54.92% (39 respondents) who consider that the relations between managers and engineers are inadequate. However, 15.5% (11respondents) said that the relations between engineers and managers are strong and so are the relations between managers and technicians, which 9.9% (7 respondents) testify to.

This gives a clear picture of the perception that some employees are privileged, noted by 69% of staff (49 respondents). 66.2% (47 respondents) believe that the main reason for it is that they may be enjoying support from the top stratum of the administration. Perhaps this also accounts for the lack of competition between one worker and another in carrying out their duties.

The other factor hampering the success of carrying out maintenance in the targeted cement factories as explored in the Table IV is the lack of trained staff. Although about 41.7% 5 of the interviewees mentioned the availability of training programs to all staff, the participants' answers suggested some else. Nearly 70.4% of them (50 respondents) said they had not received any kind of training, either internal or external. They use their experience alone. As a result, 57.8% of maintenance workers (41respondents) cannot deal with complex equipment, leading to poor maintenance. This can often cause a maintenance backlog, according to 54.9% of participants. About 33.3% (4 interviewees) confirmed this in stating that their factories outsourced their maintenance activities. This in turn makes maintenance more costly and may affect the efficiency of the production systems' performance, as can be evidenced by the number of stoppages, in the view of 62 % (44 respondents), who claimed that their factories had 2 or more stoppages per month. This number is considered very high. More attention should be given to issues directly related to maintenance, such as training programs.

33.3% (4) of the interviewees added that more technical trained staff was needed, but 8 others (about 66.7%) believed that the level of current staff performance could go up if they could receive sufficient training. This was confirmed by about 95.8% (68 respondents) who believed that training programs are important for improving their skills and enabling them doing their job better. The main reason behind the shortage of such programs is the lack of senior management interest, in the opinion of 50 participants (70.4%), while 21 respondents (29.6%) see the lack of funds as another possible reason.

TABLE III. WORK ENVIRONMENT AND MANAGEMENT ISSUES

Questions	Options	Number of Respondents	%
Does monthly salary meet your basic financial needs?	Yes	32	45.1
	No	39	54.9
	Total	71	100
Would you wish to move to another job?	Yes	22	31
	No	49	69
	Total	71	100
Do you do other work to supplement your income?	Yes	46	64.7
	No	25	35.2
	Total	71	100
Do you receive support from management when carrying out maintenance?	Yes	6	8.5
	No	20	28.1
	When I ask	15	21.1
	If there is a big problem	30	42.3
	Total	71	100
Does your salary include a performance related incentive?	Yes	0	0
	Sometimes	7	9.9
	No	64	90.1
	Total	71	100
How would you describe the relationship between engineers and managers	Strong	11	15.5
	Medium	21	29.6
	Weak	39	54.9
	No relationship	0	0
	Total	71	100
How would you describe the relationship between technicians and managers?	Strong	7	9.9
	Medium	8	11.2
	Weak	49	69
	No relation	7	9.9
	Total	71	100
How would you describe the relationship between engineers and technicians?	Strong	40	56.3
	Medium	22	31
	Weak	9	12.7
	No relation	0	0
	Total	71	100
Are some employees privileged?	Yes	49	69
	No	22	31
	Total	71	100
What makes them privileged?	Administration support	47	66.2
	The desire to be creative	20	28.2
	Other goals	4	5.6
	Total	71	100

TABLE IV. TRAINING PROGRAMS

Questions	Options	Number of Respondents	%
Have you attended any training courses?	Yes	21	29.6
	No	50	70.4
	Total	71	100
What types of equipment are you familiar with?	Complex	30	42.2
	Simple	41	57.8
	Total	71	100
Does your firm have a maintenance backlog?	Always	39	54.9
	Sometimes	24	33.8
	Rarely	8	11.3
	Never	0	0
	Total	71	100
How many stoppage of production does your firm have?	Two or more stops per month	44	62
	Less than two stops per month	27	38
	Total	71	100
Do you think training programmes are very important?	Yes	68	95.8
	No	3	4.2
	Total	71	100
What is the reason for the lack of training opportunities?	Lack of senior management interest	50	70.4
	Lack of funds	21	29.6
	Lack of desire for training	0	0
	Total	71	100

In relation to the documentation and management issues, although 9 interviewees (75%) mentioned that documentation was an important aspect of improving maintenance, no clear system of recording maintenance was mentioned. Table V clarifies that, as 64.8% (46 respondents) said, no records are kept of the maintenance tasks completed. Fig.4 shows that 71.7% (33 out of 46 respondents who said there is no documentation for maintenance) linked this to the lack of senior management interest, while 6.5% (3 out of 46) thought that there was no need for documentation. Here it can be said that such an attitude can affect the improvement of maintenance in a negative way, as it precludes sufficient information being kept on each device to use when maintenance is next needed. Record-keeping helps overcome any problems and obstacles that might have been encountered last time. 74.7% of staff (53 respondents) agreed with this point by remarking that no program had been set up to evaluate the effectiveness of the maintenance carried out.

TABLE V. MAINTENANCE DOCUMENTATION AND RECORDING

Questions	Options	Number of Respondents	%
Is maintenance documented in your firm?	Yes	25	35.2
	No	46	64.8
	Total	71	100
Does your firm have programs to evaluate the effectiveness of the maintenance that is carried out?	Yes	53	74.7
	No	18	25.4
	Total	71	100

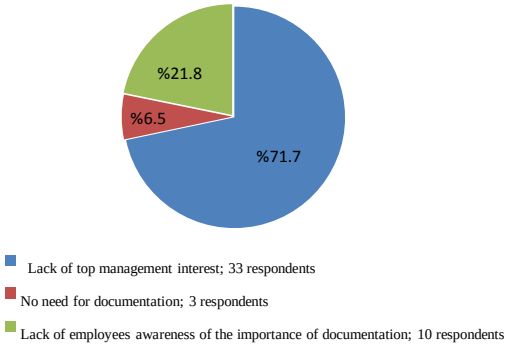

Figure 4. Reason/s for no maintenance records kept / total respondents 46

IV. DISCUSSION

The evidence presented from the survey that the level of implementation of modern maintenance strategies such as RCM is very low. This could have a direct effect on the firms' productivity, since maintenance with the old strategy which is currently in place or without any strategy can never be as effective as it should be to fulfill today's basic maintenance requirements. Thus, production becomes very costly and less reliable. This can be seen from the low production rate in comparison with the capacity of the four factories as originally designed. In general the poor maintenance can be linked to the lack of training programs in a situation where most of the staff needs to be trained so they can keep pace with developments in the field of maintenance. In addition top management lack any interest in improvement, shown by the big gap between top management and other staff. The lack of awareness of maintenance and its importance make maintenance a very complex task. This can be traced primarily to the lack of specialist staff who can do their job effectively. It can be argued that experts in employee relations consider this an important aspect which has a very bad effect on the implementation of maintenance. For example, staff cannot be motivated to perform their work as they should because of the discrimination against some workers by the administration. Moreover, low wages and the lack of incentive payments force many workers to take on other jobs. This in turn reduces their performance level and is likely to result in employee dissatisfaction.

This research attempted to understand the current implementation of maintenance strategy in Libyan cement companies and to explore how to adopt an effective maintenance strategy like the RCM strategy. This will be as a part of a maintenance development program through which the reliability of production systems could be increased and thus continuous production could be ensured. To set it up, an organization's total environment related to maintenance issues should be addressed, including the maintenance strategy currently in place, employee relations and management aspects. This paper is seen as part of the mission to bring it about. However, it might be difficult to implement a modern strategy in countries such as Libya. For example, it was found in the literature review that the problems associated with

performance could be due to the lack of specialist managers, which is linked to the tribal systems in Libya, because managerial appointments depend on the support of the tribe regardless of qualification and experience. This can be overcome by privatizing the nationalized sector or letting firms form partnerships with foreign organizations. The present research could form part of a training course for both managers and employees in industrial companies whereby they could study in detail the issues that must be addressed to improve maintenance and make it as successful as it ought to be. The most encouraging finding from the case study is that staffs are interested in improving maintenance in their factories and developing their skills to show positive benchmark that Libyan industry could aspire to.

The proposals above could be a basis for developing identification of both the external and internal factors that form barriers and problems facing the implementation of maintenance and finding ways of improving maintenance to meet the organization's objectives. Fig.5 shows a novel approach to addressing such the obstacles in the target companies. This approach is built on two main lines: the human factors which are generated from staff training, staff motivation and staff satisfaction; and the production environment which generated from both internal factors such as the maintenance strategy currently in place and management system used, and the external factors such as the market place and the availability of raw materials.

V. Research Limitations

The unavailability of documents, either on maintenance or on workers themselves complicated the evaluation process, because such documents would have made a reliable reference point. The information from documents can be compared with the results of a researcher's questionnaires and interviews to make the research results more reliable and valid. It should also be admitted that the educational level of most of the participants in this study was considered low; hence, their answers occasionally reflect their opinions rather than the conditions around them. This must have a negative effect on the reliability of the final results of the study.

VI. Conclusion

This study investigates the barriers and problems which hinder the success of the maintenance strategies applied in some cement plants in Libya. It explores RCM as a strategy by which production systems can be taken to the highest level of reliability, thus ensuring continuous productivity. RCM as an approach is based on the identification of components whose failure can cause undesirable consequences and directly affect the continuity of production in a factory. The results of this study reveal that, in the cement factories that were targeted, many problems and obstacles hampered the success of maintenance efforts. For example, a lack of understanding of maintenance and its importance is one of the biggest barriers to the successes of maintenance and thus reduces the reliability of production systems. This is evidenced by the failure to use a suitable strategy of maintenance as the only strategy that is used at present is reactive, or what is known as 'running to failure'. As a result, the number of stoppages in production systems during production time is considered to be very high. This leads to the factories sometimes being unable to meet even half of local demand. The results of the study show that two main factors lie behind the lack of understanding of what maintenance involves and how important it is. The first is the failure to train employees and accustom them to up-to-date methods such as RCM so that they can work as efficiently in fully reliable production systems as competitiveness requires; it was one of the main objectives of the present research to demonstrate this. The other factor is the maintenance qualification level. At present, more than 50 percent of employees rely on experience alone when it comes to maintenance work and have qualifications in some unrelated area. Finally, the study shows that there is a big need to find ways which through the maintenance can be improved and thus ensuring the reliability of production systems. For this, the factors that are facing the success of maintenance will be addressed through implementation of RCM strategy. This will be along with the studying the circumstances that should be addressed to ensure the success of implementing RCM.

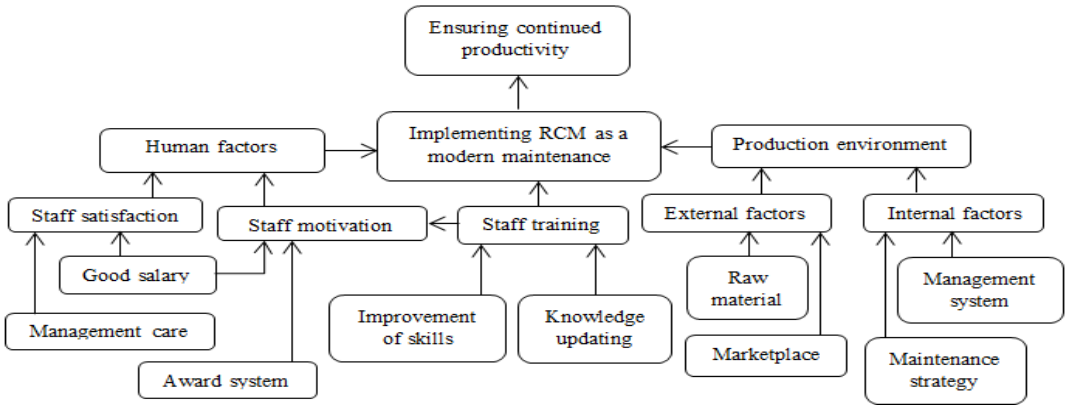

Figure 5. A new model to overcome the problems and barriers hindering the improvement of maintenance in the targeted cement factories (author)

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