World Academy of Science, Engineering and Technology
International Journal of Economics and Management Engineering
Vol:14, No:6, 2020

A Case Study on Barriers in Total Productive Maintenance Implementation in the Abu Dhabi Power Industry

A. Alseiari, P. Farrell

***Abstract*—**Maintenance has evolved into an imperative function, and contributes significantly to efficient and effective equipment performance. Total Productive Maintenance (TPM) is an ideal approach to support the development and implementation of operation performance improvement. It systematically aims to understand the function of equipment, the service quality relationship with equipment and the probable critical equipment failure conditions. Implementation of TPM programmes need strategic planning and there has been little research applied in this area within Middle-East power plants. In the power sector of Abu Dhabi, technologically and strategically, the power industry is extremely important, and it thus needs effective and efficient equipment management support. The aim of this paper is to investigate barriers to successful TPM implementation in the Abu Dhabi power industry. The study has been conducted in the context of a leading power company in the UAE. Semi-structured interviews were conducted with 16 employees, including maintenance and operation staff, and senior managers. The findings of this research identified seven key barriers, thus: managerial; organisational; cultural; financial; educational; communications; and auditing. With respect to the understanding of these barriers and obstacles in TPM implementation, the findings can contribute towards improved equipment operations and maintenance in power organisations.

***Keywords*—**Abu Dhabi power industry, TPM implementation, key barriers, organisational culture, critical success factors.

I. Introduction

TODAY maintenance in power organisations significantly affects business strategies, with power plant maintenance focusing on cost-effective, safe, and reliable power supplies. The complexity of such maintenance requires that staff are adeptly skilled and thus able to effectively contribute towards plant safety and power availability, both of which are critical in achieving optimal technological utilisation [1]. This has been corroborated by a concurrent emerging cognizance regarding the significance of modern maintenance practices, with specific reference to maintenance strategies focused on improved reliability and proactive techniques of power assets. Also, focus has been re-diverted to optimising internal specialisation and economies of scale for efficiency increase, due to rising global competition. The underlying aim herein, is to focus on delivery performance, flexibility, and quality to match emerging market demands, and towards leveraging competitiveness in dynamic environments. In addition, parameters like inventory increase, throughput reduction, and poor due-date performance can adversely affect effective management of maintenance functions, all of which are reflected in poor organisational competencies. Therefore to achieve performance excellence in the power industry, it is imperative to consider maintenance as process reliability investments rather than operational expenses requiring minimisation. Correspondingly, to support the achievement of a distinctive status in the power industry, exhibiting exceptional high power supply security, factors of development capabilities and equipment technology have emerged as essential factors. Today, from simply being viewed as an unnecessary overhead expense, maintenance has developed as an essential strategic tool, which can contribute towards augmented competitiveness. Additionally, maintenance investment has been observed to positively affect lead times, dependability, safety, quality, and flexibility, which is corroborated by recognition of maintenance as a full partner in world-class manufacturing (WCM) awards. Thus, the shift from being considered as a function of an isolated nature entailing need-based assorted activities, maintenance today forms an integral part of business strategic goals. Across the world, for senior managers this has moved maintenance positioning into boardrooms as a critical strategic issue. It is essential to implement efficient and effective maintenance practices as a means to developing world-class reliable plants in power organisations.

TPM system implementation offers an ideal approach, and in maintenance activities will lead to performance improvement. This system promotes an alteration in the thought processes of employees, and focuses on challenging organisations through systematic methodologies. The ideology, underpinned by the prevention principle, aims to transform workplaces into learning environments through active staff participation in daily improvement methodologies. TPM essentially combines operation and equipment maintenance. According to Yamashina [2], and Ahuja and Khamba [3], several companies with TPM implementation have benefitted with improved operation and maintenance systems in terms of delivery, reliability, cost, quality, and flexibility, as shown in Fig. 1.

For the development of effective TPM systems, organisations usually need two to three years of optimal implementation and establishment, accompanied with

A. Alseiari is with the Operation and Maintenance Directorate, Abu Dhabi Water and Electricity Authority, Abu Dhabi, UAE (phone: 0097150 2188779, e-mail: alsayaaari@hotmail.com).

P. Farrell is with the School of Engineering, University of Bolton, Bolton, UK (e-mail: P.Farrell@bolton.ac.uk).

amicable teamwork approaches from shop floor operators to senior managers. The implementation of TPM serves as a strategic improvement initiative whose efficacy is evidenced in maintenance engineering activities that show improved quality. Overall, businesses aim to attempt to achieve more with less input and with evident augmentation in operation facilities effectiveness; this strategic tool has been observed to result in improved performance in industrial companies. A progressive shift in maintenance oriented thought processes in world-class companies is radically different from the breakdown maintenance traditional perspective. The methodology entailed by TPM strategically focuses on equipment management to achieve equipment effectiveness and maximisation, through to enhancing power supply quality.

Manufacturing priorities	TPM considerations
Productivity (P)	Reduced unplanned stoppages and breakdown improving equipment availability and productivity Provide customization with additional capacity, quick change-over and design of product
Quality (Q)	Reduce quality problems from unstable production Reduced in field failures through improved quality Provide customization with additional capacity, quick change-over and design of product
Cost (C)	Life cycle costing Efficient maintenance procedures Supports volume and mix flexibility Reduced quality and stoppage-related waste
Delivery (D)	Support of JIT efforts with dependable equipment Improves efficiency of delivery, speed. and reliability Improved line availability of skilled workers
Safety (S)	Improved workplace environment Realizing zero accidents at workplace Eliminates hazardous situations
Morale (M)	Significant improvement in *kaizen* and suggestions Increase employees' knowledge of the process and product Improved problem-solving ability Increase in worker skills and knowledge Employee involvement and empowerment

Fig. 1 Organizational priorities and goals realized through TPM

Today, TPM has evolved into project comprehensive equipment-centric efforts, in comparison to the initial introduction as industrial equipment performance improvement methodologies and practices, and thus optimises industrial organisation productivity. Through expansive employee participation from all departments and continuous improvement, TPM implementation ensures equipment operational efficiency.

II. Literature Review

TPM introduces systematic maintenance programmes involving novel practices for plant and equipment maintenance. In the 1970s, the Japanese car industry saw the establishment of TPM at the Toyota Car Company, Nippondenso. Originating with introduction of preventive maintenance in 1951 in Japan, TPM is an innovative Japanese concept. It establishes maintenance as an essential business function, which promotes sustained profits through aligning all business functions including manufacturing [3]. TPM involves improvement in operational processes related to machine reliability and efficiency, and it encourages all employees to attain zero accident, defects and breakdowns. TPM contributes to equipment reliability optimisation and plant asset efficiency. It also introduces production-driven improvement methodologies. Through all-inclusive life-cycle approaches, focused on minimising operation defects, equipment failures, and accidents, TPM is an effective equipment management tool, which also provides operation support groups by an involvement of operation staff and senior managers. It involves the participation of all departments including facilities, operations, maintenance, design engineering, construction engineering, project engineering, inventory and stores, accounting and finance, purchasing, and plant and site management. TPM combines people-oriented approaches with technology or systems to contribute to world-class level equipment effectiveness [4]. Thus, through combined best practice principles of teamwork, continual improvement, and modern working practices, TPM integrates maintenance and operation functions [5]. A continual improvement process is structured with an equipment-centric focus and optimises the operation system life-cycles. This is achieved through, identification and elimination of losses in operational efficiency in equipment effectiveness, and involves employee participation throughout operational hierarchy levels. TPM programme implementation is oriented towards promoting better equipment availability with concurrent job satisfaction and employee morale augmentation, and therefore it has emerged as an effective tool for overall company performance improvement. It has been observed that strategic TPM implementation, has successfully resulted in positively impacting 'bottom-line' results. In addition, maintenance costs and overall operational costs have witnessed significant decreases with a concurrent capacity improvement. Also, TPM implemented workplaces have developed much ecologically sound and safer environments with reductions in unexpected machine breakdowns

occurrences. This strategic result has reduced disrupted equipment operation and saved capital costs to companies [6].

The term "pillars" or "elements" is used to denote TPM's basic practices and the entire TPM structure is based on eight pillars of autonomous maintenance, thus: education and training; focused improvement; development management; office TPM; planned maintenance; quality maintenance; and safety, health, and the environment. This exceptional eight-pronged approach ensures excellent planning, organising, monitoring and controlling practices. The improvement in continual performance is achieved in maintenance by augmenting the effectiveness and efficiency of individual industrial processes and activities in TPM approaches. The Overall Equipment Effectiveness (OEE) standard is used to measure improvements and the parameters of performance, quality, and availability are used in its computation. Also, to account for maximum equipment effectiveness, the 100% theoretical availability is systematically reduced by considering the "six big losses" in its calculation [3]. These include **quality losses** (1) process defects, (2) reduced yield, **performance losses** (3) minor stoppages, (4) slow cycles or speed, **availability losses** (5) plant failure, (6) setup and adjustments. Fig. 2 shows the six big losses. This calculation, however, fails to achieve a complete analysis according to Waeyenbergh and Pintelon [7], since it ignores profit and cost components; thereby in competitive systems or machine comparisons, its applicability is limited. Thus, in the power industry, this suggests the limited relevance and validity of individual TPM methodologies as maintenance concepts. Correspondingly, to effect improved understanding of improved machine utilisation, it could be argued that losses for OEE need to be broadly classified. In addition, diverse OEE measurement levels and factors, affect in different ways various business domains and industries. It is necessary that operators and maintenance staff show high knowledge and skill levels in TPM philosophy implementation, as that will further enable colleagues to share job functions and develop new skills [5]. TPM implementation is a complex process, faced with many challenges and obstacles. Ahuja and Khamba [3] have detailed barriers to TPM implementation. Similarly, Waeyenbergh and Pintelon [7] describe the limitations of TPM as a complete maintenance concept and simple maintenance policy; this includes ambiguity in policies and rules. Wireman [8] shares that "*there is no single correct method for the implementation of a TPM programme*", which is elaborated by Bamber et al. [9] who conclude that there is "*a complexity and divergence of TPM programmes adopted throughout industry*".

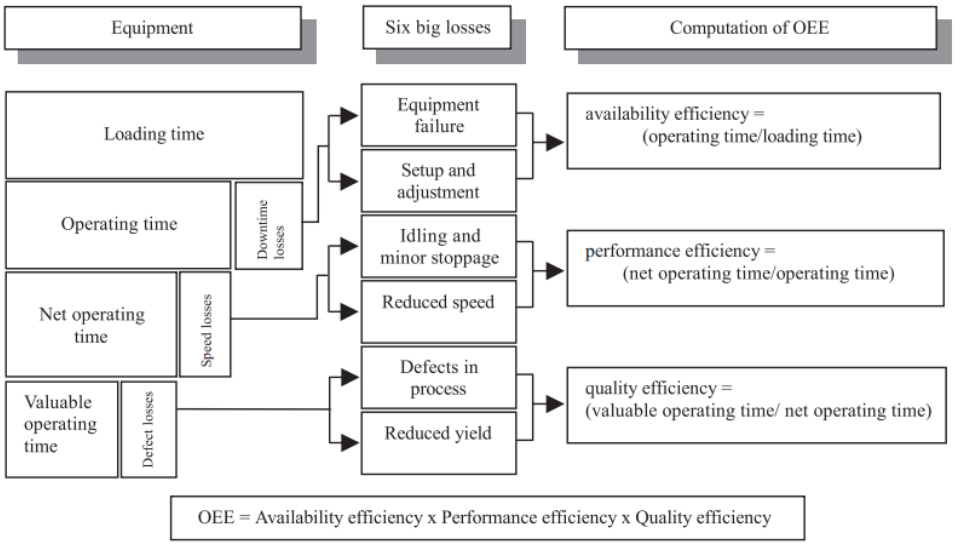

Fig. 2 OEE and Computation Procedures

III. Research Methodology

The understanding of TPM's significance and impending need has been demonstrated by several industries. Although, in this specific area to evidence research applications, there is a lack of research literature focusing on the Middle-East power industry. Consequently, the current study focuses on evaluating factors that pose a barrier to TPM implementation in Abu Dhabi power organisations, using the Abu Dhabi-based power company (CXD) as a case study. The study involved semi-structured interview sessions conducted with organisation employees at different levels in CXD, and focused on acceptance levels to change and specific barriers faced by them. Sixteen employees from the organisation, including maintenance, operation, and senior managers were identified to ensure homogeneity of the study [10]. For TPM implementation oriented studies, according to Ng et al. [11], the recommended interview sample sizes are 20 and 30, while another research by Tamer and Ayham [12] used a sample size of 13 respondents in their TPM applicability study. Therefore, having 16 interviewees for this research is deemed suitable as it achieved the aim of this study [13]. Furthermore, knowledge elicitation techniques were utilised [14] for discussion and analysis of the interviews.

IV. Findings and Discussion

This section of the findings discuss the following in the context of the Abu Dhabi power organisation CXD: the characteristics of the power organisations culture, the maintenance management state, comparison between the organisational culture and TPM principles, and finally barriers to TPM implementation.

A. The Characteristics of the Power Organisations Culture in the UAE

Abu Dhabi is the capital city of the Arab country in the United Arab Emirates with a minority population of UAE citizens, and then Pakistanis, Indians and Sri Lankans constituting the majority of the population. Some part of the population includes Jordanians, Iraqis, Palestinians, Lebanese, with a minority of Europeans, North Americans and Africans. In the UAE, Arabic is the official language of communication, while English predominates the private sector, making these two as official languages. Within Abu Dhabi power organisations, for study purposes, the multi-lingual and multicultural diversity of the organisation workforce has been identified by the authors and subsequently divided into three main classifications of:

1. Workers: staff dealing in physical tasks
2. Foreman and above: staff dealing in administrative or supervision tasks
3. Senior staff: staff holding managerial positions

The study revealed senior staff nationalities to be predominantly, Asians, Arabs, Europeans and Americans. Asian is the predominant nationality of the workforce below senior management level, and the preferred language of communication is Hindi and Urdu, but English is used between management and operatives. With the multiple language literacies, communication can be cumbersome and poses a problem in Abu Dhabi power organisations. The workforce structure includes very few women in the department of maintenance and operations, although some hold senior staff member positions. The study revealed that in earning patterns, workers earn 3.5 times less that staff employees, who in turn earn 3.5 times less than senior staff. Also, the recruitment and selection for workers is based on their skill level, while for staff, the selection is on the basis of their technical competency. Most workers were found to be high school qualified with few holding diplomas, and similarly, the majority of staff and senior staff held a bachelor degree with some also holding postgraduate degrees. Thus, in the Abu Dhabi power industry, limited use of best maintenance practice knowledge may be attributed to low qualifications of workers, which limits their capability to conduct high advanced maintenance practices, such as prognostic techniques and predictive maintenance. However, in the last decade, with expanding demand in the power networks there has been a steep increase in the numbers of workers. In Abu Dhabi power organisations, this indicates greater need for control, administration and improvement in skills as a primary objective of managers. However, this is compounded by language limitations and the difficulty in communication, and whilst it was found that it is relatively easy to demonstrate expectations and underpinning technology details to the workers. Also, it is evident that top-down and down-up communication is adversely affected by identical issues of communication, which can be evidenced by limited proficiency in English or Arabic by workers, making it extremely difficult to explain ideas. In addition to communication issues, it was apparent there were issues revolving around non-compliance of orders and a non-participative culture. The study observed an autocratic approach by management which was precipitated in communication aspects with workers and staff in written and verbal communications. The study found the following unfavourable characteristics in Abu Dhabi power organisations for TPM implementation in the current maintenance practices:

1. Lower hierarchy levels demonstrated highly limited written communication abilities.
2. Intra- and inter-organisational (within and external) practice of limited written communication.
3. Wide hierarchical level gap due to verbal communication difficulty.
4. Controlling and domineering attitude and perspective of management towards subordinates, with their participation, considered unwelcome and critically ignored.
5. Subordinates oriented towards submissive behaviour, and refraining from sharing and voicing their opinion.
6. Financial punishment and blame attribution culture during non-compliance.
7. Reward and punishment accorded solely on the hierarchical superior's judgement.
8. Higher hierarchical employees displayed extreme reluctance on being grouped with lower ones for fear of authority loss and assumed no value addition by the lower hierarchical level employees to teams.
9. Fear of insubordination and resultant punishment limited the lower hierarchical level employee participation.
10. Management concern for employee well-being, majorly perceived as cost implication versus foreseen financial benefit.

These company characteristics highlight the high power distance, as revealed in the study in the participant organisation and is elaborated by Hofstede and Hofstede [15] in the statistical data provided by them. The power distance scale score of both Arab countries and India show among 74 countries and regions, a high positioning at 12^{th} and 17^{th} places, respectively.

Literature evidences the conflicting nature of high power distance culture with successful TPM implementation. TPM programmes necessitate employee empowerment, which is in direct conflict with subordinate and submissive worker employee structures, since they are limited in opining their disagreement. Also, the unquestioned obedience culture might be underpinned by limited communication abilities, which is evidenced in complete adherence to superior decisions, to the exclusion of subordinates from decision-making processes.

According to Hofstede and Hofstede [15], such a work culture is indicative of "contacts between superiors and subordinates are supposed to be initiated by superiors only", thus highlighting bottom-up communication barriers. The workforce's multi-lingual and multi-cultural characteristics reinforce the high-power distance culture associated communication barriers, which is demonstrated through workforce low literacy levels. Also, teamwork and inter-mingling is discouraged with the perceived threats to privileges and status by the higher hierarchal levels employees.

In conjunction with Hofstede and Hofstede [15], the current study authors identified the higher feminine nature in power industry organisations as rather to being masculine. In comparing between masculinity and power distance, among 74 countries and regions, Arab countries and India, scored lower in masculinity, with 31st and 28th ranks, respectively. According to Hofstede and Hofstede [15] "from the most feminine to the most masculine country, the range of masculinity index scores for men is about 50% wider than the range for women". With the higher percentage of men in the workforce as compared to women, the masculinity score is expected to be higher. Thus, it was found the organisation's cultural characteristics stand in conflict with the critical success factors (CSFs) for successful application of TPM recognised in literature such as: involvement and empowerment; employee participation, communication systems; and team working which are crucial for successful TPM implementation. Employee management is directly linked with these CSFs for successful implementation of TPM programmes.

B. Maintenance Management State in the Abu Dhabi Power Industry

The maintenance strategies of Abu Dhabi power organisations can be improved with an assessment of their status, and according to the authors, the study revealed a nearly non-existent state of maintenance practices. These power organisations consider maintenance expenses as overheads, which result in availability loss, low quality, and environmental and human threats. The dual perspectives of the technology used and management's approach were adopted by the authors to evaluate the situation. In accordance with the technological standpoint, difficulty in instrumentation and operation and utilisation of predictive maintenance tools by technicians, in addition to the lack of clear maintenance procedures and instructions to use these tools, were found as major barriers by the majority of respondents (78%). Also, the lack of user-friendly quality of computerised maintenance management systems (CMMSs) and wastefulness were identified as other issues by the majority of operation and maintenance staff responses (80%). The study shows a lack of availability of effective training programmes, technical knowledge and information, and lack of awareness of the benefit of CMMS system utilisation. Herein, the authors summarise the maintenance practices followed in the Abu Dhabi power industry, from the managerial standpoint (see Table I).

TABLE I
SUMMARY OF THE STATE OF MAINTENANCE IN THE ABU DHABI POWER INDUSTRY

Maintenance organisations are developed most of the time randomly and do not reflect the functional needs of the business.
Little documented standard maintenance procedures exist.
If these procedures are available it is rarely in a readable, updated form suitable for technicians' use.
Documentation and recording of maintenance activities are always heavy, uneasy and unpleasant tasks for all levels of maintenance practitioners.
Equipment manuals, catalogues and repair instructions are rarely supplied in a complete form.
If equipment documentation was supplied, it is never found in its proper place.
In all cases, equipment documentation is normally in a foreign language, has a different format and with missing or mixed standards and specifications.
For cultural and historical reasons, maintenance work is always done based on experience and sophisticated maintenance engineers are difficult to find.
Individuality on the personal and departmental level governs the pattern of interaction between organisation elements and most sectors.

Table I presents the apparent managerial and organisational barriers, as revealed in the study, towards the TPM programme successful implementation, which includes, weak support structure for TPM initiatives, documentation and administration issues, maintenance policy improvement disinterest, ambiguous organisational objectives.

TABLE II
TPM PRINCIPLES VS. ABU DHABI POWER ORGANISATION CULTURE

TPM Principles	**Abu Dhabi Cultural Barriers to TPM**
TPM is people oriented, requires total employee involvement.	Abu Dhabi society suffers from a weakness in work group culture where there is a general preference for individual work and not working in teams.
Maintenance goes from being the responsibility of the Maintenance Department to being everyone's responsibility.	Organisation structure in most companies is characterised by centralisation and authoritarianism. Employees are keen to keep their authority and refuse to delegate any of their responsibilities.
Cultural change can be obtained by obtaining competent leaders and managers.	Workers rarely try to acquire new knowledge and have no motivation to improve the quality of work.
Investing in education and training is a must.	Workers rarely try to acquire new knowledge. Also, the idolisation of routine and red tapism makes investing in education and training a difficult process to actually set up training programmes and engaging in favouritism stands in the way of providing training to those who deserve the training and require it for the benefit of the company.
Top management support is critical to ensure successful TPM implementation.	Most senior management believe in proper procedures and conformity to rules rather than goal achievement or risk-taking as the key to effectiveness and promotion.

C. Maintenance Management State in the Abu Dhabi Power Industry

As revealed in the study, Table II summarises the inconsistency as found by the researchers in the TPM and Abu Dhabi organisational culture.

Thus, from the apparent divergence and variance in the TPM literature, TPM principles and power organisational culture in Abu Dhabi, TPM program implementation can be very challenging. This is revealed through the data collection and analysis of the respondents (CXD senior managers,

operation, and maintenance staff) opinions compiled through the semi-structured interviews. With respect to the Abu Dhabi power organisation, the subsequent sections provide a description of the key barriers challenging successful TPM program implementation.

TABLE III
CATEGORISATION OF BARRIERS TO TPM IMPLEMENTATION IN THE ABU DHABI POWER INDUSTRY

#	Barriers	Barriers Category
1	Insufficient top management support	Managerial
2	Lack of standard operating producers	
3	Procedures definition and maintenance	
4	Unwell-design of reward system	
5	Conduct of human resources evaluation	
6	Poor preventive maintenance schedules	
7	Inadequate use of tools, techniques, and methodologies	
8	Lack of long-term commitment of management and employees	
10	More paper work	Organisational
11	Documentation problem	
12	Difficult to measure results	
13	Ineffective long term planning	
14	Lack of improving maintenance policy	
15	Poor structure to support TPM initiatives	
16	Non-clarity of organisational objectives	
17	Various cultures of workforce	
18	Lack of motivation	Cultural
19	Employees resistance to change	
20	Less empowerment to take decisions	
21	Operators unwillingness to accept more load	
22	Lack of job security for maintenance staff	
23	Maintenance staff do not trust in operators ability and skills	
24	Required cost and time	Financial
25	Manpower costs	
26	Insufficient training for staff	Educational
27	Lack of understanding technical information	
28	Less educated employees	
29	Lack of understanding of TPM principles and concepts	
30	Lack of utilising CMMS system	
31	Poor coordination between maintenance and operation departments	Communicational
32	Insufficient information and historical data of power plants	
33	Lack of experience and knowledge sharing	
34	Lack of consultancy provided by audits	Auditing
35	No audit system on maintenance tasks as well as 5s	

D.Barriers to TPM Implementation in the Abu Dhabi Power industry

The current CXD maintenance practices were analysed in addition to the TPM implementation barriers. The barriers as identified highlight necessary actions by senior management in strategies for successful implementation of a TPM programme. The identified barriers include managerial; organisational; cultural; financial; educational; communications; and auditing, with Table III, providing a brief description of the barriers.

V.CONCLUSION

The findings from the study evidence the challenging nature of TPM programme implementation in the power industry in the Middle-East. This difficulty can be attributed to the considerable cultural transformations warranted towards TPM initiative implementation due to the basic requirement of mindset refinement amongst company employees. The current research has conducted a critical evaluation of the diverse challenges and barriers influencing successful TPM implementation in CXD power company. The study, broadly categorises, obstacles as revealed in the study in seven categories, namely: managerial; organisational; cultural; financial; educational; communications; and auditing. In addition, for successful implementation, an investment in time, capital and resources are mandated, and furthermore, management should ensure the absolute dedication and commitment of the entire organisation and workforce towards TPM. For this to come to fruition, it is necessary that the work culture alters from "*It's not my job but yours*" to "*It's our job*". In addition, within an organisation, and at all levels, free flow of information and communication, which transcends both horizontally and vertically, should be encouraged. For successful TPM implementation, managers should also plan for standardisation of operational and maintenance processes. Correspondingly, to schedule and organise maintenance and modification programs, managers should allow operators to conduct routine maintenance activities. This should be followed by all-inclusive, expansive and extensive TPM training focused on its benefits throughout the organisation. Senior management commitment is a highly decisive factor in successful TPM programme implementation. Therefore, even in variable work circumstances, successful managers should efficaciously be able to employ TPM initiatives, including employee involvement and promotion throughout maintenance and production processes. This will further contribute to improvement of equipment operation quality, optimisation of process flows, and minimising maintenance and operating costs. Moreover, ensuring employee empowerment will promote autonomy in authority and responsibility of employees for a total elimination of the six big losses. With the involvement of employees at all levels, the gap between the problem and the effective decision makers is reduced, thereby resulting in speedy and accurate corrective action, as two-way communication is promoted through employee empowerment. However, factors like traditional mistrust, as apparent between the workforce and managers, pose as empowerment barriers. Empowerment is an imperative tool to leverage successful change management processes, particularly in circumstances of resistance, denial, exploration and commitment phases of change.

Additionally, in times of progressive industrial societies, for maintenance departments to achieve their optimal functioning status and capacity, it is necessary to train maintenance employees towards meeting future requirements, in addition to current industry needs. Therefore, continual and progressive training should be designed with an aim to achieve improvement of individual potential of maintenance staff

members. Training will ensure an understanding of the underlying reasons for TPM implementation and the associated change benefits, which can be optimally achieved through TPM training, empowering and convincing of sustainability of TPM programmes. An absolute commitment by managers towards TPM programme implementation is necessary and instead of trying to 're-invent the wheel' for TPM implementation methodology, the key to successful implementation lies in following organisations who have successfully followed TPM programmes. The idea is to use the maintenance services of TPM instituted organisation philosophies as a benchmark and effect an improvement in the overall of operations and maintenance effectiveness of plants through identification of optimum maintenance management methods and practices. Therefore, with senior managements' zealous commitment coupled with radical culture change, TPM initiatives can be successfully implemented in the Abu Dhabi power industry. This continual journey of TPM implementation requires several years before its benefits will be visibly apparent, however, the challenges of the implementation process produce great rewards in the long run.

ACKNOWLEDGMENT

The authors would like to acknowledge the Abu Dhabi Water and Electricity Authority for providing facilities and assistance to prepare this paper.

REFERENCES

[1] T. Reiman, and P. Oedewald, "Measuring maintenance culture and maintenance core task with CULTURE-questionnaire—A case study in the power industry," Safety Science, vol. 42, pp. 859-889, 2004.
[2] H. Yamashina, "Japanese manufacturing strategy and the role of total productive maintenance," Journal of Quality in Maintenance Engineering, vol. 1, pp. 27-38, 1995.
[3] I. P. S. Ahuja, and J. S. Khamba, "Total productive maintenance: literature review and directions," International Journal of Quality & Reliability Management, vol. 25, pp. 709-756, 2008.
[4] P. Willmott, and D. McCarthy, TPM: A Route to World Class Performance. Oxford: Butterworth-Heinemann, 2001.
[5] F. Lee Cooke, "Implementing TPM in plant maintenance: some organisational barriers," International Journal of Quality & Reliability Management, vol. 17, pp. 1003-1016, 2000.
[6] A. Gosavi, "A risk-sensitive approach to total productive maintenance," Automatica, vol. 42, pp. 1321-1330, 2006.
[7] G. Waeyenbergh, and L. Pintelon, "A framework for maintenance concept development," International Journal of Production Economics, vol. 77, pp. 299-313, 2002.
[8] T. Wireman, Total Productive Maintenance: An American Approach. New York: Industrial Press, 1990.
[9] C. J. Bamber, J. M. Sharp, and 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, pp. 162-181, 1999.
[10] A. Bryman, and E. Bell, Business Research Methods. Oxford: Oxford University Press, 2015.
[11] K. C. Ng, G. G. G. Goh, and U. C. Eze, "Barriers in total productive maintenance implementation in a semiconductor manufacturing firm: A case study". 2012 IEEE International Conference on Industrial Engineering and Engineering, pp. 377 – 381.
[12] H. H. Tamar, and A. M. J. Ayham, "The Applicability of Total Productive Maintenance for Healthcare facilities: an Implementation Methodology," International Journal of Business, Humanities and Technology, vol. 2, pp. 148-155, 2012.
[13] M. N. Marshall, "Sampling for qualitative research," Family Practice, vol. 13, pp. 522-525, 1996.
[14] M. Firlej, and D. Hellens, Knowledge Elicitation: A Practical Handbook. Prentice Hall UK, 1991.
[15] G. H. Hofstede, and G. J. Hofstede, Cultures and Organizations: Software of the Mind. UK: McGraw-Hill, 2005.

A. Alseiari received his B.Sc. degree in Electrical Engineering (Networks and Communications Engineering) from Al Ain University of Science and Technology at United Arab Emirates and his M.Sc. in Maintenance Management from Glasgow Caledonian University at Scotland in the UK. He is currently pursuing his Ph.D. degree at University of Bolton in improving assets management and development of maintenance strategies in the Abu Dhabi power utilities. His current research is with Dr. Peter Farrell investigating the critical factors that affecting the successful implementation of TPM strategy in the Abu Dhabi power industry. Eng. Alseiari is working at Abu Dhabi Water and Electricity Authority. He has more than ten years' experience in operation and maintenance management for power distribution networks.

P. Farrell has sixteen years' industry experience and over twenty-five years in higher education. He is a Reader in at the University of Bolton, and has over ninety publications, including four textbooks. His early industry work was as a quantity surveyor; then as contractor's site manager, responsible for multi-million pound new-build construction projects. He has been an External Examiner at seven institutions, including internationally, and is academic journal referee and book reviewer. Peter is a Fellow of both the Chartered Institute of Building (FCIOB) and the Royal Institution of Chartered Surveyors (FRICS), and formerly acted for three years as Chair of the CIOB Greater Manchester Branch. His current work includes leading the development of a new Asset management degree programme.