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Total Productive Maintenance and Innovation Performance in Malaysian Automotive Industry

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Abstract- Modern manufacturing requires that to be successful organisations must be supported by both effective and efficient maintenance. One approach to improving the performance of maintenance activities is to implement and develop a total productive maintenance (TPM) practices. The maintenance concept is important in the manufacturing environment and it provides support for productivity. The purpose of this paper is to identify the TPM constructs and innovation performance measures for Malaysian automotive industry and also to develop research model of the TPM and innovation performance measures relationship for Malaysian automotive industry. A conceptual model based on previous studies has been proposed. This model will be used to study the relationship between TPM practices and innovation performance for Malaysian automotive industry. Based on the proposed conceptual model and reviewed, research hypotheses are being developed. The paper culminates with suggested future research work.

Keywords— Total Productive maintenance, Innovative performance, automotive industry, SEM

I. INTRODUCTION

The automotive sector is an important industry to the Malaysian economy. This sector's contribution to the economy is large and closely related to manufacturing and services sectors. Automotive sector at Malaysia began with the importation of vehicles which then progressed to assembly operations and the development of the automotive component industry.

The challenges in automotive industry were increased. Then by that, the strategic direction and policy framework for the automotive industry must be reviewed. Malaysian automotive industry must focus on quality improvement to fulfil the specific needs and to exceed the customer expectations [1]. Automotive industry is the most actively involved industry in the quality effort, low production cost, continuous improvement activities, development of supply chains, and adoptability technology advanced. As a matter of fact, World Class Manufacturing (WCM) achieved global competitive advantage through the use of their manufacturing capabilities as strategic weapon and providing world class performance element like productivity, quality, safety, environment, delivery, morale, flexibility, and cost [2], [3].

Modern manufacturing requires that to be successful organisations must be supported by both effective and efficient maintenance. One approach to improving the performance of maintenance activities is to implement and develop a Total Productive Maintenance (TPM) strategy. TPM is a unique Japanese philosophy, which has been developed based on the productive maintenance concepts and methodologies. This concept was first introduced by Nippon Denso Co. Ltd. of Japan, a supplier of Toyota Motor Company, Japan in the year 1971. TPM is an innovative approach to achieve the goals zero breakdowns, zero abnormalities, zero defects and zero accident [4].

TPM is an efficient and strategic planning for business management.TPM approach will directly affect the level of efficiency and effectiveness in the manufacturing organization [4], [5]. TPM in this definition covers four areas: autonomous maintenance, planned maintenance, quality maintenance and education and training. Therefore, the TPM is an important activity for a business in term of maintenance factor. It was not regarded as a non profitable activity. But it does can be more profitable in the long term [6].

Furthermore, [7] defines as one of the innovative approach, current and complement the strategies of WCM such as Total Quality Management (TQM), TPM, Just-In-Time manufacturing (JIT), total employee involvement, continuous improvement and other practices. This innovative approach will be effect to the innovation performance in organization if accompanied by Research and Development (R&D), new technology and good knowledge. Meanwhile, [8], internal process factors such as the manufacturing process and networking will affect innovation performance.

By these issues, this paper aims to assess the implementation of TPM will increase innovation performance or not. Besides that, this paper looks at the methods of implementation of TPM in automotive industry.

II. BACKGROUND AND HYPOTHESES

2.1 Total Productive Maintenance

In 1971 the Japanese introduced and developed the concept of (TPM), in response to the maintenance and support problems encountered in manufacturing environment. TPM describes a relationship between production and maintenance, for continuous improvement of product quality, operational efficiency, capacity, assurance and safety [9]. The goal of TPM is an aggressive strategy focuses on actually improving the function and design of the production equipment and innovation of the production [10].

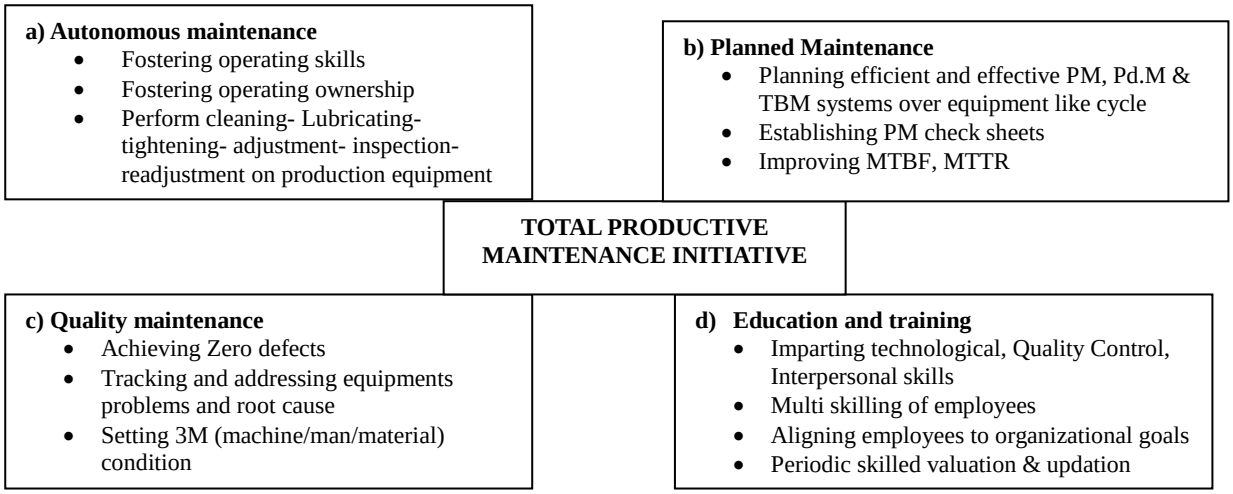
According to [9] in [4], the word TPM has three meanings that describe the principal features of TPM:

i. Total effectiveness indicates TPM's pursuit of economic efficiency or profitability which includes productivity, cost, quality, delivery, safety, environment, health and morale.
ii. Total maintenance system includes maintenance prevention and maintainability improvement as well as preventive maintenance.
iii. Total participation of all employees includes autonomous maintenance by operators through small group activities: the small group activities promote planned maintenance through "motivation management".

Hence, [6] found that TPM implementation a significant impact on improving the manufacturing process. TPM is very important in achieving the objectives of the company to become a competitive company. It also can optimize the use of equipment in an effort to reduce cost. Hence, it can improve efficiency in the management of manufacturing companies, thereby providing a sound platform for the organization to compete effectively in the dynamic environment.

TPM is generally divided into two elements, namely elements that short team and long term element. The short term elements are more focused in autonomous maintenance for production department. Then it also focused in a planned maintenance for maintenance department, and skill development for operation and maintenance staff. Besides that, for the long term element more focused on the new equipment design that involve the innovation practise. Hence, it's also involves the elimination of sources of lost equipment time [11], [6].

The entire edifice of TPM is built and stands, on eight pillars [12], [13], [14]. The unique eight pillars in TPM is autonomous maintenance, focused improvement, planned maintenance, quality maintenance, education and training, safety, health and environment, and office TPM and development management [6], [15], [16], [17]. But in this study focused on part of the pillar only because not all pillars can be relate with innovation performance. The activities involved with various TPM pillars have been describe in Figure 1.



Fiq. 1 The Pillars of TPM [6]

This pillar is geared towards developing operators to be able to take care of small maintenance tasks, thus freeing up the skilled maintenance people to spend time doing more value-added activity and technical repairs. The operators are responsible for the upkeep of their equipment to prevent it from deteriorating [18].

Planned Maintenance

It is aimed to have trouble-free machines and equipment producing defect-free products for total customer satisfaction. This breaks maintenance down into 4 groups that were defined earlier [6].

- Preventive Maintenance;
- Breakdown Maintenance;
- Corrective Maintenance; and
- Maintenance Prevention.

With planned maintenance efforts evolve from a reactive to a proactive method and use trained maintenance staff to help train the operators to better maintain their equipment.

Quality Maintenance

It is aimed towards customer delight through highest quality through defect-free manufacturing. The focus is on eliminating non-conformances in a systematic manner, much like Focused Improvement. An understanding is gained of what parts of the equipment affect product quality, eliminating current quality concerns and then moving to potential quality concerns. Transition is from re-active to pro-active (Quality Control to Quality Assurance) [6], [18].

Education and Training

It is aimed to have multi-skilled revitalized employees whose morale is high and who are eager to come to work and perform all the required functions effectively and independently [18], [19]. Education is given to operators to upgrade their skill. It is not sufficient to know only "know-how" but they should also learn "know-why". By experience they gain, "know-how" on how to overcome a problem and what is to be done.

According [20] the initiatives of TPM are focused to addressing major losses, and wasted associated with the production system by affecting continuous and systematic evaluations of production system, thereby affecting significant improvement in production facilities. Table 1 below shows the previous studies is related to the TPM.

***Table 1*: Previous studies about TPM**

Dimension	Autonomous maintenance	Planned maintenance	Quality maintenance	Education and training
[6]	*	*	*	*
[18]	*	*	*	*
[21]				*
[11]	*	*		
[19]	*			
[21], [22]	*	*		*
[15]	*		*	*
[24]	*			*
[25]	*	*	*	*
[26]				*

2.2 Innovation Performance

Currently, the popular press has a pronounced fondness for the word "innovation". Innovation is seen as the economic needs which can provide a return value to an organization in the short and long term. The word innovation is also found in corporate mission of most organizations. Innovation elements were included in the organization performance and it's called innovation performance. There are several previous studies that describe the definition of innovation performance.

Table 2: Dimension Operational of Innovation Performance

Dimension	**Dimension operational**
Innovation performance	Innovation performance is the result of the innovative activities implementation with the quality ideas and effective implementation [27]
	Innovation is seen as a process which result from various interactions among different actors [28]
	Innovation requires a comprehensive network to accelerate the information dissemination and need information and resources that can be trusted [29]
Therefore, briefly the innovation performance refers to the level of innovation organization, effects from the implementation of several processes and influenced from specific factors.	

Based on previous research, innovation performance is divided into several parts. Meanwhile, according [27] innovation performance is divided into four areas, namely Incubation, evaluation, process innovation, and strategy and structure. While that of [30] says that innovation from the perspective of technological innovation, there are three areas of employee training, employee motivation, and organization control. However, it is quite different with [31] which state the innovation performance from different perspectives. Innovation performance can be grouped into five different groups: new product, new method of production, new sources of supply, exploitation of new market and new ways to organize business. Therefore, based on previous studies, this study will be divided into three areas of innovation performance to suit the environment in Malaysian automotive industry. It is divided into an environmental innovation, employee innovation and technology innovation.

2.3 TPM Implementation in Manufacturing Effected Innovation Performance

TPM is very important in manufacturing process. In develop a strong manufacturing system must have (TQM) that act as a brain, while the TPM as a powerful muscle or in other words TPM as a strong manufacturing capability. Then, to connect the brain to the muscles need a strategic system called JIT. Therefore, in manufacturing must have TQM, TPM, and JIT. This fact be supported by [24], [32] say that TQM, TPM, and JIT are very important to build a good manufacturing system in Japan. Likewise with [32] statement, TQM and TPM approaches have an impact in manufacturing in Indian context.

Furthermore, [25] also give such a statement that TPM and TQM is one of the fundamental components of WCM. TPM is a continuous-flow manufacturing concepts which will lead to efficient and effective maintenance [23]. According [33] TPM implementation initiatives have shown an increase improvement in equipment efficiency and effectiveness in manufacturing performance. Regarding from this research, TPM deployment has significantly contributed toward improving the manufacturing system productivity, quality, safety, and morale. It's also shown that TPM ensuring the cost effectiveness of manufacturing function within the organizations.

Generally, there is no study that shows a direct implementation of TPM can affect innovation performance except [24]. His research shows the continued maintenance will have a direct impact on innovation in Japan manufacturing industries. However with the current Japanese nation has to deal with competition, they need to adopt a new strategies to facing with these issues. Many studies that examine the implementation of TPM give impact on manufacturing performance. But, roughly in many branches of manufacturing performance, such as finance and innovation. It can be related with this study is to review implementation of TPM can be affect innovation performance.

TPM will improve manufacturing performance because of the planned maintenance activities and increase the efficient and effectiveness use of equipment. It is supported by [34] which show that TPM and manufacturing performance have significant and positive relationship. Likewise as studies conducted by [35], shows that the TPM will reduce costs and improve the quality and also directly impact to manufacturing performance.

Furthermore, modern manufacturing requires that to be successful organisations must be supported by both effective and efficient maintenance [23]. One approach to improving the performance of maintenance activities is to implement and develop a total productive maintenance (TPM) strategy [23], [36]. According [36], revealed the importance of management leadership, employee involvement, education and training, strategic planning and communication for TPM in Chinese setup. [37] also identified top management support, alignment of management initiatives and change, employee training, autonomy to employees and communication as important factors for the success of TPM in a European context.

On the other hand, [26] has been found that the four factories under investigation have low productivity and production levels when compared with the design values. There is no clear TPM strategy and also it has been 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 a management strategy and reward structure. According [6] TPM is an initiative programme to eliminate defect, accidents, and damage in the workplace. Improvement in manufacturing process will bring to the innovation's element. Innovation in manufacturing will help organizations to striving WCM. This statement supported by [26] in his research, shown that the excellence of its production capability and that those who conquer manufacturing will eventually conquer technical innovation.

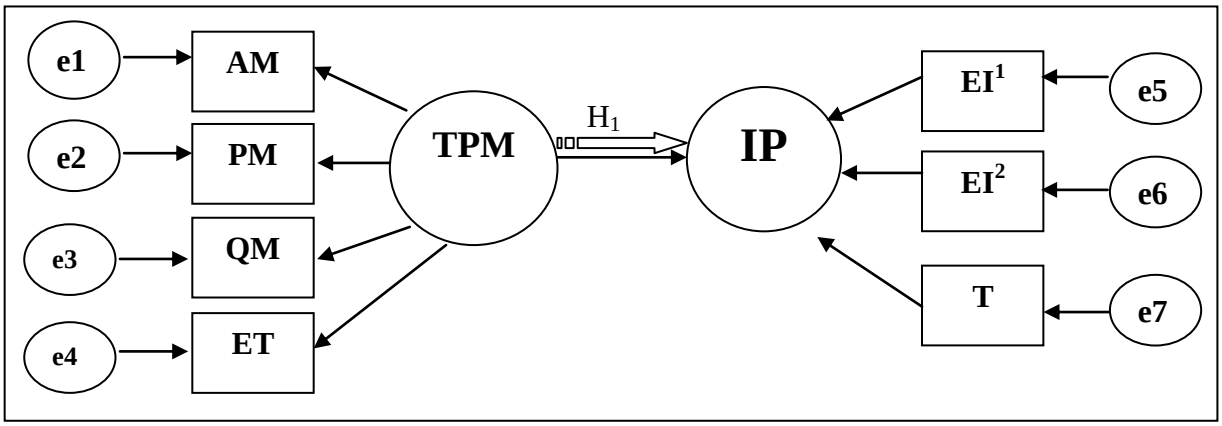
Innovation is an important factor to ensure the organization can compete in the global market. Innovation will usually involve the maintenance and improvement activities to improve the quality of a product or service. TPM program also provides a competitive advantage in global for manufacturing organizations which in their striving for world class performance [38]. This statement was supported by [39] said that TPM is one approach to improving performance on maintenance activities in the organization. In addition, continues maintenance factor is very essential in the TPM approach. The TPM implementation methodology provides organizations with a guide fundamentally transform their shop-floor by integrating culture, process, and technology. Combination of the culture, maintenance process and technology advances will indirectly lead to innovation performance.

As well as [41], a major contributor of TPM says that TPM is an innovative approach to utilize equipment effectiveness, eliminates corruptions and breakdowns and promotes continues autonomous maintenance by operators. It must be done on a regular basis or though day-to-day activities involving the total workforce [6], [40], [42]. Trough these activities, element of innovation can be applied in each maintenance activity.

By [24] TPM is a comprehensive maintenance system starting from the designing of new equipment to the daily autonomous maintenance by operators. Generally, the new product will be designed and the innovative will be directly engaged. Each equipments that is designed will have the weakness and it must be accompanied by the improvement and modification activities to maintain organizations competitiveness in the globally.

2.4 A Proposed Conceptual Model

Based on comprehensive review of previous study, a conceptual model has been proposed to model the relationship between TPM and innovation performance as presented in Figure 2. This proposed model has adopted the conceptual model proposed by [6]. However, some amendments especially on TPM practices and innovation performance constructs have been made.



*Note: TPM=Total Productive Maintenance, IP=Innovation Performance, AM= Autonomous Maintenance, PM=Planned Maintenance, QM=Quality Maintenance, ET=Education and Training, EI^1=Environmental Innovation, EI^2=Employee Innovation, T=Technology.

Fig. 2 A Proposed Research Model

2.5 Research Hypotheses

To understand the relationship of TPM practices on innovation performance in Malaysian automotive industries, the following hypotheses will be used and tested. Thus, these hypotheses have been developed based on the proposed conceptual model and previous research mainly from [6].

Several studies show a relationship between TPM and manufacturing performance. According [6] found that TPM implementation a significant impact on improving the manufacturing process. Meanwhile [34] which show that TPM and

manufacturing performance have significant and positive relationship. Likewise as studies conducted by [35], shows that the TPM will reduce costs and improve the quality and also directly impact to manufacturing performance. [32] also noted that TQM and TPM approaches have an impact in manufacturing in Indian context. Therefore, the following hypothesis will be tested.

H_1: *There is a positive and direct significant relationship between TPM implementation and Innovation performance in Malaysian automotive industry.*

III. METHODOLOGIES

In this study, sampling method by using structured questionnaire. The population of this study comprised in Malaysian automotive industry. Questionnaires will distribute to respondents from the listing of automotive industry obtained from Malaysian Automotive Component Parts Association (MACPMA), Proton Vendors Association (PVA), and Kelab Vendor Perodua. To analyze the data, one statistical technique was adopted. Structural equation modelling techniques was utilize to perform the require statistical analysis of the data from the survey. Exploratory factor analysis, reliability analysis and confirmatory factor analysis to test for construct validity, reliability, and measurements loading were performed. Having analyzed the measurement model, the structural model was then tested and confirmed. The statistical Package for the Social Sciences (SPSS) version 17 was used to analyze the preliminary data and provide descriptive analyses about thesis sample such as means, standard deviations, and frequencies. Structural Equation Modelling (SEM using AMOS 6.0) will use to test the measurement model.

This study is expected to arrive at the following conclusion: This study has important implication for total productive maintenance and innovation performance in Malaysian automotive industry. As such, it is expected to benefit both researchers and practitioners.

IV. DISCUSSION

Many studies have been performed to identify critical success factors for successful implementation TPM practices. However, no previous study had tried to investigate the relationship between TPM practices and innovation performance, especially amongst automotive industry in Malaysia. A conceptual model has been proposed to examine the relationship between TPM practices and innovation performance for Malaysia automotive industry and to develop research model of the TPM and innovation performance measures relationship for Malaysian automotive industry. Based on proposed model and a previous studied, research hypotheses are being develop. The next step of this study is to design a questionnaire, which will be used for pilot study data collection in Malaysia automotive industry.

V. CONCLUSIONS

This study is expected to arrive at the following conclusion: This study has important implication for total productive maintenance and innovation performance in Malaysian automotive industry. As such, it is expected to benefit both researchers and practitioners.

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