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Total Productive Maintenance: A Study of Malaysian Automotive SMEs

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Abstract— **Today maintenance is currently considered as an important function and becoming increasingly difficult to ignore since the impact of effective and efficient maintenance is important to increase the productivity and maximize the effectiveness of the overall equipment effectiveness. Total Productive Maintenance (TPM) is a systematic approach to understand the equipment's function, the equipment's relationship to the product quality and the likely cause of failure of the critical equipment conditions. Introducing TPM requires strategic planning and few studies had been made in the field of maintenance within the context of Malaysian Small and Medium Enterprises (SMEs) especially in automotive SMEs. Technologically, automotive industry is the most important and strategic industries in the Malaysian manufacturing sector must be supported by efficient and effective equipment management. This paper discusses the state of TPM implementation in Malaysian automotive SMEs and investigation of Critical Success Factors (CSFs) associated in implementing TPM. A survey through questionnaires has been applied to this study to determine the level of TPM practices in automotive industry. The Statistical Package for Social Sciences (SPSS) software was utilized to perform the required statistical analysis of the data from surveys. The paper systematically categorized the TPM knowledge and understanding and critical success factors (CSFs) in TPM implementation. This research would provide new data and findings on the TPM implementation that could be use for future study towards improving manufacturing competencies through equipment maintenance in the automotive organizations.**

Index Terms— **TPM, Critical Success Factors, Malaysian Automotive SMEs**

I. Introduction

OVER past years, various innovative techniques and management practices such as Total Productive Maintenance (TPM), Total Quality Management (TQM), Business Process Reengineering (BPR), Planning (MRP), Enterprise Resource Planning (ERP) and Just in Time (JIT), have become increasingly popular [1] and have been used extensively. However, the efforts mentioned above may have some limitations to be integrated in the manufacturing environment if the plant equipments are unreliable [2]. For global market survival in the changing and increasing competitive industrial arena, uninterrupted equipment will play a major role in increasing the productivity of production equipment [2]. Therefore, the quality of maintenance itself is important, since it affects equipment performance and consequently, the final product quality [3]. TPM is a partnership between maintenance and production to improve product quality, reduce waste, reduce manufacturing cost, increase equipment availability, and improve the company's over state of maintenance [4]. TPM also has been widely recognized as a strategic weapon for improving manufacturing performance by enhancing the effectiveness of production facilities [5]. However, according to McKone et al, [6] the environment contextual factors, such as country, organizations and managerial factors are important to the execution of TPM programs. The process of TPM implementation is a journey and not all companies are able to implement TPM successfully based on studies by Cooke [7] and [8].

The Small and Medium Enterprises (SMEs) in Malaysia have been slow to adopt and implement TPM due to some difficulties faced in attempts to adopt and implement TPM [4],[9],[10]. The numbers of TPM implementations has grown in various industries throughout the world especially in manufacturing organization and it was identified that TPM offers huge improvement in maintenance activities of various organizations and has significantly shown a positive impact towards their operational and organizational performances [1],[2],[4],[11],[12]. In other words, TPM has become highly recognized as a tool to deal with matters relating to plant maintenance, plant engineering and product design.

Therefore, it is crucial to identify the Critical Success Factors (CSFs) to ensure a successful implementation of TPM within the SMEs in Malaysia for the automotive industry as the focus segment. The automotive industry is one of the most important and strategic businesses and actually support a large number of SMEs that are supplying components, subassemblies to car manufacturers and assemblers. The development of the automotive industries, has contributed to the economic performance of the country, in terms of the generation of employment and the growth of supporting industries. The CSFs are important factors to be understood in assisting the automotive SMEs to realize and implement TPM in their companies. The CSFs may be formulated to minimize the barriers of TPM implementation. Moreover, it will assist the automotive SMEs to enhance their manufacturability to compete globally with effective maintenance management system and the TPM concept achieved through well defined CSFs improved operating conditions in existing plant and increased employees' knowledge and skill.

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II. TOTAL PRODUCTIVE MAINTENANCE

Maintenance management has to become more productive, efficient and innovative in order to cope with the changing business environment [13]. Within the last few decades, there has been an evolution of perceptions on the concept of plant maintenance from a reactive perception of repairs to proactive perception maintenance [1],[5],[14]. TPM which had been in place within the development of plant maintenance has the potential of meeting the current demand of changes in manufacturing process ensuring the availability and reliability of plant equipment and emphasizing lean manufacturing. TPM is the new approach to the development of maintenance system [15]. Seiichi Nakajima whom was also known as the father of TPM through the central idea of team participation in small work group brings the concept of maintenance and production together. The emergence of TPM is to both functions (production and maintenance) coupled with good working practices brought about a greater understanding of the respective functions [7],[16].

The main TPM Structure is divided into eight pillars and the activities involved are; Overall Equipment Effectiveness, Autonomous Maintenance, Planned Maintenance, Education and Training, Early Equipment Management, Quality Maintenance, Office TPM, and Safety, Health and Environment. These pillars as suggested and promoted by Japan Institute of Plant Management (JIPM) which eventually increase substantially in labour productivity through controlled maintenance, reduction in maintenance costs and reduced production stoppages and equipments downtime.

TPM, considered as the latest maintenance system has shown advantages in many aspects of manufacturing environment today. TPM establishes a total (company-wide) maintenance system encompassing maintenance prevention, preventive maintenance and improvement related maintenance [21] whose purpose is to prevent losses and waste. More and more companies globally are benefiting from the philosophy and values with a structured implementation framework [4],[17],[18],[19],[20]. A systematic and long term TPM approaches lead to the improved manufacturing performance that contributes to the overall improvement in reliability and maintainability, safety, quality, productivity, cost, waste and further enhancing the competitiveness of the organization.

TPM emphasize good working practices between production and maintenance [7],[11],[22],[23]. However, it has been shown that the relationship between production and maintenance is full of conflicts [24]. The implementation of TPM can be seen as a major challenge to be implemented and its adaptation of TPM within different industry size especially the SMEs which is still lagging behind with the reactive concept of maintenance [9],[10],[25]. The need to understand the CSFs for successful TPM implementation is crucial in order to meet the purpose of this study. The investigation into CSFs has made the TPM implementation within the automotive SMEs much easier to comprehend. Different studies of TPM CSFs have been conducted by various researchers within all sectors industry [3],[17],[21],[26],[27],[28]. Therefore identifying the CSFs of TPM implementation which was carried out by researchers seems appropriate to facilitate the TPM implementation process. From all the above studies made on the CSFs of TPM clearly indicated that these factors facilitate the implementation of TPM that ensure the successful of TPM implementation. Table 1 shows a summary of the main aspect of TPM CSFs.

Table 1: Summary of TPM CSFs

Researcher	**CSFs Identified**
Ahuja & Khamba (2008b)	• Top Management Contribution • Cultural Transformation • Employee Involvement • Traditional and Pro-Active Maintenance Policy • Training and Education • Maintenance Prevention and Focused Production System Improvement
Seth & Tripathi (2005)	• Focus on Customer Satisfaction • Leadership for Improvement • Strategic Planning for Improvement • Education and Training • Information Architecture • Performance Measurement System • Material Management • Equipment Management • Process Management • Management of Financial Resources •
Bamber et al. (1999)	• The Existing Organization • Alignment to Mission • The Involvement of People • An Implementation Plan • Knowledge and Beliefs • Time Allocation for Implementation • Management Commitment
Hannson & Backlund(2002)	• Support and Leadership • Strategic Planning with Vision and Mission • Implementation Plan • Buying in and Empowerment • Training and Education • Communication and Information • Monitoring and Evaluation
Siong & Ahmed (2007)	• Management Support • Employee Participation • Knowledge and Skill • Training and Education • Maintenance Strategy • Supplier Support

III. PURPOSE AND METHODOLOGY

The needs and importance of TPM is highly felt in today's manufacturing environment. But little research has been conducted in this area within Malaysian industry and a survey had been conducted through questionnaires to determine the TPM implementation level and the CSFs. A short and easy questionnaire was develop and sent either electronically, through friends and mailed. The target population for this study consists of the automotive SMEs. The Statistical Package for the Social Science (SPSS) software was utilized to perform required statistical analysis of the data from the surveys. The ANOVA statistical analysis was first employed to test the whether there are any significant mean different for TPM implementation on level of knowledge and understanding with years of TPM involvement. Secondly, a paired comparison was used to analyze the difference between level of importance and practices for the CSFs of TPM. Before the statistical analysis was conducted it was necessary to first evaluate the reliability and validity of the instrument to ensure that the findings would be reliable and valid.

IV. RESULTS AND DISCUSSIONS

The surveys covered 550 companies with 94 responses considered valid. This constitutes a response rate of 17% an mainly were completed by the engineers and managers as intended since they directly involved in the process and have first hand knowledge the level of TPM implementation. The reliability analysis, assessed with Cronbach's Alpha value range from 0.608 to 0.946 (Table 2). The values of Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO) are greater than 0.5 and Bartlett's Test of Sphericity is observed (Table 3).

Table 2: Cronbach's Alpha Coefficient

Factor Variables	Cronbach's Alpha	
	Level of Importance	**Level of Practices**
Top Management Commitment	0.890	0.804
Resource Management	0.608	0.762
Performance Measurement System	0.762	0.860
Continuous Improvement System	0.896	0.911
Education and Training	0.851	0.811
Work Culture and Involvement	0.935	0.946

Table 3: KMO and Bartlett's Test

Factor Variables	Level of Importance		Level of Pratice	
	KMO	**Bartlett's**	**KMO**	**Bartlett's**
Top Management Commitment	0.802	0.000	0.755	0.000
Resource Management	0.560	0.000	0.671	0.000
Performance Measurement System	0.688	0.000	0.817	0.000
Continuous Improvement System	0.791	0.000	0.824	0.000
Education and Training	0.672	0.000	0.635	0.000
Work Culture and Involvement	0.775	0.000	0.735	0.000

Table 4 shows the TPM knowledge and understanding in three levels based from the scores of respondent companies. Level A shows that 16% have good understanding and knowledge of TPM, level B (+/-1 standard deviation from mean) shows 66% with average understanding and knowledge of TPM and level C shows 18% with low understanding and knowledge of TPM. The average mean score of TPM Opinion by respondent companies is 41.

Table 5 indicates that there is significant difference between years of TPM involvement and TPM Opinion. This result is significant at the p<0.005 level. It clearly indicates that the respondents are well aware of the aims and the concept of TPM implementation based on the numbers of years involved in TPM. It shows the duration of TPM involvement significantly influenced the understanding of the TPM concepts and aims. Based from table 4 as mentioned earlier also has indicated 82% of responses have the understanding and knowledge of TPM with 16 % at level A and 66% at level B.

Table 4: Score of Understanding and Knowledge of TPM

Level	Scores	No of Respondent	(%)	(%)
A	50	3	3.20	16%
	48	2	2.13	
	47	10	10.64	
B	46	6	6.40	66%
	45	8	8.51	
	44	2	2.13	
	43	6	6.40	
	42	9	9.57	
	41	8	8.51	
	40	7	7.45	
	39	5	5.32	
	38	5	5.32	
	37	3	3.20	
	36	3	3.20	
C	35	6	6.40	18%
	34	1	1.05	
	33	2	2.13	
	32	5	5.32	
	31	3	3.20	
Total		**94**	**100.0**	**100.0**

Table 5: One Way ANOVA

Variables	Mean	F – value	P – value	Sig
TPM Opinion	3.9500	5.240	0.007	**YES**

The following paired comparison is an attempt to find out whether there is any significant difference between the two levels; importance and practices in CSFs. The mean scores have shown that the level of importance has a higher degree values. Table 6 indicates that there are significant difference between level of importance and practices as perceived by the respondents. These results are not significant at the p>0.005 level for all factor measured variables. Most of them realized the importance of the elements in the CSFs of TPM but were unable to be translated into practice in the automotive SMEs.

All the factors of CSFs which are Top Management Commitment, Resource Management, Performance Measurement System, Continuous Improvement System, Training and Education and Work Culture and Involvement being accepted as important and required to be put into practice in ensuring the successful implementation of TPM.

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Table 6: Paired Comparisons of CSFs Level of Importance and Practices

Factor	Mean Importance	Mean Practices	t_{calt}	p-value	Sig
TMC	3.978	3.291	11.66	0.000	**YES**
RM	4.236	3.563	9.71	0.000	**YES**
PMS	4.306	3.548	12.41	0.000	**YES**
CIS	4.023	3.521	10.06	0.000	**YES**
TE	4.409	3.284	15.14	0.000	**YES**
WCI	4.284	3.726	8.49	0.000	**YES**

TMC– Top Management Commitment, RM– Resource Management, PMS– Performance Measurement System, TE– Training & Education, CIS– Continuous Improvement System, WCI– Work Culture Involvement

V. CONCLUSIONS

Throughout this study, it is found that TPM as part of overall maintenance management evolution plays an important role for keeping the assets in good condition to further enhance the manufacturing performance. Currently, most of the existing literature has mainly discussed the implementation of TPM in large industries. However, this study has provided the background and understanding for the Malaysian automotive SMEs to implement TPM. The analyzed results showed that years of involvement had increased the level of understanding and knowledge of TPM as indicated in table 3 and 4. Therefore, this findings supported that TPM has been accepted and practiced within the automotive SMEs. The analyzed result in table 5 has shown the CSFs of TPM differences between level of importance and practices. The CSFs of TPM are found to be important in ensuring the success of TPM program. However, these factors were unable to be practiced by the automotive SMEs. The CSFs of TPM as mentioned in table 5 and evidence from the CSFs of TPM as mentioned by most studies [3],[17],[26],[27] have been the factors that support the success of the TPM implementation in most organization globally. Most studies [1],[2],[4],[8], [9] mention that the successful implementation of TPM program can improve the manufacturing performance leading the organization to achieve competitive advantage and bring wide range of benefits. The differences between companies and countries may affect the implementation process, but key factors of CSFs remain consistent and similar especially with the TPM implementation in manufacturing industry.

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