DECLARATION

I hereby declared this report entitled "The Application of TRIZ to Reduce Speed Loss in Semiconductor Manufacturing Industry" is the results of my own research except as cited in references.

Signature	:	
Author's Name	:	Suzanne Lim Shien Thung
Date	:	8 June 2016

APPROVAL

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

.....

(Project Supervisor)

ABSTRAK

Industri pembuatan semiconductor telah bertumpuan untuk menambahbaikan produktiviti dengan meningkatkan keberkesanan peralatan dalam persekitaran yang berdaya saing. Kajian ini dijalankan di sebuah syarikat pengeluar semikonduktor yang terletak di Melaka. Kajian ini fokus kepada mesin ujian elektrik yang merupakan mesin kesesakan dalam bahagian pengeluaran TSLP. Pada masa ini, mesin ujian elektrik menghadapi keberkesanan peralatan keseluruhan (OEE) dan prestasi mesin yang rendah disebabkan oleh masalah kehilangan kelajuan. Tujuan kajian ini adalah untuk meningkatkan prestasi OEE dan mesin dengan mengenalpastikan punca kehilangan kelajuan mesin ujian elektrik: untuk menganalisiskan data bagi penyelesaian yang boleh dilaksanakan dengan menggunakan kaedah TRIZ dan untuk mencadangkan penyelesaian bagi mengurangkan kehilangan kelajuan. Data nyata bagi 10 mesin telah dikumpulkan daripada 'Cerberus System Database'. Ishikawa Rajah dan Carta Pareto telah mengenalpastikan 9 punca kehilangan kelajuan. Hanya tiga punca yang ketara akan member tumpuan untuk memgurangkan kehilangan kelajuan iaitu ujian semula, masalah semasa tetapan lot dan perubahan parameter. Bagi memggambarkan penggunaan TRIZ, matrik percanggahan dan beberapa prinsip berdaya cipta telah digunakan untuk menjana idea penyelesaian. Empat penyelesain telah dicadangkan bagi memgurangkan kehilangan kelajuan tetapi hanya sat penyelesaian lakasana dalam syarikat iaitu tindakan pembersihan pin pogo. Kehilangan kelajuan telah menurun sebanyak 2% berdasarkan satu minggu perintis dijalankan dalam satu mesin ujian elektrik. Peningkatan OEE dalam 0.08% untuk 10 mesin boleh membawa kira-kira RM400,000 daripada keuntungan tahunan.

ABSTRACT

Semiconductor manufacturing industry concentrates to enhance the productivity by improving the equipment effectiveness under the highly competitive environment. This study was conducted in a semiconductor manufacturing company which located at Melaka. This study focused on the electrical testing machine which is the bottleneck machine in TSLP production line. Currently, the electrical testing machine is facing low overall equipment effectiveness (OEE) and low machine performance which are caused by speed loss problem. The purpose of this study is to increase the OEE and machine performance by identifying the causes of speed loss for electrical testing machine; to analyze the data for feasible solution by using TRIZ methodology and to propose solutions to reduce speed loss for electrical testing machine. The real time data for 10 electrical testing machines were collected from the Cerberus System Database. There were total 9 potential causes of speed loss that were identified using Ishikawa Diagram and Pareto Chart. Only three significant causes were focused to reduced speed loss which are retest, lot setting problem and parameter changes. To illustrate the application of TRIZ, the Contradiction Matrix and few Inventive Principles were applied in generating the solution ideas. Four solutions were proposed to reduce speed loss but only one of the solutions was implemented in the case company which is the pogo pin cleaning action. The speed loss had decreased by 2% based on one week pilot run in one of the electrical testing machine. The increase of OEE in 0.08% for 10 machines can brings approximately RM400,000 of yearly profit.

DEDICATION

This thesis is especially dedicated to my beloved family members and friends.

Thank you for the encouragement and support.

ACKNOWLEDGEMENT

First and foremost, I am highly indebted to my beloved supervisor, Associate Professor Dr. Chong Kuan Eng for his patient guidance and constant supervision as well as useful critiques throughout the project. His willingness to give his time so generously has been very much appreciated. His enthusiastic encouragement always motivates me in completing my project.

I would also like to express my deepest gratitude to my industry supervisor, Mr. Alan Ng for his advice and assistance in data collection part during the industry visit. He always enthusiastic in helping me to complete my final year project. I would like to extent my special thank to Professor Madya Norhaziah Binti Md Salleh whose guiding me in applying TRIZ methodology. Without her vital knowledge and information provided, I could not successfully solve the problem in this project. In addition, I would like to express my appreciation for the information and cooperation provided by the case company for allowing me to conduct the project over there.

Last but not least, I wish to thank my family members and friends who are direct or indirect help me in carrying out my final year project throughout the semester.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

A	-	Availability
BM	-	Breakdown Maintenance
EPT	-	Equipment Performance Tracking
FYP 1	-	Final Year Project 1
FYP 2	-	Final Year Project 2
JIPM	-	Japan Institute of Plant Maintenance
KPI	-	Key Performance Indicator
OEE	-	Overall Equipment Effectiveness
P	-	Performance
PdM	-	Predictive Maintenance
PM	-	Preventive Maintenance
Q	-	Quality
RCM	-	Reliability Centered Maintenance
SDT	-	Schedule Downtime
SMED	-	Single Minute Exchange of Dies
TFM	-	Total Fabrication Monitoring
TPM	-	Total Productive Maintenance
TSNP	-	Thin Small Non lead Package
TRIZ	-	Theory of Inventive Problem Solving
UDT	-	Unscheduled Downtime

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Semiconductor manufacturing industry competes to enhance the productivity since the concentration on rapid economy recovery impedes its development (Chamness, 2013). Generally, productivity is a measure of production efficiency that converts input to output. The semiconductor industry has undergone tremendous changes comprised of the diversity in management approaches, product and process technologies, customer prospective, supplier perspective as well as competitive behavior. The global competition among the manufacturing industries has brought to higher demands on itself over the ever-changing environment by the progressive tensioning from customers, supplier and competitors (Miyake and Enkawa, 1999). Therefore, the concentration on developing the levels of productivity is critical to meet the customer demands. In order to improve the competitiveness among the manufacturing industries, the performance improvement initiatives must be instill over all aspects of the production operations (Ben-Daya and Duffuaa, 1995).

The semiconductor manufacturing industry has been increasingly promising over the years under the highly competitive environment. The industry has grown rapidly from

over $1 billion in 1964 to $335.8 billion in 2014 (Tanner, 2015). It aims to achieve growth in terms of income and productivity. Many manufacturing industries have adopted the concept of Total Productive Maintenance (TPM) in order to attain the optimal productivity. TPM is a fundamental program for the improvement of maintenance functions in industry. TPM implementation may helps to minimize losses for up to millions dollars annually (Gosavi, 2006). Hence, TPM has been justified to improve the productivity. TPM is an approach that provides the understanding for frequency of failure of the corresponding critical equipment (Nakajima, 1988).

The productivity measurement metrics of semiconductor manufacturing industry has been a crucial research field over the years (Braglia et al., 2008). Literally, the efficiency metrics interpretation is an essential in order to achieve the effective productive process. Overall equipment effectiveness (OEE) is a measurement that used in TPM. OEE is a useful metric for equipments efficiency evaluation by comparing their particular theoretical potential. OEE measurement has been generally used in manufacturing industry as to determine the equipment performance in the production process especially in semiconductor manufacturing industry (Huang et al., 2002). There are three measurement parameters under OEE which consists of availability, performance and quality (Nakajima, 1988). Availability rate represents in percentage of the machine schedule time that available to operate. Performance rate shows the percentage in comparison between the actual and the designed speed of the equipment. Quality rate is the good part produced over the total production in percentage. The availability includes downtime loss, performance includes speed loss and quality includes quality loss.

This study focuses on equipment speed loss which is an element under machine performance. When the machine is running, but is not running at the ideal speed is called speed loss. There is a gap between the actual operating speed and ideal operating speed as the larger the gap, the larger the speed loss. Speed loss can be separated into two categories which are idling and minor stoppages and reduced operating speed. Idling and minor stoppages is anything that cause the machine stops for under five minutes. Reduced operating speed is anything that keeps the machine from running at

the maximum speed. Larger speed loss can cause low machine performance as well as low OEE score.

By adopting OEE, the real time accurate information on how well the machine operates can be shown. The information is vital to determine the opportunity for productivity improvement. It helps to emphasize and eliminate the negligible minor stoppages that slow down the machine running speed and uptime of the production line. In addition, OEE increase the return of investment (ROI) by increasing the output of production. ROI is the ratio to measure the benefit gained from an investment. High profit comes with small enhancement in OEE as 50% enhancement in ROI can be achieved by 10% increment in OEE (Hansen, 2001).

1.2 Problem Statement

This study is conducted at one of the semiconductor manufacturing industry in Melaka state. The case company provides the semiconductor and system solution for the automotive and electronics industry. There are four main products produced by the case company included the discrete semiconductor, power semiconductor, logic semiconductor and sensor semiconductor. The product applications are for wireless communications, chip card and memory products. This study focused on electrical testing machine which is the bottleneck machine in the Thin Small Leaded Package (TSLP) production line. The electrical testing machine is used to test the chips.

The electrical testing machine is currently facing low throughput and low overall equipment effectiveness (OEE). Low throughput means low productivity. When the productivity is low, it indicates that the machine is not run effectively which resulted in low machine performance. The high speed loss is identified as the main problem that causes low OEE during the testing process. Thus, the case company planned to reduce speed loss in order to increase OEE and poor machine performance. The current OEE

score of the machine is 73.8% and the targeted OEE score is 73.9% by reducing speed loss from 10.7% to 8.7% in order to gain higher productivity.

1.3 Objectives

The main aim of this study is to increase OEE and machine performance of electrical testing machine by reducing speed loss. There are three objectives that need to be achieved to complete this study:

i. To identify the causes of speed loss for electrical testing machine.
ii. To analyze the data for feasible solutions by using TRIZ methodology.
iii. To propose solutions to reduce speed loss for electrical testing machine.

1.4 Scope

This study was conducted in Discrete Department in the case company. Data is collected from 10 electrical testing machines in the Thin Small Leaded Package (TSLP) production line. The main product of the electrical testing machine is for telecommunication, automotive and consumer purpose. This study focused on equipment speed loss which under machine performance in OEE metric. The machine availability and product quality are not considered in this project.

1.5 Significance of Study

The key benefit of the study is to reduce the speed loss in order to increase OEE and machine performance. This study helps to identify the causes that contribute to the speed

loss by analyzing the data collected, and hence, come out with the problem solutions. The machine performance had increase when the speed loss is reduced. By solving the problem, the case company can gain high throughput and hence increase the company profit. Customer satisfaction will eventually increase as the customer demand is fulfilled.

1.6 Organization

The structure of the study is as follows:

Chapter 1 covers the context and factual information on the topic to be discussed. The short overview of the study is given. The specific study issues that need to be addressed are set out in the problem statement. This is followed by the objectives of the study and its scope. Finally, the significance of study is stated.

Chapter 2 presents the literature review of the study. It encompasses the total productive maintenance (TPM), overall equipment effectiveness (OEE), equipment process performance and speed loss based on the relevant written documents such as journals, articles, theses, project paper, books, internet and other resources. The summarizing and analyzing of the published work are shown in this chapter.

Chapter 3 provides outline of the methodology of the study. The detailed and precise procedural information on the data collection and interpretation approach are indicated. The information given consists of the selected method that adopted in the study.

Chapter 4 shows the results and discussion of the study. The results section reveals the collected data obtained while the discussion section analyzes and interprets the finding of the study. Some proposed solutions for equipment process performance are comprised in this chapter.

Chapter 5 gives the overall summary of the study. It summarizes the significant key findings and information in the study. It concludes the findings of the study based on the

previous chapter and underlines the main outcomes. The recommended actions to be taken based on the findings are conducted in this chapter for future research.

CHAPTER 2

LITERATURE REVIEW

2.1 Maintenance

As demonstrated by Gits (1992), maintenance can be defined as "all activities aimed at keeping an item in, or restoring it to, the physical state considered necessary for the fulfillment of its production function". The maintenance function is well known as physical asset management (Jain et al., 2015). Maintenance is the staff responsibilities and priorities as to prevent equipment problems. Generally, maintenance is activities that keep the equipment running under optimal condition (Bartz et al., 2014). Maintenance involved the person in charge to the equipment in order to predict the machine breakdown and to make improvement. It is a crucial part of strategic planning for productivity as well as elementary to equipment availability. Production equipment maintenance concerned the equipment availability and reliability and therefore increases company performance. Nevertheless, maintenance activities exist to prevent the degradation of equipment and facilities caused by its natural wear and use. Due to increased competition in the global market, company should concentrate on serving customers with world-class performance. As a result, large companies have to regulate their capacity in order to respond to new and demanding world class standards.

Currently, maintain the quality and productivity had become vision attention. Proper maintenance can improve productivity (Bartz et al., 2014).

2.1.1 Type of Maintenance

There are five main type of maintenances which are Breakdown Maintenance (BM), Preventive Maintenance (PM), Predictive Maintenance (PdM), Reliability Centered Maintenance (RCM) and Total Productive Maintenance (TPM). Each of it has its own advantages and limitations. The descriptions for each type of maintenance are shown as Table 2.1.

Table 2.1: The type of maintenance and its descriptions

Type of Maintenance	Descriptions	Advantages	Limitations
Breakdown Maintenance (BM)	-It is applied when the machine is shutdown and there is no significant effect on production process or cost (Wireman, 1991).	-The downtime and repair cost for non-critical machine are less than other type of maintenance.	-The unscheduled downtime, excessive damage, spare parts issues, high maintenance cost and long waiting and repair time (Telang, 1998).
Preventive Maintenance (PM)	-It is also known as Time Based Maintenance (TBM) (Pai, 1997). -It is routine repair activity included the machine cleaning and lubrication, spare parts replacement and adjustment and inspection process.	- It preserves the equipment health status in order to prevent machine failures (Telang, 1998). - It eliminates the machine breakdown probability and decrease the equipment deterioration level (Ahuja and Khamba, 2008).	-Damage occur when due to incorrect procedure.
Predictive	-It is also known as	- It predicts the parts	-Costly if implemented

Maintenance (PdM)	Condition Based Maintenance (CBM). - It measures and analyzes the data of machine deterioration and monitors the machine conditions by using surveillance system (Vanzile and Otis, 1992).	service life by inspection (Ahuja and Khamba, 2008) - It performs the maintenance when the need is imminent and not after the specified machine running time (Herbaty,1990).	incorrectly.
Reliability Centered Maintenance (RCM)	-It optimizes of maintenance requirement to achieve the specified level of reliability (Ahuja and Khamba, 2008). - It involves determining what must be done to ensure every physical component continues to perform in the way that its user wants to do (Eti *et al.*, 2006).	-It increases the equipment availability, performance, reliability and reduces the maintenance cost.	-High start up costs.
Total Productive Maintenance (TPM)	- It is a philosophy developed according to Productive Maintenance concept (Nakajima, 1988).	- It optimizes the equipment effectiveness, reduce breakdown, losses and cost to gain high productivity.	-Takes long time to adopt in this strategy.

2.2 Total Productive Maintenance (TPM)

In 1971, Japan has proposed and evolved the concept of Total Productive Maintenance which is well known as TPM (Nakajima, 1988). Over the last two decades, TPM approach is broadly implemented in various industries as rapid development in business environment (Eti et al., 2006). TPM is to continuously improve and optimize the