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Research paper

A Review on Critical Success Factors for Total Productive Maintenance and Development of Research Framework

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Abstract

Total Productive Maintenance (TPM) is holistic maintenance management approach aimed at integrating the role of maintenance and production department to share responsibility in taking care the production equipment of a company. In the right environment, TPM implementation would make significant contribution to company's profitability particularly in increasing the production efficiency and improving the product quality. Despite many TPM implementation frameworks have been studied, there are still many companies, particularly under the classification of Small and Medium Enterprises (SMEs) are struggling and found themselves either failed right at the start-up or during the process of TPM implementation. Apparently, that there is still inadequate guidance about how TPM should be adopted, managed and integrated with other key quality initiatives in the SMEs environment. This paper is part of an ongoing research aimed at developing a framework for systematic TPM implementation in Malaysian SMEs. It focuses on the understanding of the concept of Critical Success Factors (CSFs) of TPM. The proposed conceptual framework will provide a holistic guidance and understanding of the CSFs to be adopted and adapted in managing the maintenance activities in Malaysian SMEs. This would enable the SMEs to improve their maintenance management practices in relation to world-class manufacturing standard.

Keywords: Maintenance management; Research framework; Total Productive Maintenance; Critical Success Factors.

1. Introduction

With the growing dependence on the automation and mechanization, maintenance of manufacturing equipment is becoming more complex and critical [23]. Because of such characteristic, manufacturing industry players, particularly under classification of Small and Medium Enterprises (SMEs), are under gigantic pressure to minimize downtime for their survival [24]. Reliable manufacturing equipment has been considered as significant contributor to organizational competitiveness ([6]; [27]). The SMEs in the West have adopted Total Productive Maintenance (TPM) as an effective maintenance strategy for world class performance beside other branch in maintenance management such as normal Preventive Maintenance (PM), Reliability Centered-Maintenance (RCM) and Condition-Based Maintenance (CBM) ([14]; [2]). The adoption of TPM approach by a careful consideration on the Critical Success Factors (CSFs) constructs has proven to improve the maintenance efficiency and have a significant contribution towards profitability of the organization through an increased in the production efficiency, improved in product quality, lowering operating cost, timely delivery to customers, ensured safety of the workplace and improved morale of the employees ([29]; [1]). Particularly, the emphasis on CSFs would shorten the learning curve in adopting the TPM methodology ([22]; [18]; [1]). Therefore, this paper seeks to understand and discuss briefly the CSFs of TPM. The aims of this paper are twofold. First, it offers a review of TPM and its related CSFs. Secondly, a proposed research framework is presented. The design of the framework integrates and covered main aspects of CSFs constructs in TPM implementation. This paper is part of an ongoing research aimed at developing a framework for systematic TPM implementation in Malaysian SMEs. It focuses on the understanding of the concept of CSFs of TPM.

2. The Significant Role of Small and Medium Enterprises in Malaysian Economic

Small And Medium Enterprises (SMEs) are considered backbone of economic growth in all countries [2]. In Malaysia, manufacturing sectors as a whole and SMEs in particular have a great contribution in the country's gross domestic product (GDP) [31]. Currently 97% of business establishments in Malaysia are SMEs, which contributed 37% to the country's GDP, 65% to employment, and nearly 18% to exports. The Malaysian government is expected the contribution in GDP by SMEs to achieve the target of 41% of the GDP by year 2020. SMEs are defined by a numeral of factors and criteria: size of the company; number of employees; worth of assets; structure, and; organization size [5]. SMEs contribution in providing job opportunities cannot be denied. SMEs also play an important role as feeder or supplier of goods and services to large organizations. In manufacturing sector, SMEs act as an original equipment manufacturer (OEM) of components, parts, and sub-assemblies to larger. Lack of product quality supplied by them could adversely affect the competitive ability of the larger organizations [29]. Relative to a larger organizations, majority of SMEs have a simpler systems and

procedures, which allows flexibility, immediate feedback, fast decision-making and fast response to customer. In spite of these supporting characteristics of SMEs, they are under gigantic pressure to sustain their business survival due to fierce global competition, technological advancement and changing needs of customers [23]. Of significance, SMEs requires an innovative approach to optimize the maintenance of manufacturing equipment to ensure the product supplies to the end customer have superior, competitive and reliable quality ([27]; [6]).

3. TPM Philosophy

Philosophically, TPM shares a commonality features with Total Quality Management (TQM) philosophy particularly in employee participation, cross-functional training, empowerment of employees through a small group activity (SGA), focus on plant efficiency through quality, and emphasize on the continual improvement ([9]). The entire philosophy of TPM as productive maintenance aims to maximize overall equipment effectiveness (OEE) through a total participation of all level of employees in the operational hierarchy ([16]; [29]; [20]). Under TQM philosophy, the defects of the products are eliminated at their processes rather than scrutinized only at the finished product [20]. TPM aims towards achieving zero equipment breakdowns. It is a concept adopted from TQM approach towards zero manufacturing defects and minimizing production losses [15]. The definition of equipment effectiveness is no longer restricted to availability. However it encompasses quality as the complementary factor ([29]; [18]). The word "total" in TPM as defined by [20] has three meanings as depicted in Figure 1. It outlines three principal features of TPM. ***Total effectiveness*** describes TPM aims towards economic efficiency particularly in maximizing productivity (P) without compromising on quality issues (Q), optimizing the operational cost (C), meeting the timely delivery to customers (D), improving the safety, health and environment of the workplace (S), and boosting the morale of employees (M). On the other hand, ***Total maintenance*** describes the TPM aims towards a systematic maintenance of equipment through a continual maintenance improvement activity. ***Total participation*** denotes the need of holistic involvement of all employees.

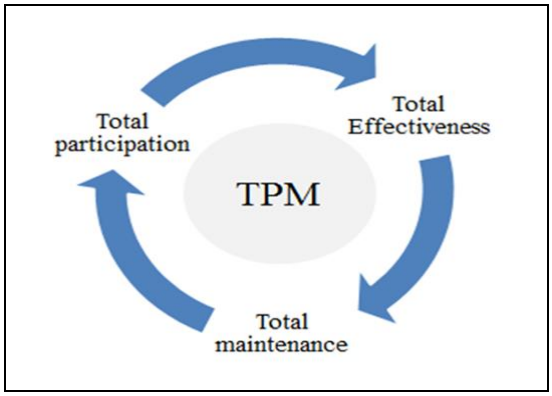

Figure 1: The meaning of total in TPM (Adopted from: [20])

4. Critical Success Factors

Critical success factors (CSFs) are defined as a set of key ideas used to assist the organizations to accomplish their strategic goals ([30]; [8]). It is a set of characteristics, conditions, or variables, which have limited in number (usually range from three to eight) which have a direct and serious impact on the effectiveness, efficiency, and viability of an organization, program, or project. Those CSFs constructs must be thoroughly considered and constantly performed by the organization in order to achieve the organizational goals [8]. The idea of CSFs was first introduced in the 1960s and since then, evolved and has been implemented in different ways [19].

4.1 CSFs Constructs in TPM

Many studies investigate the CSFs constructs of TPM in which the issues discussed are varied and diverse. The SMEs needs to really consider the CSFs constructs in TPM implementation in order to succeed. This would serve as a benchmarking activity towards successful TPM implementation ([22]). Based on the review of the present literature of TPM, seven CSFs constructs having the most significant impact in TPM implementation, were summarized based on content analysis and affinity diagram technique ([30]; [12]), these include: management commitment and leadership; employee participation; strategic planning; structured implementation approach; training and education; effective communication, and; monitoring and evaluation. Figure 1 summarizes the CSFs constructs derived from literature. The subsequence sections provide detailed explanation and discussion of the CSFs constructs.

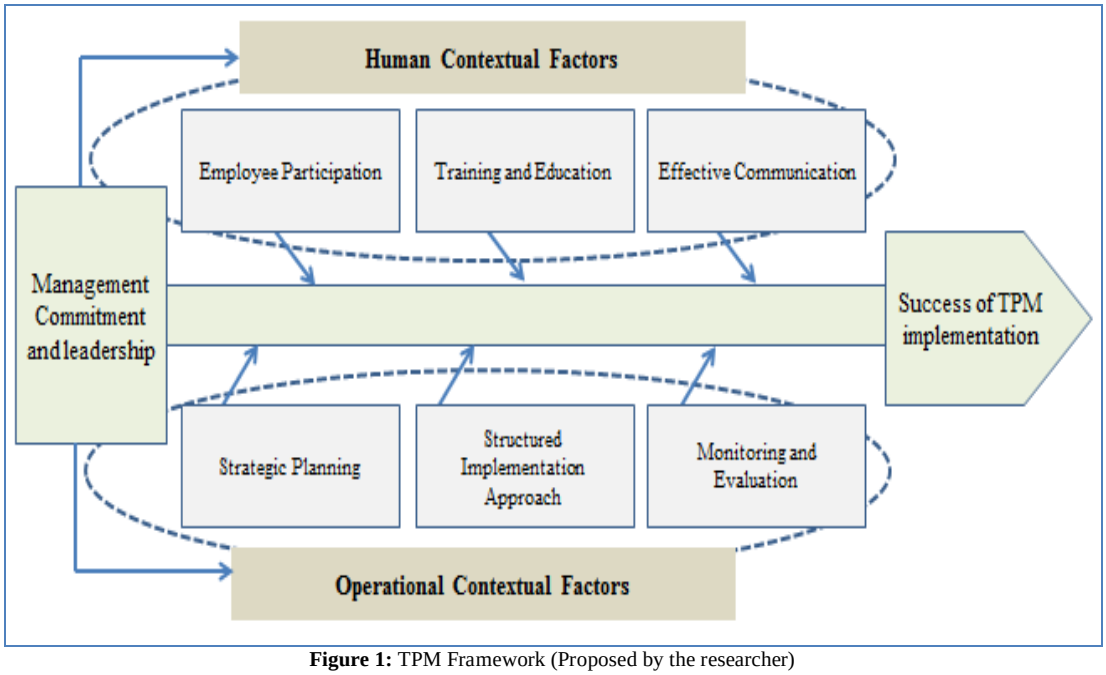

Figure 1: TPM Framework (Proposed by the researcher)

4.2 CSF 1: Management Commitment and Leadership

The roles of management to support the TPM implementation is vital and have been addressed by most of the papers discussed on the CSFs issues. A total commitment from management is a key factor which must be carefully established before initiating the TPM implementation program. A major resources required to support the TPM program, particularly on human, materials and financial resources are under the decisive role of management, thus the management commitment is prerequisite [22].The importance of TPM as a constituent of manufacturing management needs to be really understood by the management [9]. The management should have an imperative role in determining the TPM policies, objective, strategies, allocation of resources and align with the company's business goals [13]. The attentiveness from top management would boost up the morale of employees and motivated them to lend their support and striving for the company's goals in TPM program. [4] stressed on the significance of top management leadership. They noted on the importance of management participation, not to just support and commitment, however to be fully involved in determining strategy, hands on the implementation process, coaching and evaluating progress TPM is a structured activity that can improve the management of plant assets when properly implemented. Therefore the management should use various strategies to entice the participation from employee. [22] viewed that effective rewards and incentive scheme provided to employee is part of management responsibility towards gaining support and commitment from employees. This is due to the nature of human moves towards doing the things for which they are rewarded and vice versa. [4] supported that achievements of TPM program must be compensated with rewards and incentive, aimed at encouraging and motivating the employee. [18] viewed that the attractive rewards and incentive scheme provided would act as an influential element that are essentially need to enhance the performance and sustainability of TPM program. They argued that rewards and incentive demonstrates the evident of management support and interest in TPM program, therefore it would generate motivation among the employees to render a full support and participation.

4.3 CSF 2: Employee Participation

Although management commitment and leadership is crucial for the success of TPM implementation, however it is not decisive factor. The readiness of employees to support and participate in TPM program, is another essential factors to be considered [25]. Human factors are the basis for the TPM development. No matter how well plants are equipped with advanced manufacturing techniques, it is operators neither manager nor systems who affect the plant's performance ([17]; [25]). TPM initiative demands a radical change in the mind-set of employees towards improving the work culture of an organization [22]. The evolution of shifting the mind-set of employee is a tough task for the top management and it requires patience and time, investment of dollars and allocation of resources [26]. The organization need to have a strong organization structure to ensure the smooth running of implementation process. The involvement of middle management to support the implementation program by coordinating and guiding their down line is essential to the success of the TPM program [18]. The middle managers are in charged for the first-line supervision and their roles in this sense are about either to make or break the success in TPM implementation. The culture change issue requires an exceptional consideration throughout the TPM implementation process as stressed by previous researchers. Embedded activities in TPM program such as AM and SGA would broaden the role of production employees from their typical routine job. In TPM, the operators' job scope will be expanded from merely operating machines to a more technical task such as carrying out basic maintenance and recognizing machine failures [1]. The principle of TPM is on the share of responsibility of taking care the equipment by both production, maintenance and supporting personnel in a team [18].

4.4 CSF 3: Strategic Planning

In order to ensure the success of TPM implementation, the approach should be realistic with appropriate strategic planning. Strategic planning is defined as recognizable set of activities. These include: establishing and clarifying the company's vision, mission and driving forces; assessment of the company's internal strengths, weaknesses, external opportunities and threats (SWOT); developing necessary action plan; allocating an appropriate resources; integration and control various parts and processes of a company; deploying the tasks towards pursuing goals; fostering communication and teamwork among management and staff; measuring results and monitoring progress, and; making necessary adjustments to the company's direction in response to a changing environment ([21]; [9]). [8]) cautioned that although the purpose

of strategic planning is straightforward, to outline where company wants to go and how it's going to get there by its nature is complex and dynamic. TPM implementation is not an instantaneous effort, the feasible maturity state for TPM implementation highlighted from literature, is from three to five year ([18]; [24]; [20]). Therefore an appropriate strategic planning with a clear identification of company goals and how it's going to attain those goals is a must [22].

4.5 CSF 4: Structured Implementation Approach

Despite the fact most of the research on TPM development tends to emphasize and distinguish the uniqueness of approach, it should be noted that the framework available on the TPM implementation process are not obligatory and voluntary for company to adopt [25]. In an extreme case, the company adopting the TPM methodology by fully mapping to a complete implementation framework as studied by [32]. In this particular case, the company takes a holistic adoption of TPM implementation framework and absorbs them to match with their own internal capabilities. Different country and industry will require a different approach of TPM there is no single right method to approach the TPM [3].
The principles of TPM methodology are organized as 'pillars'. The numbers of pillar in literatures may vary, however the mostly accepted model is Nakajima's model [20]. Since TPM methodology is originally from Japan, there is a need of change on the fundamental approach of TPM in order to align with the culture of the country. An attempt to adopt a TPM approach follow the same way as is implemented in Japan, using a "cook-book" style will result in failure [3]. Generally for the countries outside Japan, the TPM implementation method is tailored to a specific requirement particularly subjected to a specific culture, technology capability, environment and political system [9]. In principal, there is no perfect method for TPM implementation and there has been a divergence of approaches adopted throughout the countries and industries. However, it is necessary to find a realistic method for a smooth application, with a good impact, that permits a trouble-free reformation ([30]; [7]).

4.6 CSF 5: Training and Education

Training and educational issues is another CSFs constructs to be focused in TPM implementation program ([22]; [33]). Sufficient and effective training programs would develop employee competence, skills and knowledge to detect abnormalities in the equipment condition in earliest stage [17].
[25] stressed on the need of nourishing in the technical knowledge to the employees in order to maximise the effectiveness of TPM implementation. The importance of technical knowledge is a part of the philosophy of TPM, as TPM itself is a technical process to achieve the world class maintenance. The development of operator participation is the most fundamental TPM methodology structure that often been having a lack of emphasizes in the West. They advised to emphasis on the training and education to ensure operator make a shift in their thinking and voluntarily to take care of their equipment. A sincere sense of ownership and active participation from employee towards their equipment will benefit the company [18]. The end results of TPM program would be translated into tangible benefits such as reduction in equipment breakdown, lower the cycle time, reduce in set up time and improve the product quality. The intangible benefits would be on improving the productive environment as well as spur the relationship between employer-employee (Ahmed *et al*., 2004). Through an effective training and education program, the skepticism about maintenance role as non-productive and non-profitability activity to the business operation can also be corrected [3].

4.7 CSF 6: Effective Communication

TPM promotes a synergy relationship among all organizational functions in the company, thus communication is one of the significant element in TPM [30]. Communication is vital since there are substantial interactions among various parties within the organization itself and with external parties. Due to different people from many other departments working together in one team, the effectiveness of communication is vital in preventing any communication breakdown. It is necessary to communicate and publish each phase of TPM development program to all employees and stakeholders of the company. The benefits achieved in financial terms should also be transparent. The possible element of communication included: awareness campaigns; visual management throughout the company; designing the TPM slogans; putting up the TPM posters at designated areas on the production floor; publishing TPM bulletin and introduction of TPM notice board. decision making process through employee empowerment is another part of the open communication strategy ([11];[9]).

4.8 CSF 7: Monitoring and Evaluation

Measurement of performance and evaluation on the TPM progress would enable management to review on the achievement and further improve any hiccups in the TPM implementation program ([29]; [12]). [29] highlighted the common used performance indicator in TPM included: (1) equipment performance in term of availability, reliability and OEE; (2) process performance, refers to comparative ratio of actual against the planned work, as well as of schedule compliance, and; (3) cost performance in term of labor and material costs of maintenance. TPM implementation can only be succeed in an organization that is committed to allocate time to monitor the progress of TPM ([29]; [28]). For instance, the proper assessment for the training given to employee is vital in order to ensure that employees' commitment, knowledge and skills are excellent level [17]. It is important to know whether employees really understand the terminology and philosophy taught therefore what have been preached would come forward in the workplace. The employee should understand what is expected from them [9].

5. Conclusion

This paper discusses the significant of CSFs constructs embedded in the proposed framework. The proposed framework is believed will provide a holistic guidance and understanding of the CSFs to be adopted and adapted in implementing the TPM program. This would enable the SMEs to improve their maintenance management practices in relation to world-class manufacturing standard. Those CSFs identified will be further refined during empirical research in the next stage of the main research which is ongoing. From this brief discussion, the author invites for other ideas as part of continual improvement on the proposed framework for TPM implementation in Malaysian SMEs.

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References

[1] Ahuja, I. P. S. and Khamba, J. S. (2008). Total productive maintenance: Literature review and directions. International Journal of Quality and Reliability Management. 25(7), 709-756.
[2] Aspinwall, E. and Elgharib, M. (2013). TPM implementation in large and medium size organisations. Journal of Manufacturing Technology Management. 24(5), 688-710.

[3] Bamber, C. J., Sharp, J. M. and Hides, M. T (1999). Factor affecting successful implementation of total productive maintenance: a UK manufacturing case study perspective. Journal of Quality in Maintenance Engineering. 5(3), 162-81.
[4] Bakri, A. H., Rahim, A. R. A., Yusof, N. M. (2012). Towards successful of TPM implementation: How well the management commitment being assessed?. Conference proceedings: International Conference on Management, Economics and finance (ICMEF2012).
[5] Deros, B.M, Nizam, M., Rahman, A., Jaharah, A. G., Dzuraidah, A. W., Mohd Hazri, H. and Nor Kamaliana, K. (2009). Role of senior management in TQM implementation in Malaysian small and medium enterprises. The Institution of Engineer. 72(3).
[6] Dogra, M., Shrama, V. S., Sachdeva, A. and Dureja, J.S. (2011). TPM - a key strategy for productivity improvement in process industry. Journal of Engineering Science and Technology.6(1), 1-16.
[7] Eti, M. C., Ogaji, S. O. T. and Probert, S. D. (2004). Implementing TPM in Nigerian manufacturing industries. Applied Energy.79(4), 385-401.
[8] Gates, L. P. (2010). Strategic Planning with Critical Success Factors and Future Scenarios: An Integrated Strategic Planning Framework. Carnegie-Mellon University Pittsburgh.
[9] Graisa, M. and Al-Habaibeh, A. (2011). An investigation into current production challenges facing the Libyan cement industry and the need for innovative total productive maintenance (TPM) strategy. Journal of Manufacturing Technology Management. 22(4), 541-558.
[10] Gupta, S., Tewari, P. C., & Sharma, A. K. (2006). TPM concept and implementation approach. Maintenance World, 21, 1-18.
[11] Haddad, T. H. and Jaaron, A. A. (2012). The Applicability of Total Productive Maintenance for Healthcare Facilities: an Implementation Methodology. International Journal of Business, Humanities and Technology. 2(2)
[12] Hansson, J., Backlund, F. and Lycke, L. (2003). Managing commitment: increasing the odds for successful implementation of TQM, TPM or RCM. International Journal of Quality and Reliability Management. 20(9), 993-1008.
[13] Harsej, F. and Sha'ri, M. Y. (2011). Continuous Improvement through an Integrated Maintenance Model. Contemporary Engineering Sciences. 4(8), 353-362.
[14] Irajpour, A., Fallahian-Najafabadi, A., Mahbod, M. A. and Karimi, M (2014). A Framework to Determine the Effectiveness of Maintenance Strategies Lean Thinking Approach. Mathematical Problems in Engineering. Retrieved September 25, 2014 from http://dx.doi.org/10.1155/2014/Article ID 132140.
[15] Jaina, A., Bhattib, R., & Singhc, H. (2013). Improvement of Indian SMEs through TPM Implementation–An Empirical Study.
[16] Jain, A., Bhatti, R., Deep, H. S., & Sharma, S. K. (2012). Implementation of TPM for enhancing OEE of small scale industry. International Journal of IT, Engineering and Applied SciencesResearch,
[17] Lazim, H. M. and Ramayah, T. (2010). Maintenance strategy in Malaysian manufacturing companies: a total productive maintenance (TPM) approach. Business Strategy Series. 11(6), 387-396.
[18] Majumdar, J. P. and Manohar, B. M. (2012). Implementing TPM programme as a TQM tool in Indian manufacturing industries. Asian Journal on Quality. 13(2), 185-198.
[19] Meibodi, L. A. and Monavvarian, A. (2010). Recognizing critical success factors (CSF) to achieve the strategic goals of SAIPA Press. Business Strategy Series. 11(2), 124-133.
[20] Nakajima, S (1988) . Introduction to TPM. Productivity Press, Cambridge, MA.
[21] Nickols, F. (2011). Strategy, strategic management, strategic planning and strategic thinking. Distance Consulting, 200, 8.
[22] Poduval, P. S., Pramod, V. R. and Raj, J. V. P. (2013). Barriers in TPM Implementation in Industries. International Journal of Scientific and Technology Research. 2(5).
[23] Pophaley, M. and Vyas, R. K. (2010). Plant maintenance management practices in automobile industries: a retrospective and literature review. Journal of Industrial Engineering and Management. 3(3), 512-541.
[24] Rolfsen, M. and Langeland, C. (2012). Successful maintenance practice through team autonomy. Employee Relations. 34(3), 306-321.
[25] Seng, O. Y., Jantan, M. and Ramayah, T. (2006). Implementing total productive maintenance (TPM) in Malaysian manufacturing organization : An operational strategy study. Strategic Maintenance Management: Current Practices. Bandyopadhyyay, P.K. (Eds), pp 196-208.
[26] Seth, D. and Tripathi, D. (2005). Relationship between TQM and TPM implementation factors and business performance of manufacturing industry in Indian context. International Journal of Quality and Reliability Management. 22(3), 256-277.
[27] Sharma, M. and Kodali, R. (2008). TQM implementation elements for manufacturing excellence. The TQM Journal. 20(6), 599-621.
[28] Singh, J. and Singh, H. (2012). Continuous improvement approach: state-of-art review and future Implications. International Journal of Lean Six Sigma. 3(2), 88–111.
[29] Singh, R., Gohil, A. M., Shah, D. B., & Desai, S. (2013). Total productive maintenance (TPM) implementation in a machine shop: A case study. Procedia Engineering, 51, 592-599.
[30] Shen, C. C. (2015). Discussion on key successful factors of TPM in enterprises. Journal of applied research and technology, 13(3), 425-427.
[31] The STAR report (13th July, 2017). Available at: http://www.thestar.com.my/business/business-news/2017/07/13/malaysias-sme-gdp-contribution-. Retrieved on: 10 September 2017.
[32] Tsang, A. H. and Chan, P. K. (2000). TPM implementation in China: a case study. International Journal of Quality and Reliability Management.17(2), 144-157.
[33] Yamashina, H. (2000). Challenge to world class manufacturing. International Journal of Quality and Reliability Management. 17(2), 132-143.