CHAPTER 1

INTRODUCTION

Maintenance, with its multifaceted activities, resources and management, has been important to manufacturing organizations. However, in recent years, the need to manage the different facets of maintenance effectively has gained more importance due to changing operational technologies, and changing organizational role of maintenance (Alsyouf 2007). Several manufacturing organizations have switched to Lean Manufacturing, Just-In-Time production, Enterprise Resource Planning, Supply Chain Management and Six Sigma programs (Jardine and Tsang 2006). In such organizations, the scope of maintenance has shifted from a narrowly defined organizational perspective to an organizational strategic perspective. And hence, maintenance performance measures, measurement and management are given due importance in order to utilize the scarce maintenance resources more effectively, and in the process improve the organizational efficiency and effectiveness (Simoes et al 2011).

1.1 MAINTENANCE PERFORMANCE MEASUREMENT

Maintenance is vital for sustainable performance in any industrial operation. The quality of maintenance system plays a pivotal role in the success and survivability of any organization. Effectiveness of maintenance and its quality need to be measured for the justification of investment in maintenance. This is realized by implementing and using an appropriate performance measurement system (Parida and Chattopadhyay 2007).
Furthermore, without any formal measure of maintenance performance, it is
difficult to plan, execute, monitor, control and improve the maintenance
process. Measurement of maintenance performance is necessary for
continuous improvement and for identifying and resolving priorities.
Maintenance performance measurement has received much attention from
researchers due to a paradigm shift in maintenance. Neely et al (1995) defined
performance measurement as the process of quantifying the efficiency and
effectiveness of an action. Researchers have proposed different criteria for
measuring maintenance performance (Ghalayini and Noble 1996;
Kutucuoglu et al 2001; Gomes et al 2004). Tsang (1998) and Parida and
Kumar (2006) have identified important factors that need to be considered in
the road toward effective performance measurement management.

A comprehensive list of maintenance performance indicators is
presented by Coetzee (1999). A classification of 21 indices under four
categories, viz. machine/facility maintenance efficiency, task efficiency,
organizational efficiency, and profit/cost efficiency are identified. The use of
performance ratios such as availability, mean time to failure, man power
utilization and overall maintenance cost effectiveness has been suggested.
Although the measures form a balanced view of the maintenance system, they
are yet limited to the operational and tactical aspects. The measures appeal to
different performance hierarchies but it is difficult to identify the specific
hierarchies to which they belong. They are also numeric and hard measures
with no clear connections to the corporate strategy.

Total Productive Maintenance (TPM) provides a metric, termed the
Overall Equipment Effectiveness (OEE), which is defined as a function of
equipment reliability, quality rate and equipment performance efficiency
(Nakajima 1988). This metric offers a starting point for developing
quantitative variables for relating maintenance measurement to corporate
strategies (Kutucuoglu et al 2001, Bamber et al 2003). The OEE measurement tool has its strength in the way it integrates different vital aspects of manufacturing into a single measurement tool. Simoes et al (2011) have conducted a literature survey on maintenance performance measurement and presented a conceptual framework and directions for future research. As a result of the focused literature review, 345 different measures emerged, with a total of 696 occurrences. The main 37 measures, with more than two occurrences as reported by Simoes et al (2011) are shown in Figure 1.1.

![Figure 1.1 Type and occurrences of Maintenance Performance Measures](image-url)
It is observed from Figure 1.1, that cost with 40 occurrences, was the most used maintenance performance measure. The most utilized measure represented several dimensions of maintenance performance, namely, technical, economic, safety and human resources. The least utilized measure group included several measures, such as training/learning, skills/competencies, work incentives, process performance, resource utilization, maintenance capacity, customer satisfaction and employee satisfaction. While cost is an important measure, future research should focus on deriving practical performance measures aimed at capturing other important factors of the maintenance performance effort. It is found from Figure 1.1, that the overall equipment effectiveness is also an important performance measure of maintenance with 34 occurrences (about 13 percent of the total occurrences within the group of measures). The OEE is a performance measure that can help maintenance managers improve the maintenance performance, which in turn, would improve the productivity of the organization (Simoes et al 2011).

1.2 NEED FOR THE STUDY

Due to the changing organizational role of maintenance, and the increasing complexity of manufacturing technologies, maintenance related costs have been on the increase. To manage the maintenance process, operating managers and asset owners need to measure the contribution of maintenance towards their business goals (Parida and Kumar 2006). Performance measurement remains a complex issue. This is particularly so if some absolute measure of performance is sought. What cannot be measured cannot be managed effectively. As such, close attention should be paid to maintenance performance measures, and management in order to improve the overall organizational efficiency and effectiveness.
Despite the overwhelming benefits gained through effective performance measurement and management, and the fact that organizations using integrated balanced performance management systems tend to outperform their counterparts, studies have shown that 70 percent of all those systems implementation initiatives have failed (Bourne et al 2002; Bourne 2005; Parida and Kumar 2006). In a survey of manufacturing organizations conducted by Cholasuke et al (2004), only one-third of the organizations, with good maintenance management practices realized the full benefits of their maintenance management initiatives.

The factors such as, measuring value created by the maintenance; justifying investment; revising resource allocations; health, safety and environment issues; focus on knowledge management; adapting to new trends in operation and maintenance strategy; and organizational structural changes should be considered in order to implement a good maintenance performance measurement process (Simoes et al 2011). The overall equipment effectiveness is a maintenance performance measurement tool that measures different types of production losses and indicates the areas of process improvement (Muchiri and Pintelon 2008). These losses (usually referred to as chronic and sporadic losses) are activities that absorb resources, but create no value. Sporadic losses occur randomly, but their effects often lead to large disturbances from the normal state and therefore can be easily identified and rectified. But the disturbances due to chronic losses are more difficult to identify since they can be accepted as the normal state of the process (Leflar 2001).

Researchers, in general, have ignored the losses caused due to chronic losses in the assessment of overall equipment effectiveness. It is found that various factors which may influence OEE have not been sufficiently addressed in the literature. In this study an attempt is made to
shed some light on the important factors and elements that would play a role in the effective utilization of the equipment in any manufacturing industry. The proposed study is validated with the help of statistical analysis.

1.3 AN OVERVIEW OF THE THESIS

This thesis is a research effort on the study and the empirical investigation of factors affecting overall equipment effectiveness.

A survey of the literature related to performance measurement systems and maintenance performance measurement, and total productive maintenance is presented in chapter 2. A survey of articles on the maintenance performance measures and overall equipment effectiveness is provided. The literature on the topic such as the study of various factors on performance measures is also included.

Research framework and methodology to carry out the empirical study to test the factors influencing OEE is presented in chapter 3. The factors such as Human factor, Technical factor, Maintenance factor, Production factor, Environmental factor, Economic factor, Managerial factor and Organizational factor and the elements under each factor are identified. The proposed empirical model in order to study the impact of factors on OEE is presented. The unidimensionality, reliability, convergent and discriminant validity of the factors have been tested.

In chapter 4, the relationship between the factors and the OEE is determined with regard to the availability rate, performance rate and quality rate. Further in order to test the influence of these factors on the availability rate, the performance rate and the quality rate, many hypotheses have been formulated individually for each factor with respect to medium scale
companies, large scale companies, public limited companies, private limited companies and multinational companies and the results are analyzed.

In chapter 5, the various hypotheses formulated to test the discrimination among the three groups of companies viz., public limited companies, private limited companies and multinational companies with respect to the three OEE components, viz. availability rate, performance rate and quality rate, are presented. Also the sets of hypotheses formulated to discriminate medium scale companies and large scale companies, Indian companies and multinational companies, public limited companies and multinational companies, private limited companies and multinational companies, public limited companies and private limited companies are presented and the application of statistical analysis is demonstrated.

The results obtained from the empirical investigation are highlighted in chapter 6. The conclusions, limitations and scope for further study are also presented.