Identification of Improvement Factors through Overall Equipment Effectiveness (OEE) Measurement in Manufacturing Company

Chong Chi Xin
Yunos bin Ngadiman
Faculty of Technology Management and Business
Universiti Tun Hussein Onn Malaysia
ap130422.siswa@uthm.edu.my

Abstract: This study intended to apply Overall Equipment Effectiveness (OEE) as a performance measurement tool to measure the effectiveness and performance of the production machines in the selected industrial manufacturing plant. For the purpose of this study, three production machines were selected from Company V which situated in the Senai industrial area from Johor Bahru. Apart from this, the issues and improvement factors affecting the OEE figures were discussed as part of the findings. A case study approach was chosen to conduct the study. This study employed quantitative method to conduct the analysis part of the study where empirical data will be computed to provide typical information for decision making. The primary findings of this study were the possible improvement factors that dominantly affect the equipment effectiveness of production machines in the selected industrial manufacturing plant. These findings were used to serve as a guideline to improve the existing problem for the selected production machines. The expected of result will be identify improvement factor based on the lowest performance rating of production machines. Ultimately, it was recommended that the selected industrial manufacturing plant employs OEE as their primary performance measurement tool.

Keywords: Overall Equipment Effectiveness, performance measurement tool, manufacturing company.

1.0 INTRODUCTION

Industrial manufacturing has gradually taken over traditional business and expanded it to mass produce and dominate the local economy and eventually the global economy. According to Huang et al. (2003), due to intense global competition, companies are striving to improve and optimize their productivity in order to remain competitive. Fleischer et al. (2006) stated that the competitiveness of manufacturing companies depends on the availability and productivity of their production facilities. The manufacturers have to identify the production losses and eliminate them in order to remain competitive. The condition has triggered the need for a rigorously defined performance measurement system that is able to take into account different essential components of productivity in a manufacturing process.

Nakajima (1988) had launched a total productive maintenance (TPM) concept to offer a quantitative metric namely the Overall Equipment Effectiveness (OEE) for measuring productivity of individual equipment in a manufacturing plant. The quantitative metric (OEE) can identifies and measures losses of crucial parts in a manufacturing process namely the availability rate, performance rate and quality rate. The measurement taking account of these three essential elements of a manufacturing process evaluates and indicates how effectively a manufacturing operation is utilized. The evaluation supports the betterment of equipment effectiveness and its productivity. Huang et al. (2003) stated that the OEE concept is becoming increasingly popular and has been widely utilized in industries over the world as a quantitative tool essential for measurement of productivity especially in the semiconductor manufacturing operations. Manufacturers in other industries have also employed OEE as a quantitative measurement tool to improve their total asset utilization.

Therefore I choose OEE as my study field to measure the effectiveness of the production machines of an industrial manufacturing plant. The result of OEE can evaluate the plant’s current performance and from there we can seek for the improvement factor.
1.1 Background of Study

According to Malaysian Industrial Development Authority (MIDA, 2005), manufacturing is the largest economic drive in Malaysian industrial development constituting 32% of overall economic and specifically 79% of the total exports to other countries in comparison to other contributing sectors. Referring to the same source, Malaysia is reported as one of the world’s largest exporters of electronic and semiconductors components. Achievement for better economic pursuit in Malaysia is greatly influenced by manufacturing industries and hence, focuses and attention should be allocated for the company to further improve and maintain the development.

In conjunction with the stated report that electronic products is Malaysia most dominant manufacturing company for exporting, Company V has been chosen for this study. Company V is situated in the Senai industrial area from Johor Bahru. The company specialist in Plastic Injection Molding(one of the largest in the region), Plastic Secondary Finishing, Tools design and fabrication, PCB assembly via Surface Mount Technology(SMT), Auto Insertion(AI), Chips on Board(COB), Manual Insertion(MI), Final Product Box Build having the same capability like any world renowned Electronic Manufacturing Services companies.

1.2 Problem Statement

According to preliminary study noted that OEE began to be recognized as a fundamental method for measuring plant performance in the late 1980s and early 1990s during the emergence of maintenance benchmarking, introduction of Total Productive Maintenance and the founding of the Society for Maintenance Reliability Professionals. It can be implied that OEE is still unfamiliar with for those company in Malaysia and majority of Malaysia company did not even practice OEE. As Malaysia is growing rapidly towards industrialization, it is very important to implement an effective method to improve the productivity and contributes to the growth of industries. The implementation of OEE has to see their predominant factors that exist to affect the utilization of the industrial manufacturing’s plant’s overall equipment. As to achieve high utilization or effectiveness of the overall equipments in an industrial manufacturing plant, a series of factors has to be identified.

An interview has been conducted with the production manager of few company to identify the problem related to production machines. From the feedback I noticed that Company D, Company S and Company V having the issue related to production persists. According to the production manager, Company V does face some productivity issues recent months. Few operating machines do not achieve the expected productivity level. The production manager also stated the need for the immediate identification of the root cause that impede the productivity. Hence, OEE was selected as an appropriate performance measure to identify the losses in the current operations.

1.3 Study Question

1. How to identify the current performance and effectiveness of a manufacturing company’s production machines?
2. What causes the fluctuation of the Overall Equipment Effectiveness of a manufacturing company?

1.4 Objectives of Study

1. To identify the current performance and effectiveness of a manufacturing company’s production machines through Overall Equipment Effectiveness measurement.
2. To identify the improvement factors through Overall Equipment Effectiveness of a manufacturing company

1.5 Scope of Study

A manufacturing company has been selected to carry out this study as suggested by final year project title: Identification of Improvement Factor Through Overall Equipment Effectiveness (OEE) Measurement in Manufacturing Company. The company selected for this study is
located in Senai industrial area from Johor Bahru. The reason is because time constraints and financial constraints of the study are nearer to my hometown Kulai. The study is focused on the production machine effectiveness related to the production. The findings obtained from the study are not generalizable and can only be recommended as a suggestion to the selected plant.

1.6 Significance of Study

This study applied the use of Overall Equipment Effectiveness extensively to play as a performance indicator measurement tool and also to identify the improvement factors of the production machines in an industrial manufacturing plant. The study is to showcase the practicability of OEE in measuring a plant’s performance and outline the capability and usefulness of OEE as a benchmark tool for continuous improvement. As studied, OEE provides clear visibility on the performance status in a manufacturing plant and a powerful lever of control. Thus, it is hoped through the comprehension of this study, the selected company will apply OEE in their manufacturing plant for a better measurement of performance. It is also hoped that the findings of the study provides a potential guideline or suggestion to the studied plant to improve its equipment effectiveness and efficiency. Lastly, the study is hoped to be used as a reference or guideline to other manufacturing plant and also a source for future study in relevant fields of OEE. It is hoped that this study on OEE contributes to the library of knowledge relative to OEE and will be embodied as a part into the body of knowledge or the mass collection of literatures of this context since there are less study on this context being conducted in Malaysia.

2.0 LITERATURE REVIEW

In this chapter, information or literature related to Overall Equipment Effectiveness (OEE) has been reviewed thoroughly for a clear and comprehensive understanding of the OEE measurement itself. This chapter reviews the overview of OEE, the purpose of OEE, the chronic and sporadic disturbances in the measurement, the six big losses and taxonomy of OEE, the components in OEE measurement and the example of calculation, the ideal OEE figure, the 1% OEE improvement effect and the previous study done. The reviews provide extensive knowledge related to OEE from the development of OEE as a measurement tool to its theoretical concept to its application and functions in company.

2.1 Overview of OEE

OEE measurement tool was developed from the Total Productive Maintenance (TPM) concept launched by Nakajima (1988). OEE is defined as a measure of total equipment performance, which is the degree to which the equipment is doing what it is supposed to do (Williamson R.M., 2006). Bulent Dal, et al (2000) stated that OEE is used for tracing and tracking improvements or regression in equipment effectiveness over a period of time. Production losses, together with other indirect and hidden costs, constitute the majority of the total production costs (Ericsson J., 1997). Nakajima (1988) suggests that OEE was a measure that attempts to reveal these hidden costs.

2.2 Purpose of OEE

The OEE measurement can be applied at several different levels within a manufacturing environment. Firstly, OEE can be used as a benchmark for measuring the initial performance of a manufacturing plant in its entirety. In this manner the initial OEE measure can be compared with future OEE values, thus quantifying the level of improvement made. Secondly an OEE value, calculated for one manufacturing line can be used to compare line performance across the factory, thereby highlighting any poor line performance. Thirdly, if the machines process work individually, an OEE measurement can identify which machine performance is worst, and therefore indicate where to focus TPM resources (Bulent Dal, et al, 2000).

2.3 Chronic and Sporadic Disturbances

Losses are caused by activities that absorb resources but create no value. Therefore, it is crucial to understand and measure disturbances to the manufacturing process (Bulent Dal, et al, 2000). Johnson and Lesshammar (1999) stated that the losses are due to manufacturing disturbance and classify the disturbance as either chronic or...
sporadic according to their frequency of occurrence. Chronic disturbances are defined as small, hidden and are as an outcome of several concurrent causes. On the other hand, sporadic disturbances are more significant as they quickly and have large deviations from the normal state. Sporadic disturbances are more significant as they occur quickly and as large deviations from the normal state. Sporadic disturbances occur irregularly and their dramatic effects are often considered to lead to serious problems. However, research evidence suggests that it is the chronic disturbances that result in the low utilization of equipment and large costs because they occur repeatedly (Nakajima, 1988).

2.4 The Six Big Losses

As discussed, OEE was designated to identify these losses. It is essentially a bottom-up approach where an integrated workforce strives to achieve OEE by eliminating the six big losses (Nakajima, 1988). The six big losses are categorized as breakdown, waiting, minor stoppages, reduced speed, quality defects and start-up losses. Breakdown and waiting are downtime losses considered for availability rate, minor stoppages and reduced speed are speed losses considered for performance rate and quality defects and start-up losses are quality losses considered for quality rate.

2.5 Components in OEE

\[ OEE = Availability \times Performance \times Quality \]

Availability refers to the machine or cell being available for production when scheduled. Availability component in OEE measurement is concerned with the total stoppage time resulting from unscheduled downtime, process set-up and changeovers, and other unplanned stoppages (Bulent Dal et al, 2000).

\[ Availability = \frac{Actual\ Operating\ Time}{Planned\ Operating\ Time} \times 100 \]

Performance rate takes speed loss into account which includes all factors that caused the process of the equipment to operate less than the optimum speed. Performance is determined by how much waste is created through running at less than optimal speed.

\[ Performance = \frac{Actual\ Speed}{Theoretical\ Speed} \times 100 \]

Quality rate in OEE measurement takes account of quality loss. Quality loss as defined in the literature is the factors that produced pieces that do not meet the quality standards, including pieces that require rework.

\[ Quality = \frac{Units\ produced - Units\ scrapped}{Units\ produced} \]

**2.6 Ideal OEE Figure**

Nakajima (1988) suggested that ideal values for the OEE component measures are: i. Availability in excess of 90 percent; ii. Performance efficient in excess of 95 percent; iii. Quality in excess of 99 percent. Such levels of availability, performance and quality as suggested would result an ideal OEE scores of approximately 85 percent. The literature concerning appropriate levels of availability, performance and quality is vaguely defined (Bulent Dal, et al, 2000).

**2.7 The 1% OEE Effect**

From the table, the 1% increase of OEE can generate an extra RM 179 per hour rate. From another perspective, it can be viewed as a reduce in loss due to waste by RM 179 per hour rate, which is RM1,432 for an eight hour shift per day, and a sum of RM 7,160 reduction in loss for a week.

**2.8Previous Study**

Yunos et al (2011) successfully developed a practical new approach named the Overall Equipment Efficiency on the basis of Overall Equipment Effectiveness to measure the
performance efficiency of the high capital equipment purchased in public universities in Malaysia.

Ir. K. Batumalay and Dr A. S. Santhappraj conducted a research on applying OEE through TPM in Malaysia. The outcome of the research shows the predominant TPM pillars (autonomous maintenance, focussed maintenance, planned maintenance, quality maintenance, training & education, safety, health & environment, office TPM, and development management) indeed has impact on the OEE.

Bulent Dal et al (2000) present a practical analysis of operational performance measurement at airbags international Ltd (AIL) with OEE. The researchers discussed the potential benefits of developing OEE as an operational measure and contrasts AIL’s performance with other application of OEE. The adoption of OEE as the primary performance measure for the weaving department at AIL has highlighted a number of weakness. Utilizing OEE, both the operators and management became fully aware of what constitutes waste, and how such activities could be controlled and managed more effectively.

C.J. Barner et al (2003) defined OEE and explore the purpose of this concept in modern operations. Their work discussed OEE as a total measure of performance that relates the availability of the process to the productivity and quality of the product. In their research, they also stated that the concept of OEE was appropriate to all operations containing plant and machinery. It was discussed that OEE can be used with an internally focused benchmark where an organization set improvement objectives. The research has shown that the most successful method of employing OEE is to use cross-functional teams aimed at improving the competitiveness of business.

Lastly will be the research conducted by Ki Young Jeong and Don T. Philips (2001) presenting a methodology for constructing a data collection system and developing the total productivity improvement visibility system to implement the proposal OEE and related analyses. In the research, it is stated that accurate estimation of equipment utilization is very important in capital-intensive company since the identification and analysis of hidden time losses are initiated from these estimates.

3.0 METHODOLOGY

Methodology was performed to ensure that all the data and information obtained during the data collection phase were suitable to meet the requirement of the study objectives. A case study protocol was structured in this chapter as a guideline to conduct the overall flow of the study. The protocol is to be created prior to the data collection in a single case study. Robert K. Yin (2003) presented the protocol as a major component in asserting the reliability of the case study. A typical protocol should have the following sections:

- An overview of the case study (Objectives, issues, literature review)
- Field procedures (credentials and access to sites and sources of information)
- Case study questions (Specific questions that the investigator must keep in mind during data collection)
- A guide for case study report (Outline, format for the narrative)

3.1 Study Design

The purpose of research design is to answer the research questions where every method has a special feature of technical and data analysis (Mohamad Najib, 1999). This study was attempted to provide an independent assessment of the applicability of OEE as a performance measure in an industrial manufacturing plant. Therefore, a case study approach is appropriate and chosen as the study design. Robert K. Yin (2003) noted that case studies are suitable to obtain the real data or collect information through interactive methods to achieve the objectives and answers to the research questions.

This study utilized quantitative method in the data analysis. Prior to the analysis, data collected were in two forms, primary and secondary data. Primary data was obtained by conducting cordial interview with the production manager to acquire more knowledge on the issues occurred in the production machines while secondary data collected were such as production times, production downtime, preventive
maintenance duration and other required data in the OEE measurement.

3.2 Case Study Protocol

The case study protocol constructed is to ensure the process of the study to conduct smoothly. Each item in the flow depends on the successful completion of the previous item. It is therefore important not to skip a single step to ensure the successfulness of the study. The list of items in case study protocol in sequence:

1. Preliminary interview with the production manager
2. Identify objective and scope of research
3. Literature review
4. Data collection – Primary data and secondary data
5. Data analysis – Quantitative analysis using Microsoft Excel
6. Discussion and conclusion

3.3 Interview

The interview is a two-way conversation that gives the interviewer the opportunity to participate actively in the interview (Robert K. Yin, 2003). Interview is one of the most important sources of case study evidence. The interview can focus more directly on areas that are related, at the same time being insightful and providing perceived causal inference.

The respondent that involved in the interview section was the production manager. Selected interviewee was considered to be involved in the performance measurement process and operation process of Company V. The type of interview was face to face interview which involved direct meeting with the interviewee. It was an unstructured interview which is informal and do not offer a limited, pre-set range of answers for a respondent to choose. The questions were adapted to meet the respondent's intelligence, understanding or belief. Through the process of interview, the issues or problems existed in Company V and the operations of the selected production machines were better understood.

3.4 Secondary Data

<table>
<thead>
<tr>
<th>Working hours</th>
<th>The number of working hours as according to full work schedule. The full work schedule consists of working hours for different shifts and days of operation.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of units produced</td>
<td>The number of units produced per week.</td>
</tr>
<tr>
<td>Planned Downtime</td>
<td>Planned downtime includes time for rest interval, planned maintenance activities, waiting or idling time and initial testing time.</td>
</tr>
<tr>
<td>Unplanned Downtime</td>
<td>Unplanned downtime includes stoppage time due to unexpected events and changeover and set-up time.</td>
</tr>
<tr>
<td>Machine Time</td>
<td>The length of time for production machine to produce each time.</td>
</tr>
<tr>
<td>Units scrapped</td>
<td>Quantity of defect products per week</td>
</tr>
</tbody>
</table>

The data collected from Company V were as categorized in the table above. Much of the data obtained were not suitable for direct application into the OEE formula and needed to be reconfigured in order to be useful for OEE measurement.

3.5 Data Analysis

A spreadsheet was prepared to simplify the OEE calculation. The spreadsheet was designed to follow the production process of the machine from beginning till end listing the potentially lead to losses. The four week’s data for each production machine A, B and C were entered into the spreadsheet which includes:

- Total shift time per day (min) □
- Machine time (sec) □
- Days of operation per week □
- Units produced (units) □
- Rest Interval (min) □
- Maintenance activities (min) □
- Waiting/idling time (min) □
- Initial testing time (min) □
- Stoppage time (min) □
- Changeover and set-up time (min)
- Actual operating time (min) □
- Planned operating time (min) □
- Actual output (units/hour) □
- Theoretical output (units/hour) □
- Units scrapped (units) □
There were a series of fixed reports that have been generated from the spreadsheet. The reports consist of availability analysis report, performance analysis report, quality analysis report and OEE analysis report. Graphical representations of the data were created to display a clearer picture of the three specific machines’ performance in Company V.

4.0 REFERENCES


Chan Joo Sheng (2013) A Study of The Factors Affecting The Overall Equipment Effectiveness (OEE) in An Industrial Manufacturing Plant


Yunos et al (2012) A study of total productive maintenance implementation in manufacturing industry

Yunos et al (2013) Exploring The Overall Equipment Effectiveness (OEE) In An Industrial Manufacturing Plant


Yunos et al (2015) Quantification of machine performance through overall equipment effectiveness