Chapter 1
INTRODUCTION

1.1 INTRODUCTION

Improvement in productivity has been an issue for all the firms from beginning in order to keep manufacturing expenses as low as possible. Reliability and productivity of the production systems are the attributes of the performance of a manufacturing firm [Madu, 2000]. Perfect maintenance is a function of maintenance objectives and strategies, which are mutually affected by corporate policy, manufacturing policy and other potentially conflicting interests and constraints in the company [Swanson, 1997]. Formulation of maintenance actions and policies involves general decision structure [Gits, 1992]. A maintenance strategy is a decision rule which establishes the follow-up of maintenance actions in order to maintain or restore the system in a specified state by using suitable resources.

Total Productive Maintenance (TPM) is one of the tools which serves the purpose exercising through its various pillars as it provides a basis for “perfect manufacturing” [Shirose 1992]. TPM is a structured equipment-centric continuous improvement process that strives to optimize production effectiveness by identifying and eliminating losses associated with equipment and production efficiency throughout the production system life cycle through active team-based involvement of employees across all levels of the operational hierarchy. The results of extensive literature review indicate that TPM has a strong positive impact on multiple dimensions of manufacturing performance.

The aim of TPM is to maximize equipment effectiveness by establishing Preventive Maintenance (PM) practices through various departments involving all the employees of the firm [Nakajima 1984]. TPM also establishes coordination between production and maintenance tasks and continuous improvement motivated employees [Cooke, 2000]. Willmott [1994] and Wireman [1991] also presented TPM as an effective tool to improve productivity. It aims at to establish a corporate culture in order to maximize effectiveness of overall production system involving all the
functions of a firm to achieve zero accidents, zero defects, zero breakdowns, zero abnormalities and zero losses [JIPM, 1996].

In the process of implementation of TPM, various activities are performed under its eight pillars [Nakajima, 1984; Nakajima, 1988] i.e. Focused Improvement (Kobetsu Kaizen), Autonomous Maintenance (Jishu Hozen), Preventive Maintenance, Education and Training, Maintenance Prevention, Quality Maintenance, Administrative TPM, Safety health and Environmental Issues. The education and training pillar is of utmost importance because the successful implementation of other pillars depends upon the effective education and training to develop operation and maintenance skills & other aspects related to implementation of TPM. The skilled operator will be able to identify equipment abnormalities, correct them to restore the equipment functioning and set & maintain the equipment to its optimal condition [JIPM, 1997]. Effective exercise of education and training pillar of TPM is vital for its successful implementation. Since, success of all the activities of TPM depends upon the skills of TPM core team and other employees of the firm. Hence, it is required to measure and verify the effectiveness of such an important pillar in order to use the resources effectively and to perform the activities up to their utmost degree.

The objective of this thesis is to verify the effectiveness of education and training pillar of TPM and to identify the performance measurement metrics to measure the effects of the pillar on manufacturing performance.

1.2 EDUCATION & TRAINING PILLAR OF TPM AND PERFORMANCE MEASUREMENT

Nakajima [1988] defined Total productive maintenance as productive maintenance carried out by all employees of the company through small group activities and formulated as equipment maintenance performed on a company-wide basis. “TPM is a methodology and philosophy of strategic equipment management focused on the goal of building product quality by maximizing equipment effectiveness. It embraces the concept of continuous improvement and total participation by all employees and by all departments [SME, 1995]. It is a set of structured activities that can lead to improved management of plant assets when properly performed by individuals and teams [Robinson and Ginder, 1995]. The education and training pillar ensures necessary operational and maintenance skills
possessed by the workmen to accomplish an assigned task and also effective implementation of all other pillars depends upon this pillar. Hence, it is important to measure the effectiveness of this pillar to ensure the full implementation of TPM and to achieve the objectives. The rigorous exercise of education and training pillar of TPM ensures the effective utilization of equipments in terms of availability, output quality and operating speed. Management needs information about maintenance performance for planning and controlling the maintenance process. Performance measurement is a fundamental principle of management. Like other manufacturing functions, performance measurement is important in managing the maintenance function. A performance measurement system is defined as the set of metrics used to quantify the efficiency and effectiveness of actions [Neely et al. 1995]. The factors which are to be considered during carrying out performance measurement are effectiveness i.e. satisfaction of customer needs, efficiency i.e. economic and optimal use of company’s resources and changeability i.e. strategic awareness to handle changes. Considering these factors, a number of performance measures are developed. As Sharma et al. [2011] presented a framework of measuring performance on the basis of MTBF and MTTR.

Performance measurement provides a general information basis that can be used for decision making purposes, both for management & employees and it is examined from three different levels, (1) from individual performance measures, (2) from system’s performance measurement and (3) relationship between the performance measurement system and its environment. Neely et al. [1995] also mentioned some performance measurement concepts which underline classifications of performance measures as per their financial and non-financial perspectives, positioning the performance measures from the strategic context, and support of the organizational infrastructure, like resource allocation, work structuring, and information system amongst others. Maintenance Performance Measurement is also important and it is multidisciplinary process of measuring and justifying the value created by maintenance investment, and taking care of the organization’s stockholder’s requirements viewed strategically from the overall business perspective” [Parida, 2006].

Well-defined performance indicators can potentially support identification of performance gaps between current and desired performance and provide indication of
progress towards closing the gaps. It is clear that performance measures provide an important link between the strategies and management action and thus support implementation and execution of improvement initiatives [Kaplan, 1983; White, 1996; Neely, 1999; Neely et al. 2005]. Further, they can potentially help maintenance managers to focus maintenance staff and resources to particular areas of the production system that will impact manufacturing performance. Quantifying and measuring the input and output of the maintenance process is little difficult. This is attributed to the complex relationship between maintenance and manufacturing [Pintelon et al. 1997]. Some authors term the relationship between maintenance and production as paradoxical, since the more maintenance contributes positively to the overall strategic goals of an organization, the less noticeable it becomes to top management as a value adding activity other than just adding to the cost. In contrast to this, poor maintenance can obstruct addition of value, retard the advantage of capital resource and destroy a business. Since maintenance is a service function for production, neither the merits nor the shortcomings of the service rendered are immediately apparent [Pintelon et al. 2000]. There is an agreement among authors that there is a need for a holistic performance measurement that assesses the contribution of the maintenance function to manufacturing and business strategic objectives [Tsang, 1999; Muthu et al. 2000].

The basics of education and training are self-enlightenment, as well as On-the-Job Training (OJT) to improve the skills required to perform the scheduled tasks upto their highest degree of accuracy. This is based on the view that the improvement of individual member’s skills will contribute to enhancement of these people's feeling of fulfillment with their jobs.

1.3 SKILLS
Skills generally refer to the capability to do one's job. As shown in Fig.1.1, these skills are the ability to act accurately and reflexively (without considering) in response to any phenomenon, based on acquired knowledge and experience, and to sustain that action for a long time.

The shorter the time from the detection of abnormalities to actions is, the more excellent the skills are considered to be. Skill actions based on accurate judgment are only possible if education, training, experience and information are accumulated in an
orderly fashion. Skills are the powers to act rightly and reflexively (without thinking) based on learnt knowledge in all phenomena, and to sustain it for a long time. Skilled men are excellent at acting in a reflectively shorter time from finding of a trouble to taking an action.

![Figure 1.1 Skill](image)

**1.3.1 Phases of skills**

Skills can be classified into the following 5 phases:

- **Level 0**: Do not know (not taught) Lack of knowledge
- **Level 1**: Know the theory
- **Level 2**: Can do to some degree Lack of training
- **Level 3**: Can do with confidence Learnt by doing
- **Level 4**: Can teach to others Perfectly mastered

1. **Do not know**
   
   Lack of knowledge without fully understanding principles and rules of work and equipment. Lowest in level.

2. **Know the theory**
   
   Know principles and rules of work and equipment, but cannot do when it comes to practice.

3. **Can do to some degree**
   
   Can practice, but performance causes large dispersions and has no reproducibility. One more step is required. Caused by lack of training.
(4) Can do with confidence
The body has perfectly learnt it. A very good phase to accomplish jobs anytime and anywhere without mistake.

(5) Can teach to others
The skill has been perfectly mastered. Can explain "know-why" and the method to transmit skills has been mastered.

1.3.2 Skill evaluation
When providing training, evaluate the knowledge, technology and skill level of each operator required for the position category and job grade and shortages should be improved in a planned manner. The capabilities expected from personnel who are skillful with equipment i.e. operators and maintenance staff, are described in following sections.

Capabilities required most strongly of operators
Operators should be able to conduct correct handling and adjustment of equipment, to have capacities of the following five items, and to use equipment to the maximum, as if it were part of their brains. Such capabilities are cultivated through education and training closely connected to workshops.

(a) Having the ability to detect and improve malfunctions of equipment -
  • Ability to detect equipment malfunctions.
  • Understanding the importance of oiling and knowing correct oiling methods and manners of checking oiling results.
  • Understanding the importance of cleaning (inspection) and knowing the appropriate cleaning methods.
  • Understanding the importance of localizing splashing of cut powders and coolant, and being able to prevent their splashing.
  • Ability to rectify or improve malfunctions found by oneself.

(b) Having the ability to understand equipment functions and mechanisms and find the cause family of abnormalities -
  • Understanding points requiring attention stemming from the structure.
  • Ability to perform cleaning & inspection to maintain performance.
  • Knowing the judgment basis for abnormalities.
  • Ability to find the cause family of abnormalities.
• Ability to correctly judge if equipment stoppage is required.
• Ability to diagnose failures to a certain extent.

(c) Understanding relations between equipment and quality and having the ability to predict quality abnormalities and find their cause families -
• Ability to view phenomena from a physical viewpoint.
• Knowing relations between quality characteristics and equipment.
• Understanding the range for the maintenance of static and dynamic precision and being able to carry out checking.
• Understanding the cause family of defects.

(d) Ability to carry out repair -
• Ability to replace parts.
• Ability to learn the service life of parts.
• Ability to estimate the cause of failures.
• Ability to conduct emergency steps.
• Ability to assist in overhauls.

(e) Having the ability to implement focused improvement under a suitable theme for the job of an operator, both singly and in cooperation with related staff -
• Feeling uneasy if there is waste in work, and being able to shorten the time for cleaning, oiling, inspection, setting up, and adjustment.
• Ability to conduct improvements that extend the service life of equipment parts.
• Ability to implement improvements that prevent the occurrence of failures and minor stoppages in advance.
• Ability to implement improvements that rectify cutting-blade exchange losses and that extend the service life of cutting blades.
• Ability to reduce speed losses.
• Ability to prevent quality defects in advance.
• Ability to improve procedural or method losses.
• Ability to improve the safety of equipment and work.

(f) Capabilities required of maintenance personnel -
Because excellence or non excellence of equipment affects productivity, quality and safety in many fields, improvement in the maintenance technology potential
is urgently expected. To meet such expectation, maintenance engineers are required to have the following capabilities.

- Ability to extend guidance regarding correct handling and routine maintenance.
- Ability to pass judgment as to equipment normality or abnormalities.
- Ability to examine the causes of abnormalities and to select and implement correct restoration methods.
- Ability to raise the reliability of equipment and parts to extent their service life and to prevent the occurrence of abnormalities or failures.
- Ability to enhance equipment maintainability through unit exchanges and to curtail repair and restoration time.
- Ability to pursue economy of these activities and to seek optimization.