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**APPLIED OF TOTAL PRODUCTIVE MAINTENANCE CONCEPTS
IN ENERGY INDUSTRY: ORGANIZATIONS PRACTICES**

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Abstract

The energy industry has continuously recognised the importance of a secure energy supply, as an essential element for national economic development and ensuring the continued growth of a sustainable trade and industry. As part of maintenance tools, the TPM philosophy was adopted and adapted in various industry around the world. The organization realized the need of TPM in managing their assets and strategize the machine/equipment operations. Due to that, the purpose and strategy for implementing the TPM must suit the organizational behaviour and business requirement. As the sole utility provider to the Malaysian community, this organisation has always looked forward for further improvement in the maintenance and operations. Aligned with that, this power generation industry purposely embarked the TPM initiative is to strengthen the power plant operation. However, to ensure the continuous success of TPM implementation, it is necessary to understand the insight of the top management regarding the direction of the company. Furthermore, members of the top management must understand their roles and responsibilities once the TPM is initiated at the workplace. To describe and explore detail of TPM implementation in this organization, this study applied qualitative approach.

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Keywords: Total Productive Maintenance (TPM), energy industry, maintenance strategy, TPM issues and challengers.



1. Introduction

TPM is a philosophy to enhance an organization's productivity and produce high quality goods by minimizing waste thereby reducing costs. The Japanese started the concept in the sixties when they realized that increased demand necessitated more specialized machines, which in turn required dedicated maintenance groups (Prasanth, Pramod, & Jahathy, 2013). Indeed, TPM become the holistic maintenance strategy tools because it involves whole organization to take part and play their roles and responsibilities (Afefy, 2013; Ahuja, 2008). TPM was adapted and adopted by industry to enhance the maintenance strategy that is very challenging nowadays. Organization realized that maintenance activities involves with some cost and consequently affected the organization financial performance. Due to that, the maintenance activities must align with organization goals (Induswe, 2013). The upkeep of plant equipment and machinery is crucial in ensuring the plants availability, reliability and performance, which supports their business objective. Proper operations and maintenance will also ensure the design life of the assets in generating the required revenue for the organization (Badli, 2012; Dogra, Vsihal, Sharma, Anish Sachdeva, & Dureja; 2016).

TPM commonly applied by manufacturing industry for better benefits and enhance the organization's performance by improving the product quality, reducing waste, reducing cost on manufacturing, maximizing the equipment availability, intensifying the product quality and increasing the overall equipment effectiveness. From the previous literature, Almeanaz (2010) studied the TPM implementation in the steel industry, Haddad and Jaaron (2012) have presented the research on the TPM implementation in the healthcare industry in Jordan, Habib and Wang (2008) studied the TPM effectiveness in manufacturing company in Sweden, while Sethia, Shende and Dange (2014) was carried out the study for milling process located in India. In Malaysia, Talib and Lim (2015) evaluate the Overall Equipment Effectiveness (OEE) in manufacturing machine and process industry. Thus, TPM has become highly recognized as an approach on handling and managing the plant maintenance, plant engineering, production improvement and product design. In fact, the TPM implementation has started in the power generation industry and it is limited to several companies only (Aspinwall & Elgharib, 2013).

Realizing the important of energy industry in supporting the extent of national economic, the organization taken serious action on handling the machine availability. The physical feature deals with the availability and accessibility of energy resources. The affordability of the resource acquisition and building of energy-relevant infrastructure is another important aspect that realises energy security in the economic sense. Supported to the Energy Commission inspiration, thermal power generation organisation plays the important roles strategizing the maintenance mechanism. Thermal power generation plant or thermal power station is the most conventional source of electric power (Nuraini, Salmi, & Aziz, 2018). Thermal power plant is also referred as coal thermal power plant and steam turbine power plant. In most of the places in the world, the turbine is steam-driven. Thermal power plant process involves with water heating process, turns into steam and spins a steam turbine, which drives an electrical generator. After it passes through the turbine, the steam is condensed in a condenser and recycled to where it was heated; this is known as a Rankine cycle.

According to Kumar, Peter, Lefton, and Agan Dimo (2012), Power Plant Owners and Operators are spending a large portion of their operational expenditures (OPEX) each year to maintain and upgrade their

equipment and assets. As the remaining lives of the assets are used up, the more maintenance expenditure is needed to ensure the plant's performance and conditions. Maintenance philosophies and concepts have evolved throughout the year as organizations progress ahead to remain robust and competitive with the ever changing globalization of marketplace and demands (Ahmed, Hassan, Taha, 2004; Modgil & Sharma, 2016).

Furthermore, there are studies conducted on TPM in Malaysia and are mostly applied on quantitative based. It seems that there is a lack of explanation on the holistic perspective from the level of employees. It is important to gauge the information from various perspectives particularly from top management and operators (Lazim, Ahmad, Hamid, & Ramayah, 2009). Commonly, the top management manages the organization strategy and policy which is involved in driving the organization goal, objectives, mission and vision of the organization. The top management also makes decision that affects the organization performance and at the same time holds total responsibility for the success of the organization. Clearly, the top management is responsible for controlling and overseeing the entire organization. On the other hand, operators are the main players of the organization who are directly engaged in the daily activities. The activities carried out by the operators are under the supervision and guideline of the management. Operators' involvement and contribution in the TPM activities drive the effectiveness of this program. Thus, there is a need to understand the operator's perception in order to develop an integrative view in realizing the benefits of TPM applications.

Businesses in organization comprised with a variety of different task which, when coordinated properly, create value through producing products and services. According to Deslandes (2014), in ensuring the efficient conducting each task, its require management and alignment. Therefore, the researcher anticipates encompasses the top management and operators during carry out this study. This approach creates balance business environment with aligned the best practices during implementing TPM. Therefore, this study discusses the need of TPM in place in power generation industry, TPM as one of the maintenance tools, and the issues and challengers during the TPM implementation phase (Balasubramanian, Adalarasu & Regulapati, 2009; Poduval & Pramod, 2013).

2. Problem Statement

This research is performed to study the implementation of TPM at power industry sector specifically at Coal Fired Power Plant. It covers the journey of implementation and any related issue that occurred in the organisation. The related issue is referred to benefits, challenges, limitations and the required elements to improve the current TPM implementation.

3. Research Questions

Research question has been established to get the respondents feedback based on the TPM activities that was implemented in the power plants. Questions can be seen on the research methodology guideline.

4. Purpose of the Study

The purpose of this study is to examine the issues and challenges in the implementation of TPM in coal power plant industry. Study also was done to identify which of the elements are the most important in implementation of TPM and to provide recommendation for improvement based on the important elements identified.

5. Research Methods

This study applied qualitative approach, which is explain the detail of TPM phenomena at the workplace. By doing the qualitative research, individuals are selected to participate in the research based on their experience in the phenomenon of interest. According to Steubert and Carpenter (1999), there is no need to randomly select individuals because manipulation, control and generalization of finding are not the intention of the qualitative study (Silverman, 2016). In addition, the qualitative methods required a small, purposive sample for completeness and due to that the sample size is not predetermined in this study. Furthermore, the study will involve few top management as a sample. Meanwhile, for quantitative research will involves with the employees, which is attached at operation department.

The study was carried out at a coal power plant located in Malaysia. This plant was officially commissioned in the year 2000. The plant is expected to run and be reliable in operation for the next thirty years. This power plant supplies about 20 percent of the energy demand to the grid system in Malaysia (Prina, Fanali, Manzolini, Moser, & Sparber, 2018). As such, the plant is designed and installed in accordance with internationally recognized standards such as BS, ASME, ISO, and DIN appropriate to the duty, operational requirements, statutory obligations and environmental conditions.

This study will conduct in two phases involving qualitative method. Table 1 represents the research phases proposed by the researcher during the study. Phase one is the exploratory stage involved in problem identification, to strengthen the body of knowledge through reading the TPM literature review, establishing the research questions and developing the research objectives. The second phase, descriptive stage also focuses on the qualitative analysis. This phase involves the qualitative approach methods on gathering the information. The researcher conducts the interview session with the relevant parties and related respondents who are knowledgeable in the case. The outcome from the interview session will be scrutinized and analysed further.

Table 01. Exploratory stage (Qualitative Analysis)

Phase	Activities
Exploratory Stage (Qualitative Analysis)	<ul style="list-style-type: none">▪ Identify problem statement▪ Literature review TPM▪ Establish research questions▪ Develop research objectives
Descriptive Stage (Qualitative Analysis)	<ul style="list-style-type: none">▪ Question development▪ Interview session▪ Data collection and record keeping▪ Data Analysis

As deliberated by Coker (2003), the business world commonly applies the focus group mechanism especially when doing research in the psychology and education field. Supporting by McMillan and Schumacher (2001), the focus groups could generate and develop concepts or theoretical explanations based on their experience and history beyond that. Having said that, the researcher requires the experienced employers who are directly involved to gather more information on the TPM implementation. Strategically, the researcher creates the group interview to ensure the information data precisely and in holistic view. Group Interview 1 involves with top management, the executive from which is responsible on managing and supervise the TPM program. Therefore, the focus groups persistently examined the observations, spirit and thoughts involved during the interview session. The second focus group, Group Interview 2 involves the non-executive staff from TNBJ and it includes participants from the maintenance and operation section.

According to Blackburn and Stokes (2000), the members in the focus group consist of three to eight only. The participants must be recruited carefully to ensure the group could be managed and handled properly. Morgan and Krueger (1998), advised as the focus group is small, it is easier for the researcher to capture the information when the participants are discussing the topic. Besides, all participants will be actively involved if the group is small because more time will be given during the individual session. Therefore, the researcher segregates the focus group into three different groups of TNB staff with different participants. The composition of the focus group is explained in Table 2 below.

Table 02. Composition of the Focus Group

Participants	Focus Group	Number of Participants
Managing Director/ Top Management/ TPM Facilitator	Group Interview 1	4
TNBJ employee directly involved with TPM implementation	Group Interview 2	4

Eventually, the session for Group Interview 1 will conduct individually at the suitable workplace meanwhile for the Group Interview 2, the session will perform in the form of group. In total, eight members of TNB staff have participated during the qualitative stage of the data collection. All of members has given the invitation letter to participate in this study and they have officially agreed to involved. In ensuring the interview session is well managing, a discussion guide, topic agenda and time allocation is established in Table 3.

Table 03. Discussion Guideline

Agenda	Discussion topic
Introduction	<ul style="list-style-type: none">Introduce the researcher and rolesAim and format of the focus groupConventions (confidentiality, speak one at a time, recordings, everybody's views, open debate, report of proceeding)
Research Proposition 1: What is the driving factor implementing TPM?	<ul style="list-style-type: none">Why TPM is selected as one of the management tools to improve business performance?What are the advantages of the TPM program as compared to other initiatives implemented in TNBJ?How significant is the TPM advantage to enhance the business performance?

<p>Research Proposition 2: What is the top management roles?</p>	<ul style="list-style-type: none"> ▪ What are the roles of top management in ensuring the effectiveness of the TPM initiative in a power generation industry? ▪ What is the top management approach to influence the employees for embarking on the TPM program? ▪ What are the contributing factors that lead to the progress in the implementation of TPM?
<p>Research Proposition 3: What are the issues and challenges?</p>	<ul style="list-style-type: none"> ▪ What are the difficulties experienced by the TNB on exchanging the TPM work culture compared to the current practice? ▪ What is the issues and challenges faced during implementation of the TPM program? ▪ What is the future of TPM and the recommendation by the participants?

In addition to the study scope, the researcher will meet the key person driving the TPM at the power plant. The researcher is looking forward to gathering information on the TPM strategy and to study the effectiveness of the program. Furthermore, the researcher is interested to investigate the top management roles and responsibilities on handling TPM since the program was launched in 2010. The researcher also believes there are difficult experiences for adapting and adopting the TPM as a new tool at the workplace.

Besides that, the study gives an advantage to the industry because the thermal power plant is one of the earliest that applied the TPM as a part of maintenance practices in Malaysia. Thus, the life cycle of the power plant should be considered as well in selecting the best tools. Finding of the applicable tools for managing assets in a power plant is a critical strategy for this company because it needs to maintain high reliability. The researcher will find out the TPM activities that has been done since it was started at the organization. To achieve that, assessments, observations and other research techniques will be applied during the study.

6. Findings

Total Productive Maintenance has given a tremendously impact to all level of employees in power plant in term of the understanding of the benefits and the importance of the implementation. Employees who are involved in this programme have seen on the advantages and improvements of the equipment after execution of some small improvements activity at individual area. Researchers able to find out that top management involvement also could give some influenced to employees to adapt and adopt with this programme. Top management understand that they play vital roles in making the Total Productive Maintenance activity as a culture and not just a one off activity. Continuous improvement from this programme will furnish a better equipment performance, reduce equipment abnormalities and enhance company profit (Bhadury, 2000). Table 4 are the research question applied during interview session.

Table 04. Research Question and Key Note

Research Question	Key Note from Interview Session
<p>What is the driving factor ?</p>	<ul style="list-style-type: none"> ▪ Provide an understanding of the Top management and middle management agree that TPM are beneficial and should be implemented. ▪ This question will also trigger what are the benefit of TPM towards the organization and what are their roles in ensuring the smoothness of TPM implementation since it was established

	<ul style="list-style-type: none"> The researchers try to understand the important of TPM implementation to the company returns, growth and profit. Besides that, the researcher emphasizing the needs of sustaining the power generation and the effect to the business performance.
What is the top management roles?	<ul style="list-style-type: none"> This is a question where top management should answer as well as the TPM coordinator since the Top Management might believe that their role are only in providing the necessary resource not in the morale support and the leadership to follow The management strategy on initiating the TPM to the staff and to find out the management expected outcome through the program.
What are the challenges in the implementation of TPM?	<ul style="list-style-type: none"> TPM Coordinator, Production Engineer and Technician are fully aware on the problems they faced in executing TPM activities. The factor that affects the realization and requirement of the TNB staff from the top management, community and bottom line. Identify the lacking factors in the TPM implementation process. The researcher to find and list the critical factors during the initial start of the TPM implementation. The researcher interest to explore the difficulties on handling the TPM program. The challenges and issues for the executives and technician will be able to provide a realistic insight on their problems The adaption and adoption of TPM initiative among staff and the issues on breaking the TNB existing practice and culture.
How can TPM be improved, the future of the TPM?	<ul style="list-style-type: none"> Ideally improvement should be asked to all interviewee since their view on what should be improved will vary depending on their understanding and vision of TPM. Ideally to gets the participant recommendation on expanding the TPM initiative to other power generation industry in total.

Table 5 represent the finding and outcome from the interview session with applied SWOT (Strength, Weakness, Opportunities, Threats).

Table 05. SWOT Analysis

STRENGHT	
Man/ Management	<ul style="list-style-type: none"> Influencing role of Managing Director: The leadership strength of the top management in inspiring the workforce.
Machine, Material & Technology	<ul style="list-style-type: none"> TNBJ implements Computerized Maintenance Management System (CMMS) which assist in gathering the data on equipment maintenance.
Method & Process	<ul style="list-style-type: none"> Implements other initiatives – MBWA, RIT, 5S, ISO9001/14001/ 18001, BCM, BBS, CBM, War Room Implementation pilot project to evaluate effectiveness of TPM TPM Committee formation for coordination and enhancing departmental contribution.
Environment & Work Culture	<ul style="list-style-type: none"> Persistence in continuing TPM – Although TPM has not been very successful at TNBJ, they have been persisting in continuously improve and overcome barriers that have hindered their program in the past. Knowledge sharing culture – TNBJ organizes a technical colloquium which promotes employees at all level to share their knowledge and experience.
WEAKNESS	
Man/ Management	<ul style="list-style-type: none"> Lack of sense of ownership on plant equipment’s amongst operators – TPM implementation is still in a reactive phase throughout the organization. There is still a need to develop a proactive approach.

	<ul style="list-style-type: none"> ▪ Minimal level of understanding about TPM at all level which is not been consistent with different perspective and views. ▪ Lack of effective communication on TPM policy and awareness. There was limited evidence that support information regarding TPM on organization basis.
Machine, Material & Technology	<ul style="list-style-type: none"> ▪ Safety and Critical Plant equipment – Issues on safety was often highlighted by operators to be reasons why they are reluctant to conduct TPM activities on their machine.
Method & Process	<ul style="list-style-type: none"> ▪ Lack of clear measurement - TPM initiatives not tied to financial outcome/benefits.
Environment & Work Culture	<ul style="list-style-type: none"> ▪ Destructive culture of peer influence over new employees – There were issues highlighted that new employees are very motivated to support TPM whilst senior employee sees it as a management fad/gimmick ▪ TPM is a reactive phase which need to develop proactive maintenance approach. ▪ Lack of involvement from others department.
OPPORTUNITY	
Man/ Management	<ul style="list-style-type: none"> ▪ Development of plant ownership program – Ownership program where groups/individual can adopt a machine and ensure its maintenance could be introduced to enhance ownership. ▪ Develop of career path based on TPM ranking and knowledge to motivate. ▪ Reward the proactive employees participate in TPM activities.
Machine, Material & Technology	<ul style="list-style-type: none"> ▪ Improve existing procedure ▪ Generating new ideas to improve performance
Method & Process	<ul style="list-style-type: none"> ▪ Develop TPM champion for each pillar. ▪ Integrate the TPM with other initiative ▪ Extend the TPM program to all department ▪ Top management participate actively in TPM activities. ▪ TPM in this organisation is a benchmark to others power plant ▪ Develop specific training module focus in TPM at power industry.
Environment & Work Culture	<ul style="list-style-type: none"> ▪ Sense of belonging and responsibility ▪ Improve existing practices ▪ Implement and develop new culture.
THREAT	
Man/ Management	<ul style="list-style-type: none"> ▪ Loss of motivation – exhaustion due to inconsistent direction and unclear expectation. ▪ Loss of trained core personnel in TPM due to work environment. ▪ Organisation resistance to change which the need of Senior employee’s motivation. TPM is lacking and may be destructive to their organization motivation
Machine, Material & Technology	<ul style="list-style-type: none"> ▪ Dependency on the use of technology results in complacency.
Method & Process	<ul style="list-style-type: none"> ▪ Adapting manufacturing framework for TPM causes confusion in the organization – There is a need to develop a specific framework for TPM in the power generation context. ▪ Too many additional activities and initiative which is contribute to overlap of responsibilities. ▪ Window dressing activity where the TPM activity are usually conducted during audits and outsider visit – this may lead to employee burnout without proper direction.
Environment & Work Culture	<ul style="list-style-type: none"> ▪ Shift workers are not allocated a specific time to conduct TPM activities.

7. Conclusion

As a conclusion, Total Productive Maintenance is one of the maintenance tools which required a continuous improvement process that strives to optimize and maximising production effectiveness in energy industry specifically in power plant by identifying, discovering and eliminating equipment abnormalities and losses throughout the production system life cycle through active and cooperative team based participation of employees across all levels of employees. Human behaviour and work process will determines the successful of all the planned activities in Total Productive Maintenance. The benefits and impact of this initiative can be seen through the less breakdown of the equipment and high availability of the plants supply. Total Productive Maintenance is about improving equipment reliability, performance and availability through taking ownership and pride in its upkeep. The success of Total Productive Maintenance would not take place in a very short time but it takes systematically for the implementers and organizations to have the culture and be more passion on this initiative. Total Productive Maintenance are considered as one of the form of change management in the organisation where changes in work culture, process and management systems, organisational environment, and the individual perspective within the organisation are important to ensure the enforcement, commitment and involvement from all level of the organization. Transformation in term of employee's culture, work implementation and management roles are the key of successful.

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