A Study Maintenance and Production Problems in Two of Cement Factories in Libya by Using TPM

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Abstract—**The principle of this paper is to investigate maintenance and production problems in the cement factory in Libya with particular emphasis on Total Productive Maintenance (TPM). The paper presents the use of case study approach of production data and history, field visits. There is no clear TPM strategy and it has been also found that the lack of training and personal development is the main cause of this problem. In addition, employees are found not to be motivated as a result of the lack of poor management strategy and reward structure. Based on the findings, a new framework for TPM has been developed. This TPM strategy could be implemented in other Libyan factories as a result of the potential similarities in the cultural and environmental aspects. The comparative analysis is developed into a model for international strategy design and implementation. The paper highlights limitation is the cement factories in Libya in relation to TPM and production strategies. The importance of adopting a realistic strategy and framework by managers is discussed. This work is developed as collaboration between Academia and Libyan Cement industry for solving productivity problems and develop a strategic framework of TPM for improving the Libyan industry.**

Index Terms: **Total Productive Maintenance, Libya, Cement production.**

I. INTRODUCTION

The international competition and the demand to increase productivity of manufacturing and production lines have attracted the management of industrial organisations from a wide spectrum to implement Total Productive Maintenance (TPM) as a tool for improving productivity and system's output. Total Productive Maintenance (TPM) is a maintenance program philosophy which is similar in nature to Total Quality Management (TQM) in many aspects, including the total commitment of height level management to the TPM programme, employees must be empowered to take initiatives and corrective actions, and continuity and long term strategy is needed as TPM is a continuous process [1,13]. The implementation of the available technology and cultural change of employees and management are also necessary to achieve the objectives of the process. With the implementation of TPM, maintenance is no longer the necessary evil, but it is a vitally important part of the business. The general vision of TPM eliminates any 'conflict of interest' between production and maintenance departments. If the objective is to optimise the performance of the production line, it is important to integrate both activities in a comprehensive strategy. Down-time for maintenance should be scheduled as an integral part of the manufacturing process. Total Productive Maintenance is often defined as "Productive Maintenance involving total participation" [1,2,14,15]. The objective of TPM is the continuous improvement that embraces all aspects of an organisation. In general, and according to [1-12,1,15]TPM involves maximising the utilisation of equipment to establishing a comprehensive approach towards maintenance of equipment during the entire product life span, implementing TPM by many departments including production, maintenance and management, involving all employees from top management to shop-floor workers, promoting preventive maintenance through staff motivation and raising productivity while, at the same time, improving employee morale and job satisfaction. However, implementing TPM might not be an easy task. According to [16-18,20] several aspects could influence the successful implantation of TPM including lack of senior management support, lack of budget or investment, pressure of workload, confliction of management initiatives, inefficient use of maintenance staff and senior management's tolerance of poor performance. In recent years, Libya has focused on improving its industry in general and the cement industry in particular.[3] have presented a comprehensive research work in relation to TQM, JIT and MRPII within the cement industry in Libya. It has been found that there was no clear strategy in relation to the above areas [11] in this paper, the authors investigate TPM and maintenance strategies in relation to the cement industry in Libya taking into consideration diversity of aspects on different management levels. Other recent publications, see for example [14,15,19and6] has also presented investigations within the industry in Libya from various context.

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II. MAINTENANCE STRATEGIES

For far too long, failures of machines have been thought of as inevitable events within any production system and engineers used to consider maintenance as

repair operations. There are mainly three kind of machine maintenance [16-20] and [8] unplanned breakdown maintenance, planned schedules maintenance and Condition monitoring Based Maintenance (CBM), see Figure 1. Unplanned maintenance and unpredictable failure of machines have a crucial effect on the efficiency of the production system. Low reliability of machines increases downtime, consequently causing unnecessary and unexpected costs. The planned scheduled maintenance is normally based on the statistical analysis of the machine failure history and maintenance recommendation of machines/spare parts manufacturers that normally include unnecessarily high factor of safety [4]. The third type of maintenance strategies is the condition monitoring based strategy. It is a planned maintenance based upon measuring the conditions of the critical elements of the machine during operation. The analysis can be done to predict the time to failure and thus allow maintenance to be planned [14-16] condition monitoring can decrease breakdown costs by enhancing preventive maintenance scheduling and effectiveness of maintenance operations.

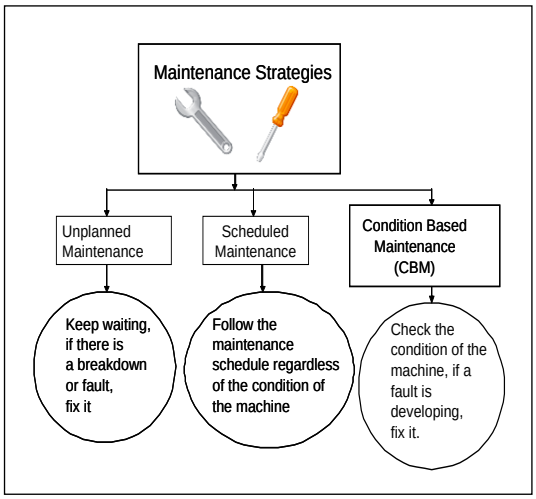

Figure 1. The Main Three Types Of Maintenance Strategies.

CBM is an evolving area of condition monitoring. In terms of the future of CBM, "it can be concluded that the future technical development might or should be heading towards prognostication and calculations of remaining useful life" [10] TPM integrates the above maintenance strategy in a comprehensive strategy with production and select the most suitable maintenance procedure that could be used to produce the most suitable [5].

III. THE CEMENT INDUSTRY IN LIBYA

Libya post 1969 has witnessed considerable industrial and urban development. City of Alkhums was one of the cities where several cement factories were built because of its strategic location and the availability of the necessary raw materials for cement production. The National Cement Company (NCC) is one of the largest companies in Libya and one of the largest producers in North Africa. NCC is located in the North-west region of Libya. It has a cement production target of 2,000,000 tonnes per annum. NCC also has additional manufacturing facilities, for example, it also produces gypsum, lime, factory bags, factory block, marble, concrete plant and Cement mixes. The company comprises two Cement factories. The first factory (SCF) was built in 1977 about 40 Km north of Souq Alkames, a town of Tripoli and has a target production of 1,000,000 Tonnes per annum. The second (ZCF) was built in designed for a production capacity of factory 1,000,000 Tonnes per annum (ZCF) was built in 1984 at Zeleten city which is about 165Km from Tripoli.. The cement produced from the two factories is for internal consumption due to the fact that the total production is required for the infrastructure of Libya. NCC produces cement according to specific Libyan specifications, which are similar to those of British Portland cement. It uses a dry process method in all factories. The management structure of NCC has a centralised management system (i.e. Head Quarter) to control all factories and plants which is located at Alkhums city due to its central geographical position. This paper is part of a comprehensive research work which was initiated by NCC to address the problems which the company is facing and develop an improved TPM strategy to enhance productivity and reduce cost.

IV. THE INVESTIGATION OF THE CEMENT INDUSTRY

In order to help the management to identify the main problems facing the two factories and identify a suitable strategy for improving the production in the two factories a comprehensive study has been initiated which includes analysis of the production data and productivity, field visits to identify some the main problems, questionnaires to technical staff at all levels and interviews with middle and top managers. This paper will present and discuss the main results addressed in this investigation and more detailed will be presented in future publications. The field visits in the two factories included the main 'obvious to see' issues that could be addressed. In order to develop a good benchmark, a visit to a UK cement factory has been also included for comparison. The results see Figure 2; indicate that there are poor maintenance procedures, lack of organisation and negative effect on the environment within the Libyan factories. Figures 2-a and 2-b indicate poor maintenance of filters in one of the factories which has negative effect on the environment. Figure 2-c indicate s a comparison between UK and one of the Libyan factories in relation to storage of material and the general organisation of the plant.

It has been found that there clear need for using the Five S's methodology to focus on organisation, cleanliness and standardisation to improve profitability, efficiency, service and safety. Figure 2-d indicates the health of some of the equipment and the level of maintenance within the factory. From the field visits, it has been found that there is significant need to implement TPM within the Libyan cement industry to provide high productivity and improve maintenance strategy. Based on

the initial field work, analysis of the production data has been collected and analysed, as described in the next section, in order to understand the history of the two factories and in order to develop a comprehensive view and analysis.

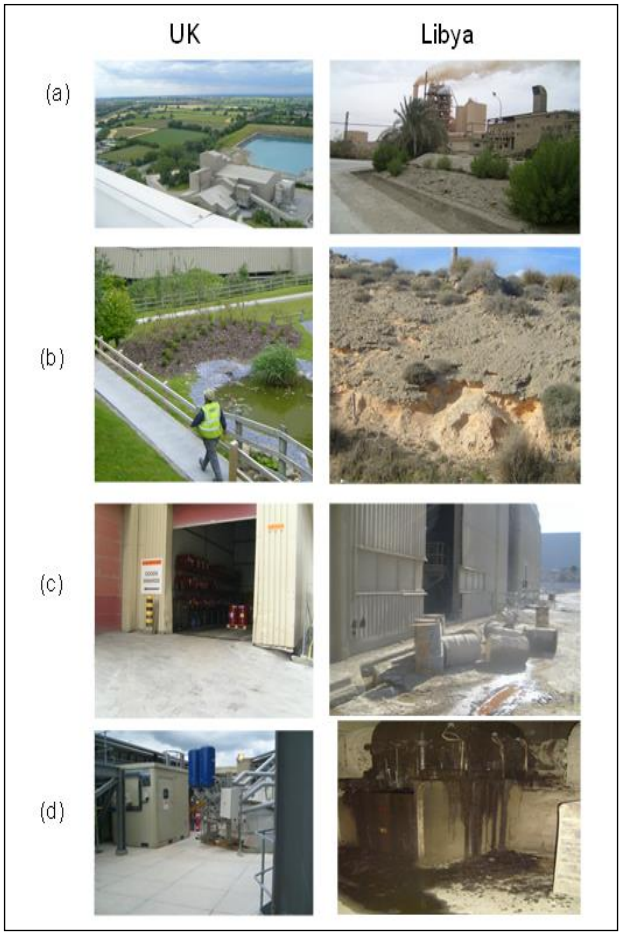

Figure 2: Filed Visits And Comparison Between A UK Cement Factory And Some Of The Cement Factories In Libya.

VI. PRODUCTIVITY DATA ANALYSIS - A CASE STUDY

Figure 3 presents the production (in thousand Tonnes) of the two factories between 1993 and 2006. It is clear that there is significant variation in the production over the years. It has been found that the majority of the fluctuation in the production of the factories is based on changing in shift hours, failure of equipment and lack of spare parts, etc. It has been found for the analysis that there is clear indication that there is a need for TPM in order to maintain production on a constant and productive level.

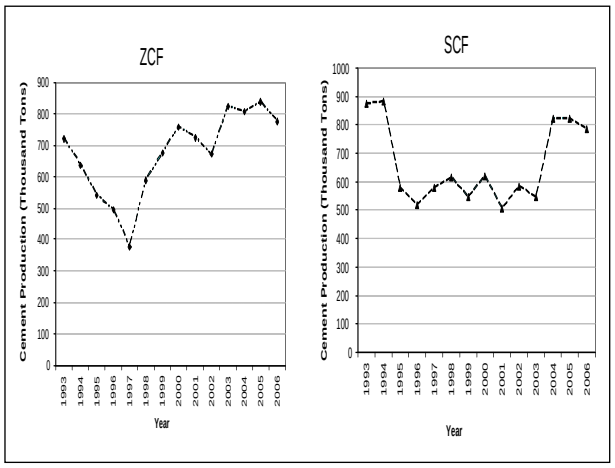

Figure 3: The Production Of The Two Factories Between 1993 And 2006.

In this paper, the data from SCF will be analysed in detail to represent some of the common problems in the two factories. The Souq Alkames factory (SCF) is designed to produce 1,000,000 tonnes annually (based on 24 hours a day operation), in order to satisfy some of the local consumption of cement in Libya. Figure 4 presents the production of the Souq Alkames factory from 1981 to 2008. The actual production in the factory started in 1981 with a production of 470,000 Tonnes, which was less than 50% of the design capacity of the factory. This is related mainly to the need for experienced workers and training of employees. There was lack of focus on maintenance strategies or maintenance training at the start of production. Between 1982 and 1983 the production increased to about 700,000 Tonnes (point A on Figure 4). However, the production dropped down between 1984 and 1986 reaching its lowest level of about 220,000 Tonnes (point B). This drop was mainly caused by the need for maintenance experience and strategies which were needed to maintain the factory to the right standard. As a results of the problem, new group of maintenance and production engineers where employed to improve the factory's performance. There was steady increase in the production of the factory between 1986 and 1993 (between points B and C). During 1993 (point C), the factory had reached its maximum production level of about 840,000 Tonnes. This simply was the maximum capacity that theoretically could be achieved from the factory based on the actual 20 hours operation a day.

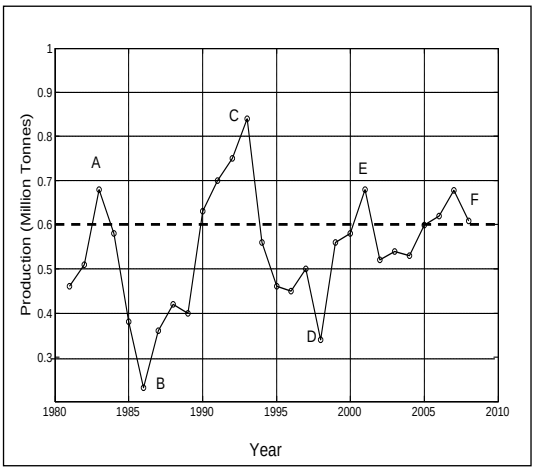

Figure 4: Cement Production In Million Tonnes In Souq Alkames Factory.

The main reason of achieving this maximum productivity was the introduction at the end of 1992 to a new department to the factory, named (Maintenance Research and Development) which focused on the development of integrated production and maintenance strategies with Total Productive Maintenance as the main aspect of the strategy. The new department realised that the factory had two shifts only (8 hours each). The factory operated from 7 AM to 11 PM. This meant that the factory had been working at a maximum production level of about 67%. (i.e. 670,000 Tonnes annually). Each shift normally included one technician, two electrical engineers, three mechanical engineers and four general service workers. Without the use of any additional resources, the new management changed the culture of the factory by introducing three shifts and extending the working hours of the factory into 20 hours and raising the theoretical production capacity of the factory into about 84% (i.e. 840,000 Tonnes Annually). In order to create the motivation and incentives to the new shift culture, the production of each shift was monitored and displayed on a production sheet in the factory. The management awarded the shift with efficient and highest production a certificate of achievement which was displayed in the factory. Moreover, another certificate of achievement was given to the shift with maximum production on monthly basis. The staffs of that shift were awarded an individual 'Champion Certificate'. Additional two days leave were given also to the Champions to reward them for their hard work. This made an innovative and dynamic environment where staff worked hard and enjoyed the rewards and incentives. Problems and bottlenecks were solved based on lean manufacturing and self-motivation.

This achievement was performed on local management level without the need for any additional resources. At 1994, a new management structure came to place, which resulted in removing incentives, empowerment and self-motivating culture of weekly and monthly certificate of achievements and the additional holidays. This resulted in staff refusing to work overnight shifts and the factory was limited to two shifts with 16 hours of operation a day in total (67% maximum production). In addition to this, the new management did not have a clear production and maintenance strategy which resulted that technical staff were reassigned to do marginal tasks within the factory. This lead to having the production going into steep decline between 1993 and 1998 (between points C and D on Figure 4). Moreover, The United Nation embargo on Libya during that period did not help the factory to obtain the necessary spare parts and equipment. Naturally the management, in response to the decline in production, had managed to increase the productivity (point E) using the same two shifts system. However, the three shift culture and increasing the working hours has been difficult to re-achieve due to the lack of staff incentives, empowerment and rewarding system. Recent production Figures (Point E on the graph) indicates about 60% of production level only. Similar aspects has been found when studying the history of the other three factories which clearly indicate lack of operation and maintenance strategy, the need for training and the lack of staff motivation for 24 hours operation within the factory.

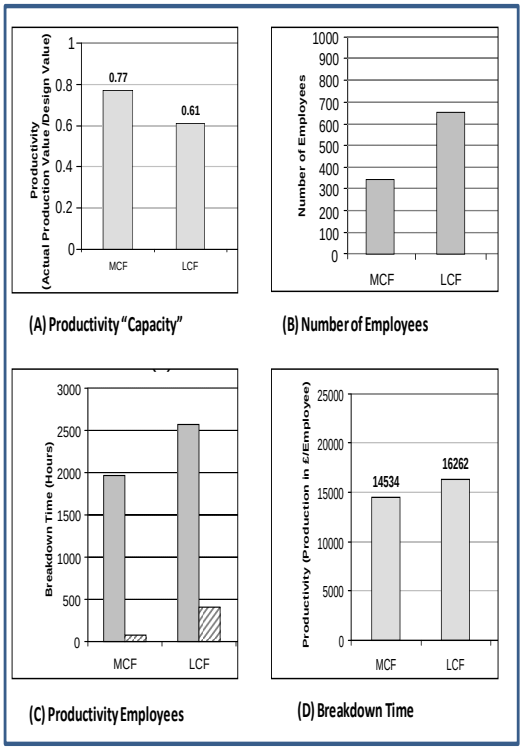

Figure 5: Analysis Of Production Figures For 2006

Taking 2006 as a bench-mark year for the two factories, from Figure 5-a it can be seen that productivity of the factories do not exceed78% of the design capacity with an average of 73%. This indicates a loss of about 891 thousand Tonnes per annum which a loss of about 73.500 M LYD assuming that a 50Kg cement bag is sold for about 4.2 LYD locally. Figure 5-b presents the number of employees in each factory. MCF has lower production capacity which is reflected in a lower number of employees. SCF have similar number of employees despite the fact that it has similar capacity. This is reflected in the productivity level per employee as shown in Figure 5-c. Figure 5-d presents the stoppage

breakdown time of the four factories for 2006. Notice that there is about 7000 hours of scheduled maintenance and about 1800 hours of unplanned breakdown. This is considerably very high which is on average about 10 weeks per factory.

VII. CONCLUSION

The findings of this research work has identified that productivity levels and the implementation of TPM are at modest and poor levels. The field visits in Libya and UK has identified a huge difference in culture, productivity, cleanliness and environmental awareness. Part of this could be related to European and British standards, particularly that the British factory visited was in a residential area in comparison with the Libyan factories. It has been found that the Libyan factories lack some of the employment of modern and well established procedures such as continuous improvements, preventive maintenance, six sigma and the 5-S practice (Structures, Systemise, Sanitise, Standardise and Self-discipline). There is clear evidence of high level of gas pollution and the effect of that on the environment. There was also evidence of poor maintenance of equipment in general including preventive/planned maintenance. It was evident also that the shop floor workers do not use protective equipment on regular basis particularly the use of masks and reflective jackets.

The analysis of historical production data indicates that the two factories operate at very low production rate and productivity in comparison with the design capacity of the factories. High level of fluctuation has been found in the two factories as a result of insufficient operational training, lack of maintenance training and lack of spare parts.

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REFERENCES

[1] F. T. S. Chan, "*Implementation of total productive maintenance: A case study*", International Journal of Production Economics, Vol 95, Issue 1, 71-94,2005.

[2] M. C. Eti, O.T. Ogajiand S. D. Probert, "*Development and implementation of preventive-maintenance practices in Nigerian industries*",Applied Energy, Vol.83 , issue 10, 1163-1179,2006.

[3] R. A. Hokoma, K. Mohamed, and H. Khalid, "*Investigation into the implementation stages of manufacturing and quality techniques and philosophies within the Libyan cement industry*,"Journal of Manufacturing Technology Management ,Vol.19 N0.7,893-907,2008

[4] Mustafa Graisa,and A. Al-Habaibeh."*Total Productive Maintenance (TPM)- Case Studies from Human Factor and Technology Perspectives*,"ASME Middle East Mechanical Expo, Bahrain,2007.

[5] F. Gustav andL. Anna, "*An analysis of maintenance strategies anddevelopment of a model for strategy formulation –A case study*," Master of Science Thesis in the Master Degree Programme, Production Engineering ChamersUniversty of Technology,Göteborg, Sweden,2012.

[6] R. Hokoma, *"Strategic impact of JIT technique for reducing the storge& eliminating the waste within petroleum industry*,"Proceeding of the 9th Mediterranean Petroleum Conference and Exhibition, Tripoli, Libya, 152-65,2006.

[7] G. J. Kacprzynski,andM.R."*Health management strategies for 21st century condition-based maintenance systems*", Proceedings of 13th International Congress on COMADEM. Houston, TX, USA, 2000.

[8] R. L. Kegg, *"On-line Machine Process diagnostics",* Ann CIRP, Vol. 32. No. 469,1984.

[9] J. S. Khamba, and I. P. S. Ahuja, "*Total productive maintenance: Literature review and directions*," International Journal of Quality & Reliability Management Vol. 25 No. 7, 709-756,2008.

[10] B.Marcus, "*Mälardalen University, Sweden, Condition Based Maintenance System Technology –Where is Development Heading?, Euro maintenance,"* Proceedings of the 17th European Maintenance Congress, AMS (Spanish, maintenance Society), Barcelona, Spain,2004, B-19.580.

[11] G. Rod, F. Ron, and K. Kaoru, "*Japanese context: an integrated management system,"* Management Decision, Vol. 46 No. 4, 565-579,2008.

[12] R. K. Sharma, D. Kumar,P. Kumar, "*Manufacturing excellence through TPM implementation: a practical analysis*,"Industrial Management & Data Systems,Vol 106 No 2, 256-280,2006.

[13] A. Shamsuddin, H. Masjuki, and T. Zahari, "*TPM can go beyond maintenance: excerpt from a case implementation,"* Journal of Quality in Maintenance Engineering Vol. 11 No. 1, 19-42, 2005.

[14] C. J. Bamber,J. M. Sharp, M. T. Hides, "*Factors affecting successful implementation of total productive maintenance - A UK manufacturing case study perspective,"* Journal of Quality in Maintenance Engineering, Vol 5, No 3, 162-181,1999.

[15] S. P. Bindra,and R. Hokoma, "*Challenges& opportunities of automobile pollution control in developing countries*,"Proceedings of the InternationalConference on Industrial and Commercial Use of Energy Conference, Western Cape, South Africa,2004,pp. 197-202.

[16] A. Al-Habaibeh, R. Parkin, "*An Evaluation of a Heat Transfer Process Using Sensor Fusion of Thermocouples and Infrared Thermography*," Proceedings of the International Conference on Condition Monitoring, Kings College, Cambridge, 2005, pp. 229-233, ISBN: 1-90189-18-2.

[17] A. Al-Habaibeh, R. Cai, M.R. Jackson, and R. M. Parkin,"*Modern Development in Sensor Technology and its Applications in Condition Monitoring*," Invited Keynote paper, The 7th International Conference On Monitoring And Automatic Supervision In Manufacturing, Zakopane, Poland,2004.

[18] I. P. S. Ahuja, and J. S. Khamba, "*An evaluation of TPM initiativesin Indian industry for enhanced manufacturing performance*,"InternationalJournal of Quality & Reliability Management Vol. 25 No. 2, 147-172,2008.

[19] A. Azmi, and M. Satsh, "*The perceived impact of JIT implementation on firm's financial/growth performance*,"Journal of Manufacturing Technology Management, Vol. 5 No. 2, 118-130,2004.

[20] AAl-Habaibeh,R.Parkin,M.Jackson,M.R.Whitby,D.R.Mansi, J. Coy,"*The Application Of An Autonomous Low Cost Infra-red Thermal Imager For Condition Based Maintenance of Machinery,"*Mechatronicsconference, Netherland,2002.

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