UNIVERSITI TEKNIKAL MALAYSIA MELAKA

PLANNED YIELD, TIME YIELD AND SIMPLE YIELD METHODS TO CALCULATE OEE METRIC IN SEMICONDUCTOR COMPANY

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing Engineering (Manufacturing Management) with Honors

by

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APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering (Manufacturing Management) (Hons.). The member of the supervisory is as follow:

……………………………….

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ABSTRAK

Dalam persekitaran business yang berdaya saing, organisasi yang baik dan berterusan mampu menambahbaikan kapabiliti pengeluaran untuk mewujudkan nilai yang cemerlang kepada pelanggan dengan meningkatkan kos keberkesanaan operasi. „Overall equipment effectiveness (OEE)" digunakan di organisasi untuk mengukur keberkesanan peralatan atau proses pengeluaran. Projek penyelidikan ini dijalankan di sebuah syarikat semikonduktor yang terletak di Melaka. Syarikat kes merancang untuk meningkatkan parameter kualiti untuk kekal berdaya saing dalam pasaran global. Pada masa sekarang, syarikat tersebut menggunakan kaedah hasil yang dirancang untuk mengira parameter kualiti. Syarikat perlu mengesahkan ketepatan kaedah semasa dan mengenalpasti kaedah yang lebih baik, jika ada, untuk mengira OEE. Tujuan kajian ini adalah untuk meningkatkan parameter kualiti dalam OEE metrik dengan mengenal pasti punca-punca yang menyumbang kepada kerugian dalam parameter kualiti; untuk mengesahkan kaedah hasil yang dirancang dengan menggunakan kaedah hasil yang mudah dan kaedah hasil masa dan mencadangkan penyelesaian yang sesuai kepada syarikat kes bagi peningkatan dalam parameter kualiti. Projek penyelidikan ini akan fokus kepada faktor kualiti di bahagian pengeluaran TSLP. Dalam usaha untuk mencapai objektif, faktor-faktor yang menyumbang kepada kehilangan kualiti telah dikenal pasti dan beberapa idea telah dicadangkan untuk mengurangkan sekerap dan kerja semula. Parameter kualiti bertambah baik sebanyak 0.1% berdasarkan satu minggu kajian awal mengenai peningkatan yang disyorkan. Ketiga-tiga kaedah untuk mengira parameter kualiti dalam OEE metrik telah disahkan dengan F-ujian.

ABSTRACT

In this highly competitive business environment, well run organizations continually strive to enhance their capabilities to create excellent value for the customers by improving the cost effectiveness of the operations. Overall equipment effectiveness (OEE) is employed in organizations to measure the effectiveness of equipment or a production line. This study is conducted at a semiconductor company located at Melaka. The case company plans to improve the quality parameter to stay competitive in the global market. Currently, planned yield figure is employed by case company to calculate the quality parameter. The company needs to validate the accuracy of the current method and to identify better methods, if any, to calculate OEE. The aim of this study is to improve the quality parameter in OEE metric by identifying the causes that contribute to the loss in quality parameter; to validate the planned yield method by using simple yield method and time yield method and propose feasible solutions to the case company for the improvement in quality parameter. This study will only focus on the quality factor in TSLP production line. In order to achieve the objectives, the major factors that contributed to quality loss were identified and several ideas were suggested in order to reduce scrap and rework. The quality parameter had improved by 0.1% based on one week preliminary study regarding the suggested improvement. The three methods to calculate the quality parameter in OEE metric were validated with F-test.

DEDICATION

This thesis is especially dedicated to my beloved family members and friends.
Thank you for the relentless support and love to me.

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TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURES

A	-	Availability
Al	-	Aluminium
Au	-	Gold
CM	-	Corrective Maintenance
DUT	-	Device under test
EOL	-	End of Line
FOL	-	Front of Line
FYP 1	-	Final Year Project 1
FYP 2	-	Final Year Project 2
JIPM	-	Japan Institute of Plant Maintenance
MP	-	Maintenance Prevention
MSP	-	Mark Scan Pack
OEE	-	Overall Equipment Efficiency
P	-	Performance
PdM	-	Predictive Maintenance
PM	-	Preventive Maintenance
PMS	-	Production Monitoring System
PrM	-	Productive Maintenance
Q	-	Quality
RCM	-	Reliability Centred Maintenance
SMED	-	Single Minute Exchange of Die
TPM	-	Total Productive Maintenance
TQM	-	Total Quality Management
TSLP	-	Thin Small Leadless Package

CHAPTER 1

INTRODUCTION

This chapter provides the background of the study which includes information on the case company. The problem statement is then presented on the issues and purpose of investigating the quality parameter in the Overall Equipment Efficiency (OEE) calculation employed in the company. The objectives are next defined followed by the scope which sets of the boundaries and limitations of the study. Finally the significance of the study and organization of this report are provided at the end of this chapter.

1.1 Background of Study

Over the past twenty years, the Malaysian manufacturing sector has achieved outstanding performance in contributing to the nation‟s gross domestic product growth and successfully attracted a massive amount of foreign direct investment to this country (Chan, 2009).

To gain competitive advantage, manufacturing organizations began to adopt productivity enhancement programmes like Total Quality Management (TQM) and Total Productive Maintenance (TPM) in order to achieve operational excellence (Tu *et al.*, 2001). TPM has proved to be the maintenance improvement philosophy in order to prevent the failure of an organization (Eti *et al.*, 2006). According to Gosavi (2006), the implementation of TPM is to reduce unexpected machine breakdowns that disrupt production and lead to losses which can exceed millions of dollars annually. In the existing system, overall equipment effectiveness (OEE), a quantitative metric, has been used for measuring implementation effectiveness of TPM (Pophaley, 2010). Huang *et al.* (2002) reported that OEE has been widely utilized in industries over the world as a quantitative tool essential in measuring the performance of equipment within a production system, especially in the semiconductor manufacturing operations.

OEE is a performance measurement which consists of three parameters, availability, performance and quality (Jonsson and Lesshammar, 1999). Table 1.1 depicts the calculations for the three parameters of OEE. A minimum score of 90% in availability, 95% in performance and 99% in quality is needed to reach the world class OEE score which is 85%. This benchmark was set by the founder of OEE, Nakajima (1988).

Table 1.1: Calculation of OEE parameters (Nakajima, 1988)

Availability (A)	$\frac{Loading\ time - Downtime}{Loading\ time}$
Performance (P)	$\frac{Ideal\ cycle\ time \times Output}{Operating\ time}$
Quality (Q)	$\frac{Total\ units\ processed - Rejects}{Total\ units\ processed}$
OEE	$A \times P \times Q$

However, the calculation of these parameters is based on basic definitions and methods. There are different ways of calculating the parameters of OEE and several modifications have been made to the equations by other companies, this may not provide an accurate value for the OEE metric. If the performance measures of the equipment are not the suitable one, the set point of benchmark value may be wrong and, as a result, the control or improvement will not perform satisfactorily.

1.2 Background of Case Company

This study was conducted in a multinational semiconductor manufacturer company located in Melaka while the case company headquarter is located at German. Melaka is one of the backend production sites of the case company with accumulative investments of more than RM6 billion. Backend production is the back portion of a semiconductor supply chain with assembly and testing facilities. In the year 2013, the case company has about 30,000 employees worldwide.

The case company provides semiconductor and system solution for automotive industry and electronics industry. Discrete Semiconductors, Power Semiconductors, Logic products and Sensor products are four main product produced by the company. The product application includes wireless communication and secure mobile solution, chip card as well as memory products. The products from the case company always stand out for their reliability, excellence quality and their innovative. Hence, the case company becomes one of the top 20 semiconductor sales leader in the world. Furthermore, the case company enjoys a global presence in Europe, North America, Asia and Japan.

The case company always wants to create and market the most advanced microelectronic products in order to survive in this competitive world. The goal of case company is to maximize value for their customers, employees and shareholder. They built upon out of technological strength to offer their customers a wide range of leading edge solution emphasizing communication, computer, chip card and automotive applications. They attract the best talent worldwide and translate advanced technologies into value for their customers and stakeholders.

1.3 Problem Statement

The case company has achieved 78% in OEE which has not reached the acceptable world-class standard, which is 85%. Hence, they desire to improve the OEE by 1%. In order to achieve this, the case company plans to improve the quality parameter to stay competitive in the global market. Currently, planned yield figure is employed to calculate the OEE. The company needs to validate the accuracy of the current method and to identify better methods, if any, to calculate OEE.

1.4 Objectives

The main aim of the study is to improve the quality parameter in OEE metric through the following objectives:

i. To identify the causes that contribute to the loss in quality parameter.
ii. To validate planned yield method by using time yield method and simple yield method.
iii. To propose feasible solutions to case company for the improvement in quality parameter.

1.5 Scope

This project mainly focused on the quality parameter in improving the overall equipment effectiveness in die bonding process. This study was conducted in Discrete Department. It focused on 20 die bond machines which are the Thin Small Leadless Package (TSLP) production line. Improvements on availability and performance parameters were not included in the scope of this project.

1.6 Significance of Study

Key benefit of this study was to improve the quality parameter so that the OEE metric was increased. This study helped to identify the causes that contributed to the quality loss in die bonding process and actions could be taken to solve the problems. By minimizing the causes that lead to quality problem, the machines could produce more parts that meet the quality specifications. In other words, quality parameter had increased when the scrap or rework is reduced.

1.7 Organization

It includes five chapters in this research study. The report is structured as below:

Chapter 1 includes a general introduction of background study followed by background of case company. This chapter also encompasses problem statement, objectives, scope of study and lastly the significance of the study.

Chapter 2 presents the literature review which includes total productive maintenance and overall equipment effectiveness (OEE) and application of OEE in industry according to journals, articles, books and other resources. It contains a thorough research of all types of published work so that how much work has been done or is currently being done can be determined.

Chapter 3 provides an overview of research methodology and describes the appropriate method chosen to carry out the study. Fundamental approach is taken in order to achieve the objectives of the project.

Chapter 4 discusses about the data collection and analysis of the study. The collected data are exhibited in this chapter followed by discussion associated with the results obtained. This chapter also includes the suggested actions to improve the quality parameter.

Chapter 5 concludes the findings of the study based on the results and discussions obtained in previous chapter. Recommendation for future research is also presented in this chapter.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction to TPM

Total Productive Maintenance (TPM) is a philosophy of continuous improvement and designed to optimize the reliability of equipment where team work is required to focus on how to sustain the basic condition of machine in order to lengthen the machine‟s life span (Ahuja and Khamba, 2008). The concept of productivity can be enhanced by daily inspection, parts replacement, trouble shooting, and accuracy checks on worker‟s own equipment is emphasised in TPM (Nhalbathi and Kholopane, 2013). TPM is a long term programme which involves operators, maintenance workers, management and entire organization to keep the machines run smoothly and optimizes equipment effectiveness.

Traced back to 1951, TPM is an evolving Japanese concept since preventive maintenance was introduced to Japanese. Conversely, the conception of preventive maintenance originated form USA in 1960s. Nippon Denso, part of Toyota, was the pioneer in introducing plant wide preventive maintenance and got great success in 1981 which was spread worldwide from then on.

The TPM literature has a number of definitions for Total Productive Maintenance.

- "Total Productive Maintenance permanently improves the overall effectiveness of equipment with the active involvement of operators." (Hartmann, 1992)
- "TPM is a methodology and philosophy of strategic equipment management focused on the goal of building product quality by maximizing effectiveness.

It embraces the concept of continuous improvement and total participation by all employees and by all departments." (Society of Manufacturing Engineers, 1995)

- "TPM is a program that addresses equipment maintenance through a comprehensive productive maintenance delivery system covering the entire life of the equipment and involving all employees from production and maintenance personnel to top management." (McKone *et al.*, 1999)
- "Total Productive Maintenance is an innovative approach to maintenance that optimizes equipment effectiveness, eliminates breakdowns and promotes autonomous maintenance by operators through day-to-day activities involving total workforce." (Bhadury, 2000)
- "TPM is a people-intensive, preventive maintenance system for maximizing equipment effectiveness and which involves all departments and functions in the organization." (Jeong and Philips, 2001)
- "TPM as a manufacturing initiative for optimizing the effectiveness of equipment by focusing on entire life of the machine, which involving all the contributors through active participation and teaming, making the operators the first line of defence against deterioration through autonomous maintenance." (Chen and Meng, 2011)
- "TPM is an effective tool for the minimization of downtime of machines, production losses and material scraps and for improving the working efficiency and productivity of employees and equipment." (Jain *et al.*, 2014)

According to Bamber *et al.* (1999), Japanese Approach and Western Approach are the two main approaches that define TPM. The Japanese Approach put emphasis on the function of co-partnership, events of small group and the involvement of all workforces in the TPM process to achieve objectives of equipment improvement; whereas the Western approach puts more concentration on the machine where operator"s involvement and participation are required (Pomorski, 2004).

"The core objective of an effective TPM initiative is to bring critical maintenance skilled employments and production workers together" (Labib, 1999). Willmott (1994) has stated that there are three vital aims of TPM, which are zero breakdowns, zero defects and zero accidents. The unexpected failure of equipment can be minimized by the implementation of TPM.

By implementing TPM, the two parts of organization which are production unit and maintenance unit should work cooperatively. The execution of TPM will enhance productivity within the entire organization where by the equipment‟s condition is at optimum level that ensures high level of availability (Chen and Meng, 2011). Robert (2002) concluded that maintenance should no longer be considered as an activity which had no profit; maintenance should be treated as a necessary and extremely essential part of the business. Thus, implementing TPM can minimize the frequency of unscheduled breakdown and to ensure machines can produce quality goods at a desired production rate.

TPM is a manufacturing-led initiative that gives emphasis to employee involvement with continual improvement attitude and the maintenance and production personnel are working dependently in unison. Swanson (2001) described that training the employee, involvement of operator, teamwork and preventive maintenance are the four key components of TPM. In short, TPM strive for integrating the organisation to distinguish and utilise its own potential and skills and to retain the equipment in good condition without affecting the manufacturing operation. Therefore, the paradigm shifts of TPM are from being reactive to being proactive to ensure the equipment is sustained in optimal condition all the times.

2.1.1 Evolution toward TPM

Maintenance of equipment must be done cautiously and in a timely routine to prevent machine breakdown. If one machine breaks down, the entire production line will be affected. Over the last three decades, the maintenance function has undergone evolution. The maintenance function is also known as a physical asset management (Jain *et al.*, 2014). The type of maintenance concept is clarified in Table 2.1.

Table 2.1: Types of maintenance

Breakdown Maintenance	It is the maintenance strategy that repairs the failure equipment but does not significantly affect the production. Prior to 1950, worldwide manufacturing organization adopted this maintenance strategy. According to Telang (1998), the disadvantages of this concept are there would be unexpected stoppages, excessive damage, problems of spare parts and troubleshooting, expensive repair costs, and lastly excessive maintenance time.
Preventive Maintenance (PM)	Also known as Time Based Maintenance. Scheduling maintenance was presented in 1951 to prevent equipment breaks down and prolongs the service life of equipment. The probability of equipment performance deterioration is estimated within a particular time interval and PM relies on this estimation for maintenance activities. The maintenance work includes replacement of parts, lubrication of equipment, cleaning, and adjustment of bolts and nuts. The sign of deterioration of the production equipment is inspected throughout PM (Telang, 1998).
Predictive maintenance (PdM)	Also known as Condition Based Maintenance. The maintenance is used to predict the life of critical equipment components and replacing them. "Measurement of the physical condition of equipment encompasses temperature, noise, vibration, lubrication and corrosion are deployed in the diagnostic techniques" (Brook, 1998), which will result in cost avoidance. In order to stay competitive, organizations must employ PdM instead of Time Based Maintenance for the equipment that causes the loss of production if there is occurrence of breakdown (Brook, 1998).
Corrective maintenance (CM)	This maintenance strategy was primarily employed to prevent failure of equipment. It is then further expanded to be adopted to the improvement of equipment in order to enhance equipment performance and reliability. The corrective

	maintenance will provide helpful information in maintenance prevention for the new equipment and enhancement of currently existing manufacturing facilities.
Maintenance Prevention (MP)	This strategy was announced in 1960s where the designs of equipment are maintenance free. The maintenance prevention initiatives must begin at the design stage during development of new equipment. The aim of MP is to ensure the reliability of equipment and user friendly so that operators can handle and operate the equipment easily. The earlier equipment failures are the response from the production areas, clients and marketing department. To ensure a process for new manufacturing system which is hassle free, the feedbacks are important.
Reliability centered maintenance (RCM)	This maintenance was first initiated in 1960s but was predominantly focused on airplane maintenance and used by aircraft companies and government accommodations. The maintenance demands of any physical asset in its operational perspective are determined using RCM, a logical seven steps process. "RCM involves determining what must be done to ensure that every physical component continues to perform in the way that its user wants to do" (Eti, Ogaji and Probert, 2006). The lists of maintenance actions and schedule are the output for the study of RCM in an equipment system which employed to increase the availability, operating performance and reliability of machine and reduction in cost of maintenance (Eti *et al.*, 2006).
Productive maintenance (PrM)	In order to increase the equipment productivity, PrM is used to reduce the cost of total equipment for the whole life of equipment which consists of design, fabrication, maintenance and operation cost and equipment degradation cost. Reliability and maintainability of equipment are the main characteristics of PrM philosophy. PM, CM and MP are the maintenance strategies that used to improve the productivity