THE CHALLENGERS AND SUSTAINABILITY OF TOTAL PRODUCTIVE MAINTENANCE (TPM) IMPLEMENTATION IN POWER GENERATION INDUSTRY: A CASE STUDY IN TNB JANAMANJUNG SDN BHD

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Abstract - This case study focuses on the challenges and barriers based on the four factors (1) Human (2) Technology (3) Method and (4) Environment that has been identified in the context of TPM implementation in a Malaysian Power Plant. The purpose of identifying the barriers is to formulating a strategy in enhancing and reviving the TPM implementation for the Case Study Organization (CSO). This research has led to the recommendations in improving the TPM development and implementation program of the case study organization. Findings indicate that although there was a need to integrate the 4 elements, the human factor such as management commitment & participation, rewards & recognition is a priority for TCSO.

Index Terms - Total Productive Maintenance, Power Generation, Barriers, Challenges.

I. INTRODUCTION

Maintenance forms an important aspect in the operations of Power Plant. 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. 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 [4], [27]. 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 progresses ahead to remain robust and competitive with the ever changing globalization of marketplace and demands [2]. The fast paced global demand today has forced organization to evolve from reactive maintenance (Breakdown Maintenance) to proactive maintenance as TPM. TPM is unique in a sense that the maintenance of equipment is the responsibility of the whole organization [33]. This holistic concept of maintenance allows TPM practitioner to enhance their Plant operational management in maximizing productivity and ultimately, profits. Many organizations embark to implement TPM in an effort to increase productivity and reduce operational expenses, but fail to implement TPM due to lack of planning and preparation to overcome the obstacles and barriers. Organization that failed to identify the barriers and provide a suitable mitigation ultimately abandoned their TPM initiatives due to frustration and incompatibility [14], [42]. Due to this, TPM researchers and practitioners have dedicated much of their works in identifying the barriers and providing solutions to ensure the success of TPM implementation.

II. LITERATURE REVIEW

Traditionally the responsibility of maintenance work in an organization is managed by the maintenance department. As industries evolved to meet the challenging global demands there is a need for ensuring equipment availability in top condition. Equipment failures and inefficiency has resulted in loss of revenue due unplanned shutdowns and outages. To address this growing concern TPM was introduced by Nippon Denso Co. Ltd. Of Japan to optimize equipment effectiveness, eliminate breakdown and promote Autonomous Maintenance through the involvement of the whole workforce in the organization [20]. The concept of TPM changes the culture of the organization from reactive maintenance (Breakdown Maintenance) to a proactive approach and is commended as a cost-effective solution for equipment maintenance and is widely adopted in many industry industries with successful results [3], [43]. The success of many organizations in different industries has sparked various debates by researchers and practitioners on the relevancy and effectiveness of TPM in different context (i.e. types of company and company characteristics) and industries. As founded by McKone (1990), that failures in the implementation of TPM are the result of failures to identify the contextual framework in the implementation of TPM. Literatures on the success factors and barriers are well established, especially in

the context of manufacturing industries. The deficit of research being conducted in the power generation industries and understanding its unique barriers has not been addressed. The successful implementation of TPM depends on a number of factors which may be categorized into four elements (1) Human (2) Technology (3) Method and (4) Environment.

Concept of TPM

At the core of TPM is the concept of 5S which is the foundation of the pillars of TPM. 5S which consists of sort, set in order, shine, standardize and sustain is a workplace organization technique which promotes a clean, safe and organized work area which will assist in productivity [5], [13]. An unorganized workplace tends to demotivate the workers and is prone to safety issues and accidents. 5S also creates the feeling of belongings and ownership to their workplace which is essential for the effectiveness of TPM implementation [7], [11]. 5S creates a foundation of well-organized work environment where the work area is clean with tools and parts are much easier to find and it is much easier to spot emerging issues such a fluid leaks, material spills, metal shavings from unexpected wear, hairline cracks in mechanisms. The eight pillars of TPM are mostly focused on proactive and preventative techniques for improving equipment reliability.

1. Autonomous Maintenance
2. Planned Maintenance
3. Quality maintenance
4. Focused Improvement
5. Training and education
6. Safety environment
7. TPM in administration

The objective of TPM is to increase the availability of the equipment through;

1. Reduction in machine and equipment breakdowns
2. Reduction in unplanned outages
3. Reduction in machine and equipment defects

A. Human Factor Affecting TPM

One of the unique aspects of TPM is the introduction of autonomous maintenances which is described as an operator involvement in maintaining their equipment and machine [37], [38]. The approach towards maintenance prior to TPM implementation is that, the operator shall operate and run the machine whilst the maintenance will come and fix the machine if there are any problems. Autonomous Maintenance changes the approach to maintenance by having the operators who have more knowledge of the machine they are operating to do the basic maintenance such as cleaning, tightening, lubricating and inspecting. This does not mean that the maintenance will be free of conducting the maintenance of the machine; it only allows them to focus on the more critical aspect of maintenance such as overhaul, parts management and equipment improvement. The implementation of AM will prevent accelerated deterioration machineries and equipment that are critical to the operation of the organization and promote a sense of ownership to the operators in maintaining their equipment. This innovative concept of maintenance has proven to be effective in improving the productivity of the people and the equipment. TPM integrate and synergizes the role of people and their equipment in creating a harmonistic environment where productivity is optimized. People play an important role in the successful implementation of TPM. According to Kulkarni & Dabade (2013), the key focus of TPM is on enhancing, exploring and leveraging on the capabilities of people in realizing their needs such as self-esteem, morale, safety and job satisfaction. Key barriers that are relevant to this issues highlighted by Kulkarni & Dabade (2013), includes total organizational involvement and participation, employee empowerment, employee attitude and behavior, teamwork & coordination, motivation & recognition and role of management.

B. Technological Factor Affecting TPM

Advancement in technology has propelled many organizations to become more competitive. Innovative approach that is available has helped organizations to become more productive [5]. Evolution of maintenance strategy was partly due to innovative approach in machine diagnostics which allows efficient maintenance. Investment in technologies depends on the different maintenance strategies that are adopted by the organization (i.e. preventive maintenance, corrective maintenance or predictive maintenance, etc.) [32]. Barriers that are often associated with failures of TPM implementation include lack of state-of-the-art (modern) technology and lack of understanding about the role of technology [3], [4]. Technology push and market pull work in combination to create more dynamic and unstable conditions, thereby making the concept of manufacturing strategy evermore crucial for firms. Adoption of new technologies is a key element to a firm's success. It investigates the extent to which advanced technology is being used by the individual technology level and at the functional technology group level, where functional group refers to collections of technologies that serve a common purpose. Previous research showed that technology is crucial to produce globally competitive products [12], [15], [18]. But developing a competitive advantage in the global marketplace depends less on the ability to develop new technology than on the ability to apply and continually refine those innovations. Many researchers are of the opinion that the lack of competitiveness of some industries is attributable to failure to apply the best available product and process technologies [19]. But using technology to build a competitive advantage is difficult [7]. Numerous

studies have explored, theoretically and empirically, the possible relationships among environment, strategy, and performance in the manufacturing sector [17], [21], [23]. However, many firms, no matter how large or small, are increasingly confronted with external environmental turbulence and complexity. As the external environment in which these design firms exist is changing rapidly and continually, how to properly adopt strategic choices in response to environmental uncertainty has become a great challenge. Past research studies have identified some key sources of environmental uncertainty, such as technology and market changes, governmental laws and regulations, social transformation, client preferences, supplier support, and the behavior of competitors [11], [19].

C. Methodological Factor Affecting TPM

Developing a clear TPM vision, mission and strategy that are in line with the organization is crucial for the long term success and sustainability of TPM implementation [20], [21], [38], [33], [44]. There is relationship with high performance industry. Ultimately it's a vital role of any industry to create a pleasant internal environment that support the customer needs and expectation. TPM needs a high performance work practices within the industry that could be a source of competitive advantage if it is properly nurtured. A high performance industry reports a clear direction of Vision, Mission and strategy which shall be embraced by employees all the levels to achieve the successful TPM approach.

D. Environmental Factor Affecting TPM

Creating a pleasant work environment and attractive working condition will help to inspire the workers in the organization; therefore, it is imperative that organization understand the pre-existing work culture and strategize their implementation of TPM which either supports the existing culture strength or create dissatisfaction to the extent that the organization itself will transform to relieve the dissatisfaction [5].

The organizational culture may influence employee's commitment and performance by setting the practices and the value for positive and meaningful work environment. Organizational culture plays an important role in achieving high performance and productivity in TPM and it is the source of competitive advantage for the organization. Cameron. K (1999) concluded that organizational performance is related to organizations with strong cultures with well integrated set of values, beliefs and the behaviors.

III. THEORETICAL FRAMEWORK

The TCO has embarked in the implementation of TPM since 2009 but had faced several obstacles and challenges that have slowed its progress towards implementing TPM. To assist in improving the TPM initiative, this research seeks to identify the barriers that are preventing the CSO from successfully implementing and sustaining its TPM implementations objectives. Loss in Power Plant availability has caused a losses of RM 175 million over the period of 2.5 years [44].

A. Research Objectives

1) To examine the issues and challenges in the implementation of TPM at TCO based on the 4 elements of (1) Human (2) Technology (3) Method and (4) Environment
2) To identify which of the elements are the most important in implementation of TPM at the CSO
3) To provide a recommendation for improvement based on the important elements identified

B. Research Questions

1) What are the issues and challenges that the CSO faced in the implementation of TPM?
2) What the critical areas of improvement that will improve the implementation of TPM at the CSO?
3) How can the existing implementation of TPM at the CSO be improved?

The CSO has embarked in the implementation of TPM since 2009 and has faced various challenges and threat towards the implementation that has affected its progress. The challenges ranges from leadership commitment, workplace culture, employee motivations, strategic directions and others factors which need to be aligned with the TPM objectives. The purpose of this case study is to identify the challenges and barriers that have hindered the progress of the TPM implementation and provide realistic solutions to the CSO.

IV. RESEARCH METHOD

In order to answer the research question in regards to the issues, barriers and challenges in the implementation of TPM at TNBJ, a qualitative case study research methodology was adopted, as the study aims to explore and understand the contextual phenomenon without having clear-cut hypotheses which can be tested [36]. This approach was adopted in order to provide a deeper description and understanding of the TPM-practice at TNBJ. A single-case study approach was employed to investigate the barriers and issues and get as close as possible to the industrial context. The goal is to provide a rich description of the social scene so as to describe the context in which events occur [36]. This particular case was chosen because it is unique since most study has investigated TPM in manufacturing context; involving the implementation of TPM in a large independent power generator in Malaysia. This

provided an opportunity to study the potential issues and challenges.

V. DATA COLLECTION

The data collection in identifying the issues, challenges and barriers in the implementation of TPM in the case study organization is collected based on primary and secondary data collection. The primary data collection, interviews are carried out with the Operations, maintenance, TPM committee, top management representatives, engineers, operators and technician. The interview questions design to accommodate a semi-structured and informal discussion. The main objective of this interview is to gather the personal opinion and perspective from respective interviewee and aims to look at their personal opinions & perceptions, insights, beliefs, and experiences. Before the interviews are conducted, the basic frameworks of the interview are discussed with the interviewee to ensure the interviewees are prepared in providing their insights and opinion.

VI. FINDING

From the interview session, the finding is presented through SWOT analysis.

A. Strength

Man/ Management	● Influencing role of Managing Director: The leadership strength of the top management in inspiring the workforce.
Machine, Material & Technology	● TNBJ implements Computerized Maintenance ● Management System (CMMS) which assist in gathering the data on equipment maintenance.
Method & Process	● 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	● Persistence in continuing TPM – Although TPM has not been totally 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.

B. Weakness

Man/ Management	● 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. ● Minimal level of understanding about TPM at all level – Understanding of TPM in TNBJ has not been consistent with differing perspective and views. ● Lack of effective communication on TPM Policy, awareness and importance – There was limited evidence that support information regarding TPM on an organizational basis
Machine, Material & Technology	● 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	● Lack of clear measurement - TPM initiatives not tied to financial outcome/benefits.
Environment & Work Culture	● TPM is in a reactive phase – need to develop proactive maintenance approach ● Lack of other department involvement. ● 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

C. Opportunity

Man/ Manage -ment	● Development of career path based on TPM ranking/knowledge to motivate and reward employees – Development of career path based on TPM Methodology will motivate employees to be more proactive to participate and involve in TPM. ● Development of plant ownership program – Ownership program where groups/individual can adopt a machine and ensure its maintenance could be introduced to enhance ownership.
Machine, Material & Technology	● Generating new ideas to improve performance ● Improvise existing procedure
Method & Process	● Integrate TPM with other initiatives ● Extend TPM to all departments

	● Top management participative role in TPM will increase morale ● Become pioneer in TPM for power generation industry – become benchmark to others ● Develop training specific to Power Generation industry ● Develop TPM champion for each pillar.
Environment & Work Culture	● Improve existing practices. ● Implement new culture to the staff ● Sense of belonging and responsibility

D. Threat

Man/ Manage -ment	● Organizational resistance to change – Senior employee's motivation to TPM is lacking and may be destructive to their organization motivation ● Loss of trained core personnel in TPM – Stress factor that leads to TPM participants to find other work ● Loss of motivation – exhaustion due to inconsistent direction and unclear expectation.
Machine, Material & Technology	● Dependency on the use of technology results in complacency.
Method & Process	● Too many overlapping initiatives conducted independently – Due to the many initiatives that TNBJ implements in the organization which are not integrated into TPM. ● Window Dressing activity – TPM activity are usually conducted during audits and outsider visit – this may lead to employee burnout without proper direction ● 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.
Environment & Work Culture	● Shift workers are not allocated a specific time to conduct TPM activities.

Besides, the challenges and issues faced during the TPM implementation is presented through ISHIKAWA model.

Man	● Complacency/ discipline ● Lack of time – too busy with daily work ● Reward structure not attractive ● Senior staff discouraging juniors ● Conduct TPM only when instructed reactive instead of proactive.
Method	● Unclear and changing guideline ● Lack of clear KPI and Auditing – leads to window dressing ● SOP for operation to perform TPM-AM Activities not in place Improvement.
Material	● Training is not structure for plant specific context ● No proper timeline and staff not sense of urgency to implement TPM
Management	● Lack of participate in TPM activity. ● Lack of communication on the importance of TPM. ● Does not encourage/enforce other department to participate. ● Does not understand their participative role in TPM.

VII. DISCUSSION & CONSLUSIONS

The role of Top Management in TPM is critical towards the success of its implementation. In the case of TNBJ, the Heads of Department will need to play a participative role in the activities of TPM. Clear communication and strategy must be in place in support of the management direction towards achieving the objective of TPM. Literatures in the area of Productivity and TPM have clearly identified that top management is the key deciding factor of the success of TPM in their organization.

The leadership concept in TPM requires that top management be involved in the activities of their subordinates. This is a critical point in TPM as participative leadership leads to enhance job satisfaction in the organization [24]. Although this may distract top management from performing critical activities of their managerial role in the organization, it must be understood that a good marketing and buy-in campaign is required to get the involvement of the whole organization.

To improve the TPM implementation it is recommended that the steering committee involves heads of other departments which shall ensure that the responsibility of their department in the effective implementation of TPM is addressed and executed. The step towards formation of the TPM Committee is crucial to move the TPM initiatives forward and tackle issues as a team. This is one of the areas which were found to lack previously, where the operation department has been the only key player without the support and understanding of other department. This disconnect in responsibility must be tackled by TNBJ so that it does not create distrust towards the

management where the division of responsibility towards TPM is not properly allocated.

The distinguishing factor of TPM compared with other maintenance initiatives is that maintenance is the responsibility of everyone within the organization. Limiting the role of TPM to only the operation department creates distrust and a feeling of unjust within the workforce. A successful TPM implementation in the organization is where everyone, starting from the Top Management post all the way to the housekeeping staff are actively involved. To create a proactive maintenance atmosphere, this concept of total involvement is necessary for the organization to adopt and disseminate through the organization.

To achieve this objective, it is recommended that TNBJ devise a marketing campaign throughout the whole organization highlighting the benefits it will have towards everyone in the organization. A proper buy-in of TPM and its benefit is necessary so that each and every one of the workforce will contribute and play an active role towards making TPM successful.

Continuity and perseverance in implementing TPM is necessary as the results may not be evident immediately. Thus the organization must not be discouraged to persist in their TPM journey and continue to improve as they progress. Many organizations tend to treat TPM as a seasonal initiative, especially when big problems start to occur. The seasonal initiatives are also one of the reasons where organizations develop a window dressing attitude towards TPM implementation. To prevent this from happening it is recommended that the organization establish a continuous auditing and monitoring of TPM implementation which shall focus on ensuring the continuity of TPM implementation in the organization.

The cultural change that is needed to ensure the success of TPM is one of the critical barriers to overcome. To become proactive in execution of daily task and forecasting potential problems in the plant requires experience and skill. It is important for the organization to constantly identify the ever changing needs of their manpower to ensure that their role and task are challenging in tandem with the rewards mechanism. Devising a strategy to support the motivation of the workforce towards self-actualization of Maslow's theory on motivation where it provides a suitable framework to inculcate proactive approach of identifying problems with their equipment and machines.

To become a proactive workforce necessary authority must be given them to make the necessary decision for the organization. This allocation of authority should be clear and within a specific context so that they are not discouraged in making the decision. Likewise, an educationalist approach is necessary where mistakes shall form part of the learning and not be penalized to the extent where they may be discouraged to take actions.

One of the key strength of TNBJ is their implementation of other initiatives such as Management by Walking About (MBWA), Rapid Improvement Team (RIT), ISO 9001 (QMS), ISO 14001 (EMS), ISO 18001 (SMS), ISO 22001 (BCM), Behavioural Based Safety, War Room, Condition Based Monitoring amongst the initiatives which are implemented at TNBJ. Treating each initiative as a separate activity tends to overwhelm the workforce with tons of work.

TPM can be further improved with the integration of the other initiatives that TNBJ has implemented to further strengthen its relevancy and effectiveness. The perception that TPM is an independent initiative has created confusion and fatigue in the organization thus resulted in demotivation of staff to support in its implementation.

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