CHAPTER 6

RESULTS AND CONCLUSION

The objective of the study is to determine the potential factors which may have an influence on the key maintenance performance indicator, viz. the overall equipment effectiveness. The Overall Equipment Effectiveness is a measure of maintenance performance and is calculated by multiplying the availability rate, the performance rate and the quality rate. An exhaustive survey of literature, carried out in the area of Maintenance Performance Measurement and OEE, is used to identify the factors that are assumed to affect OEE. The factors considered in the study are human factor, technical factor, maintenance factor, production factor, environmental factor, economic factor, managerial factor and organizational factor. An empirical model is proposed to study the relationship between each of these factors and the overall equipment effectiveness. In order to determine the influence of these factors on OEE, and also on the components of the OEE viz. the availability rate, performance rate and quality rate, an empirical study using statistical methods has been carried out. A measuring instrument is initially developed for data collection in the pilot study. After performing the reliability and the validity tests, the measuring instrument is further refined in order to collect data for the main study.

The empirical investigation to study the influence of factors on the OEE is divided into two phases as follows.
• The study of Factors-OEE relationship and the investigation of the influence of the factors on the components of the OEE

• Discrimination between the companies with respect to the components of the OEE.

The results and conclusions made from the study are presented in this chapter.

6.1 RESEARCH FINDINGS

The findings from the study are summarized in the following sections.

6.1.1 Factors -OEE Relationship and Influence of the Factors on the Components of OEE

The Regression analysis is carried out to determine the relationship between the factors and the overall equipment effectiveness. Three sets of hypotheses are formulated to determine whether there is any significant influence of the factors on the OEE with respect to the availability rate, performance rate and quality rate. The results of the ‘F’ statistics showed that the values are significant at 0.01 levels. And hence it revealed that there is a positive relationship between the factors considered in the study and the overall equipment effectiveness with respect to the availability rate, performance rate and quality rate.

Further it is proposed to determine the influence of the factors on the components of the OEE in various categories of companies such as medium scale companies, large scale companies, public limited companies, private limited companies and multinational companies. Five sets of
hypotheses are formulated to determine whether the factors have significant influence on availability rate, performance rate and quality rate in different categories of companies considered in the study. The study revealed that the factors have a significant influence on the availability rate, performance rate and quality rate in the various categories of companies.

6.1.2 Discrimination between Companies with respect to the Components of OEE

In the second phase of the study many sets of hypotheses are formulated to determine whether there is a significant difference between the various categories of companies, viz. medium scale and large scale companies, Indian companies and multinational companies, public limited companies and multinational companies, private limited companies and multinational companies, and public limited companies and private limited companies, with respect to the influence of the factors on the availability rate, performance rate and quality rate. Also a set of hypothesis is formulated to determine whether there is a significant difference among public limited companies, private limited companies and multinational companies with respect to the influence of the factors on the availability rate, performance rate and quality rate.

The independent samples “t” tests and one way ANOVA are conducted to discriminate between various categories of companies. The study revealed that in most of the cases, there is no significant difference between the different categories of companies with respect to the influence of the factors viz. human factor, technical factor, maintenance factor, production factor, environmental factor, economic factor, managerial factor and organizational factor on availability rate, performance rate and quality rate. However in some cases, either a significant difference or a considerable
difference is observed with respect to the influence of the factors on the availability rate, performance rate and quality rate. The results of independent samples “t” tests and one way ANOVA conducted are summarized in the following sections.

6.1.2.1 Discrimination between Medium Scale Companies and Large Scale Companies

The results of the study to test the discrimination between medium scale companies and large scale companies with respect to the influence of the factors on the availability rate, performance rate and quality rate are presented in this section. The study revealed there is no significant difference between the companies with respect to the influence of the factors on the availability rate, performance rate and quality rate. However it is found that there is a considerable difference between the companies with respect to the influence of the maintenance factor on the performance rate. Also it is observed that there is neither a significant difference nor a considerable difference between the companies with respect to the influence of the other seven factors on the performance rate. Hence it is found from the study that maintenance factor assumed significance in improving the performance rate than the other factors. Also when comparing the mean value of the maintenance factor influencing the performance rate between large scale companies and medium scale companies, the mean value is higher in large scale companies than in the medium scale companies. The study indicates that the influence of maintenance factor on performance rate is higher in large scale companies than in medium scale companies. The reason for this influence may be attributed to the fact that maintenance awareness is higher in large scale companies than in medium scale companies.
6.1.2.2 Discrimination between Indian Companies and Multinational Companies

A study is carried out to test the discrimination between Indian companies and multinational companies with respect to the influence of factors on the availability rate, performance rate and quality rate. The study revealed that there is a significant difference between the companies with respect to maintenance factor influencing availability rate. Also there is a considerable difference between the companies with respect to environmental factor influencing availability rate. Hence it is found from the study that there is neither a significant difference nor a considerable difference is observed between the companies with respect to the influence of remaining factors such as human factor, technical factor, production factor, economic factor, managerial factor and organizational factor on the availability rate. Also it is found that the maintenance factor and environmental factor assumed significance in improving the availability rate more than the other factors.

A significant difference is observed between the companies in the influence of the managerial factor on the performance rate. A considerable difference is observed between the companies in the influence of the maintenance factor on the performance rate. Also a considerable difference is observed between them in the influence of the organizational factor on the performance rate. The study revealed that there is neither a significant difference nor a considerable difference observed between Indian companies and multinational companies with respect to the influence of remaining factors such as human factor, technical factor, production factor, economic factor, and environmental factor on performance rate. It is observed from the study that the improvement of performance rate may depend more on the maintenance factor, managerial factor, and organizational factor than the other factors.
factors. Also it is observed that there is neither a significant difference nor a considerable difference found between Indian companies and multinational companies with respect to the influence of factors on the quality rate.

6.1.2.3 Discrimination between Public Limited Companies and Multinational Companies

The study to test the discrimination between public limited companies and multinational companies with respect to the influence of factors on availability rate, performance rate and quality rate is carried out and the results are presented in this section. A significant difference is observed between the companies with respect to the influence of the organizational factor on the performance rate. A considerable difference is observed between the companies with respect to the influence of the managerial factor on the performance rate.

The study revealed that there is neither a significant difference nor a considerable difference observed between the companies with respect to the influence of the remaining factors such as human factor, technical factor, maintenance factor, production factor, economic factor and environmental factor on the performance rate. It is observed that when the public limited companies and multinational companies are compared, two factors namely, the managerial factor and the organizational factor may play a lead role in improving the performance rate than the remaining other factors. From the study it is also understood that there is neither a significant difference nor a considerable difference observed between the companies with respect to the influence of factors on the availability rate and quality rate.
6.1.2.4 Discrimination between Private Limited Companies and Multinational Companies

The discrimination between private limited companies and multinational companies with respect to the influence of factors on the availability rate, performance rate and quality rate is tested. The study revealed a significant difference between the companies with respect to the influence of the maintenance factor on the availability rate. It is found that there is neither a significant difference nor a considerable difference observed between the companies with respect to the influence of the remaining seven factors on the availability rate.

A significant difference is observed between the companies with respect to the influence of the maintenance factor on the performance rate. A considerable difference is observed between the companies with respect to the influence of the managerial factor on the performance rate. The study also showed that there is neither a significant difference nor a considerable difference between the companies with respect to the influence of remaining factors such as human factor, technical factor, production factor, economic factor, environmental factor and organizational factor on the performance rate. The results emphasize that while comparing private limited companies and multinational companies, the maintenance factor has a significance on both the availability rate and performance rate than the remaining other factors. Further managerial factor also has a considerable influence on the performance rate. Also it is found that there is neither a significant difference nor marginal difference observed between the companies with respect to the influence of factors on the quality rate.
6.1.2.5 **Discrimination between Public Limited Companies and Private Limited Companies**

The results of the study carried out to test the discrimination between public limited companies and private limited companies with respect to the influence of factors on the availability rate, performance rate and quality rate are presented below. It is observed that a considerable difference is observed between the companies with respect to the influence of the maintenance factor on the performance rate. And there is neither a significant difference nor a considerable difference observed between the companies with respect to the influence of remaining seven factors on the performance rate. The study showed that the maintenance factor assumed significance than the remaining other factors in improving the performance rate. Also it is observed that there is neither a significant difference nor considerable difference between the companies with respect to the influence of the factors on the availability rate and quality rate.

6.1.2.6 **Discrimination among Public Limited Companies, Private Limited Companies and Multinational Companies**

The observations made from the study conducted to test the discrimination among public limited companies, private limited companies and multinational companies with respect to the influence of the factors on the availability rate, performance rate and quality rate using the one way ANOVA are presented in this section. A considerable difference is observed between the companies with respect to the influence of the maintenance factor on the availability rate. A significant difference is observed among the companies with respect to the influence of the maintenance factor on the performance rate. The study revealed that there is neither a significant difference nor a considerable difference among the companies with respect to the influence of
the remaining seven factors on the availability rate and also on the performance rate. Hence it is found that the maintenance factor plays a significant role in improving the availability rate and performance rate more than the other remaining factors. Also it is observed that there is neither a significant difference nor considerable difference among the companies with respect to the influence of the factors on the quality rate. Further the mean value of the maintenance factor influencing the availability rate and the maintenance factor influencing the performance rate is higher in multinational companies than in public limited companies and private limited companies. This showed the influence of maintenance factor is higher in multinational companies than in public limited companies and private limited companies.

6.2 CONCLUSION

Performance measurement, a system that consists of mechanisms, processes, and criteria has received a great amount of attention from researchers, practitioners and from industry as well. A large number of maintenance performance indicators are available for performance measurement in industries. It is observed from the literature that the Overall Equipment Effectiveness is used as a key maintenance performance indicator by the manufacturing industry. The OEE is calculated based on six major losses viz. failure losses, setup/adjustment losses, reduced speed losses, idling/minor stoppage losses, defect/rework losses, and start-up losses. It is found that the OEE is influenced greatly by factors beyond the equipment itself, including the operator, facilities, material (input items) availability, scheduling requirements, planned downtime, etc. Moreover it is found that the OEE does not take into account all the factors that reduce capacity utilization and other losses also need to be accounted appropriately for achieving world class performance. Also it is observed that an empirical study of the factors
influencing the OEE has been seldom carried out. In this study, an attempt is made to carry out an empirical investigation of the influence of various factors, viz. human factor, technical factor, production factor, maintenance factor, environmental factor, economic factor, managerial factor and organizational factor on the overall equipment effectiveness.

An empirical model is proposed to demonstrate the relationship between the various factors considered in the study and the OEE. The application of statistical methods showed that there is a positive relationship between the factors and the OEE. The significant influence of the factors on the availability rate, performance rate and quality rate in different categories of companies, and also the significant difference between the various categories of companies with respect to the influence of factors on availability rate, performance rate and quality rate are established using appropriate statistical tests.

6.3 LIMITATIONS AND SCOPE FOR FUTURE RESEARCH

A number of external factors such as the type of manufacturing environment, and products manufactured by the organization are not included in this study. The inclusion of these exogenous considerations may provide a more robust analysis of the results. While fairly strong relationships between the overall equipment effectiveness and the factors considered in the study are found, further investigation might shed more light on other factors that have an influence on the OEE. The organization size, age and a few other factors may have a greater impact on the OEE.

The identification of significant relationships between the factors and the OEE raises an important question about the link between the OEE and the manufacturing performance of the company. Further research should
address the issue of whether the influence of the various factors viz. human factor, technical factor, production factor, maintenance factor, environmental factor, economic factor, managerial factor and organizational factor on the overall equipment effectiveness has an impact on the plant performance and the manufacturing excellence of the company. This would provide the necessary insight for managers making decisions about how to incorporate these potential factors for productive maintenance to best support the overall manufacturing excellence.

This study is limited to only a small population of industries in South India. A study on a large scale can reveal much more information on the factors influencing OEE. Moreover, a limited study within an industry (say an automobile sector) producing similar products but with differing competitive priorities may also provide more details about why and how the potential factors affect OEE and in turn the manufacturing performance.

The empirical study is carried out using the data collected from the manufacturing industries. The observations made from the study may not be applicable to other types of industries. It might be useful to include firms from process industries in future studies to see if the type of industry plays a role in the influence of factors on the OEE. It might be interesting to know if different results emerge depending on the type of industry.

The study revealed that the factors considered have a significant influence on the availability rate, performance rate and quality rate. However the study did not consider determination of the level of influence of these factors on the OEE. The study did not attempt to identify the most influencing factor and the least influencing factor with respect to availability rate, performance rate and quality rate.
Also the reasons for the variation in the influence of factors on the availability rate, performance rate and quality rate while comparing different groups of companies are not studied. Hence a study can be carried out to determine the possible causes for the variation. The study assumed equal importance for the elements in each factor, but the relative importance of each element may differ. A weightage for the element under each factor may also be considered and the effect of this on the impact on OEE may be studied.