Faculty of Manufacturing Engineering

NEW OVERALL EQUIPMENT EFFECTIVENESS FRAMEWORK DEVELOPMENT WITH INTEGRATION OF MAYNARD OPERATION SEQUENCE TECHNIQUE FOR LOSSES VISUALIZATION

Yoong Sai Sieng

Master of Science in Manufacturing Engineering

2018

NEW OVERALL EQUIPMENT EFFECTIVENESS FRAMEWORK DEVELOPMENT WITH INTEGRATION OF MAYNARD OPERATION SEQUENCE TECHNIQUE FOR LOSSES VISUALIZATION

YOONG SAI SIENG

A thesis submitted
in the fulfillment of the requirements for the degree of Master of Science
in Manufacturing Engineering

Faculty of Manufacturing Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2018

DECLARATION

I declare that this thesis entitled "New Overall Equipment Effectiveness Framework Development with Integration of Maynard Operation Sequence Technique for Losses Visualization" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : …….

Name : …….

Date : …….

APPROVAL

I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of Master of Science in Manufacturing Engineering.

Signature	:	…….
Supervisor Name	:	…….
Date	:	…….

DEDICATION

Dedicated specially for my beloved family, friends, and supervisors.

ABSTRACT

Overall Equipment Effectiveness (OEE) is a performance indicator used to monitor the performance of the machine and identify the scope of improvement. It is a combination of the three main factors, availability, performance and quality. However, there are losses invisible in the OEE scale due to the low visibility. This will cause the optimization of the machine performance hardly achieved. To overcome the issue, modification needs to be done to visualize the losses in a better way. The aim of this study is to develop a new modified OEE framework to visualize the losses in a better way. This can be achieved through three objectives. The first objective is to investigate the integration of the OEE with other tools and modification of the OEE calculation. Second objective is to develop a new OEE framework to integrate MOST into OEE calculation. Third objective is to evaluate the effectiveness of new OEE framework in visualise losses by comparing with general OEE. Literature review is done on the integration of the OEE with other tools and also the modification that has been done on the OEE. It showed the integration of the OEE and modification on the OEE are based on the specific requirements or purposes. Next, two new equations, usability and human factor are developed to integrate the MOST into the OEE calculation. The usability is used to quantify the frequency of the setup and changeover process and human factor is indicates the human losses that occupy the available time of the machine. Finally, new modified OEE level and general OEE level are calculated by the real data taken from a wire bond machine in the studied company. The data is taken for 35 days. The outcome of the study shows the new modified OEE able to visualize the losses and show the area of improvement. Although the OEE level is same for both OEE calculations but the new modified OEE quantify the losses in a better visualization. It is beneficial for the user to identify the area of improvement correctly and monitor the losses easily. It is expected to implement in various kinds of industry to evaluate the application of the new modified OEE.

ABSTRAK

Keberkesanan Peralatan Keseluruhan (OEE) adalah satu petunjuk prestasi yang digunakan dalam memantau prestasi mesin dan mengenal pasti skop penambahbaikan. Ia adalah gabungan tiga faktor-faktor utama iaitu ketersediaan, prestasi dan kualiti. Walaubagaimanapun, terdapat kerugian yang tidak dapat dilihat dalam skala OEE disebabkan oleh keterlihatan yang rendah. Ini akan menyebabkan optimasi mesin susah untuk dicapai. Untuk mengatasi masalah ini, pengubahsuaian perlu dilakukan untuk menggambarkan kerugian dengan cara yang lebih baik. Tujuan kajian ini adalah untuk membangunkan rangka kerja OEE yang baru diubahsuai untuk menggambarkan menunjuk kerugian dengan lebih berkesan. Ini dapat dicapai melalui tiga objektif. Objektif yang pertama ialah menyiasat integrasi OEE dengan alat-alat lain dan pengubahsuaian atas pengiraan OEE. Objektif kedua ialah mewujudkan satu rangka kerja OEE yang baru untuk menyepadukan MOST ke dalam pengiraan OEE. Objektif ketiga ialah menilai keberkesanan rangka kerja OEE baru dalam menggambarkan kerugian dengan perbandingan dengan OEE umum. Kajian kesusasteraan telah dilakukan pada itegrasi OEE dengan alat-alat lain dan juga pengubahsuaian yang pernah dilakukan ke OEE. Ia telah menunjukkan integrasi OEE dan pengubahsuaian OEE adalah berdasar kepada keperluan dan tujuan khusus. Seterusnya, dua persamaan iaitu kebolehgunaan dan faktor manusia telah dibangunkan untuk menyepadukan MOST ke dalam pengiraan OEE. Kebolehgunaan adalah digunakan untuk mengukur kekerapan persediaan dan perubahan proses, dan faktor manusia digunakan untuk menyatakan kerugian manusia yang mengisi masa yang sedia ada untuk mesin. Akhirnya, tahap OEE diubahsuai baru dan tahap OEE umum telah dikira dengan data sebenar dari satu mesin bon wayar yang berada di syarikat yang dikaji. Data telah diambil selama 35 hari. Hasil kajian ini menunjukkan keberkesanan OEE diubahsuai baru dalam menggambarkan kerugian dan menunjukkan kawasan yang perlu penambahbaikan. Walaupun the tahap OEE untuk kedua-dua pengiraan OEE adalah sama tetapi OEE diubahsuai baru mengukur kerugian dengan visualisasi yang lebih baik. Ini akan berfaedah kepada pengguna untuk mengenal pasti kawasan yang perlu penambahbaikan dengan tepat dan memantau kerugian dengan mudah. Ia telah dijangka unuk dilaksanakan dalam pelbagai jenis industri untuk menilai aplikasi OEE diubahsuai baru.

ACKNOWLEDGEMENTS

I would like to express my gratitude to my academic supervisor, Assoc. Prof. Ir. Dr. Puvanasvaran A/L A. Perumal for his advice and guidance throughout the period of this research. Without his kind guidance, I might not able to complete my study.

Secondly, I would like to thank to my industry advisor, Vasathan at the Case Company, he always supports and gives me ideas when I face problems in this research.

Finally, I wish to thank to my family members and friends. They always give me strength to complete my master research. Their support, care and encouragement are the biggest support that help me been through this period.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ABBREVIATIONS

A	-	Availability
ADC	-	Automated Data Collection
AM	-	Autonomous Maintenance
AT	-	Average Time
E	-	Equipment Effectiveness
FMEA	-	Failure Mode and Effect Analysis
h	-	Accuracy Level Desired
KPI	-	Key Performance Index
MES	-	Manufacturing Execution System
MOST	-	Maynard Operation Sequence Technique
MTM	-	Methods Time Measurement
n	-	Sample Size
NST	-	Non- Scheduled Time
NT	-	Normal Time
NVA	-	Non-Value Added
OECL	-	Overall Equipment Cost Loss
OEE	-	Overall Equipment Effectiveness
OEE-MB	-	Overall Equipment Effectiveness based on Market
OEEML	-	Overall Equipment Effectiveness of a Manufacturing Line
OFE	-	Overall Fab Effectiveness
OLE	-	Overall Line Effectiveness

OPE	-	Overall Process Effectiveness
ORE	-	Overall Resource Effectiveness
OTE	-	Overall Throughput Effectiveness
OTIF	-	On Time In Full
P	-	Performance
PR	-	Performance Rating
Q	-	Quality
s	-	Standard Deviation
SMED	-	Single Minute Exchange Die
SPC	-	Statistical Process Control
TEPP	-	Total Effective Plant Performance
TMU	-	Time Measurement Units
TPM	-	Total Preventive Maintenance
WIP	-	Work In Process
x	-	Mean
z	-	Number of Standard Deviations required for the Desired Level of Confidence

LIST OF PUBLICATIONS

Journal

Puvanasvaran, A. P., Yoong, S. S., and Tay, C. C., 2017. Effect of Hidden Wastes in Overall Equipment Effectiveness Calculation. *ARPN Journal of Engineering and Applied Sciences*, *12*(22), pp. 6443-6448.

Proceedings

Puvanasvaran, A. P., Yoong, S. S., and Tay, C. C., 2017. Classification of Losses in Overall Equipment Effectiveness Calculation. *Proceeding of Postgraduate Research Seminar in Conjunction with ISoRIS 2017*, 18 July 2017, Ramada Plaza, Melaka World Heritage City, Malaysia, pp. 175-181.

CHAPTER 1

INTRODUCTION

In this chapter, the initiative of this study is highlighted with the background of study, problem statement, objectives, scope of study and significant of study. Background of study contains the general idea of this study and problem statement expresses the problem in the company that initiate this study. To overcome the problem stated in the problem statement, objectives are generated with the boundary that mentioned in the scope of study.

1.1 Background of Study

In the manufacturing sector, the efficiency and effectiveness of the production line is one of the important elements to achieve high cost effective, low manufacturing losses and produce high quality products. To measure the efficiency and effectiveness of the production, Nakajima had introduced Overall Equipment Effectiveness (OEE) calculation in year 1988. OEE not only a tool used to measure the current situation of the production and identify the productivity improvement of the machine, it also groups the losses that affect to the production into three major categories to assist user to have better vision on the production improvement potential (Verma and Dawar, 2014). The three main factors of the OEE are Availability (A), Performance (P) and Quality (Q). Each of the factors concerns with particular losses. Availability (A) indicates the unplanned downtime losses especially breakdown losses that bring huge financial loss to the company and also the

setup losses that reduce the actual production time. For Performance (P), it visualize the speed losses such as reduced speed and minor stoppage that reduce the available operating time that used to produce products while Quality (Q) measure the yield losses and defects of the product produced.

Although OEE can gives some insight to the production team or management level of the production or machine improvement potential, but not all user are satisfy with the traditional OEE. Anvari et al. (2010) claimed that traditional OEE is a fundamental measurement method and modification is needed to achieve the specific requirements for different kind of industries and also different type of purposes. The traditional OEE is modified to fit to certain situation or include certain losses and elements that are ignored or neglected in the traditional OEE. Furthermore, OEE is not sufficient to act as a performance improvement indicator because it cannot provide sufficient information to assist user to make right decision (Braglia et al., 2009). OEE is inefficient when it is used alone without any integration of other tools and techniques. On the other hand, Puvanasvaran et al. (2013) also mentioned that OEE is just a displayed value that indicates the current utilization of machine after evaluated. It is possible to improve the OEE in term of visualization of losses by integrate with other tool rather than just calculate OEE alone. According to Puvanasvaran et al. (2016a), some of the losses are tolerated, ignored or hidden in the OEE itself. Due to its limitation of visualization of losses, some of the losses might be ignored by the user such as transportation or setup time were negligence in the sight of the OEE. The management level might have a thought that their operations were in perfect or optimum but it still can be further improved by reducing the non-value added activities.

In order to overcome this issue, examination of OEE by using Maynard Operation Sequence Technique (MOST) was performed by some researchers. Puvanasvaran et al. (2016b) confirmed that MOST can quantify the hidden losses in the OEE and further improve the OEE level of the production by visualize the non-value added activities and excessive motion that performed by the worker when controlling the machine. However, this study is still use MOST and OEE separately and we still unable to monitor the waste effectively because the ideal time is not presented in the OEE. To visualize the losses effectively, the modification on OEE calculation method is needed to involve MOST into the new OEE calculation method. Then, user can quantify the hidden losses and identify the scope of improvement effectively.

1.2 Problem Statement

OEE is widely used in this industry as a performance indicator or improvement seeking tool. It is one of the important elements for continuous improvement. However, Samuel et al. (2015) claimed that OEE level up to 70% is achievable but the every one per cent of OEE improvement made beyond that is significant. Based on the Pareto 80:20 rule, the 80% of losses can be identified but the remains 20% losses are hidden, tolerated or ignored in the OEE and difficult to identified. This increases the difficulty for the industry to achieve world class OEE level which is 85% (Mohammedasif and Ramesh, 2014). On the other hand, Puvanasvaran et al. (2016a) also pointed that there are losses hidden in the OEE in traditional approach. The hidden losses could be the unnecessary process steps that classified as standard operating procedure or excessive transportation or setup time that included in the OEE calculation. In OEE, the frequency of the setup or changeover process also not pointed out which can be one of the important criteria to improve the efficiency of

the production or machine. From the view of management level, the OEE level might has maintained at a satisfy condition or at optimum stage, but indeed the OEE performance still can be further improved by reducing the non-value added activities that hidden in the OEE scale. Although OEE is a widely acceptable performance indicator but it is unable to quantify and visualize these hidden losses. This will cause the potential of the production or machine is not utilized.

Furthermore, most of the industry still required manpower to complete certain level of task; the efficiency of the manpower will resulted to the productivity of the machine or process. Talib and Daim (2010) have stated that external factor such as motivation level, emotion and environment will affect the consumption of manpower. This means that their productivity is not consistent over time and further affect to the productivity of the machine or process. The absence of the standard working procedure and standard time give chance to the manpower to lengthen the completing time. The lack of proper working procedure also increases the probability of human error and wasting the time to find tools or materials. However, the effect of the manpower working time is minimized by the long data collection period and ignored by the management level (Low et al., 2014). In OEE calculation method, although the classification of losses that proposed by Nakajima (1988) had mentioned the six big losses that classified in each of the main factor, but the setup losses and breakdown losses are fall in the same category and the great impact of the breakdown losses to the OEE drag the sight of the management level towards it rather than the setup losses. Moreover, the standard of working time is not mentioned in the OEE calculation which it can be the drawback of OEE calculation and give chance to manpower to lengthen the working time without knowing by the management level. Then, the optimization of the performance of the machine or process is hardly achieved.

The case company is a semiconductor company which most of the processes were run automatically in minimal manpower involvement. However, the machine still required manpower to set up or changeover the material, tool and equipment. The performance of the machine is somehow affected by the involvement of the manpower and it is necessary to monitor and measure the performance of the manpower correlated with the machine performance to improve progressively and achieve optimum level of the machine performance.

Figure 1.1 showed the percentage of the setup and changeover time over the total operating time for the four main processes of the case company. The percentage of the setup and changeover time over the total operating time for each processes. is from 2.5 % until 12.5 %. It is the main manpower involvement in the machine operating time where it ensures the smoothness of the machine. Therefore, it is the potential hidden improvement that can be done to improve the machine performance by longer operating time and higher output. On the other hand, it also enhances the flexibility of the processes to deal with the uncertainty situation likes sudden increase of demand.

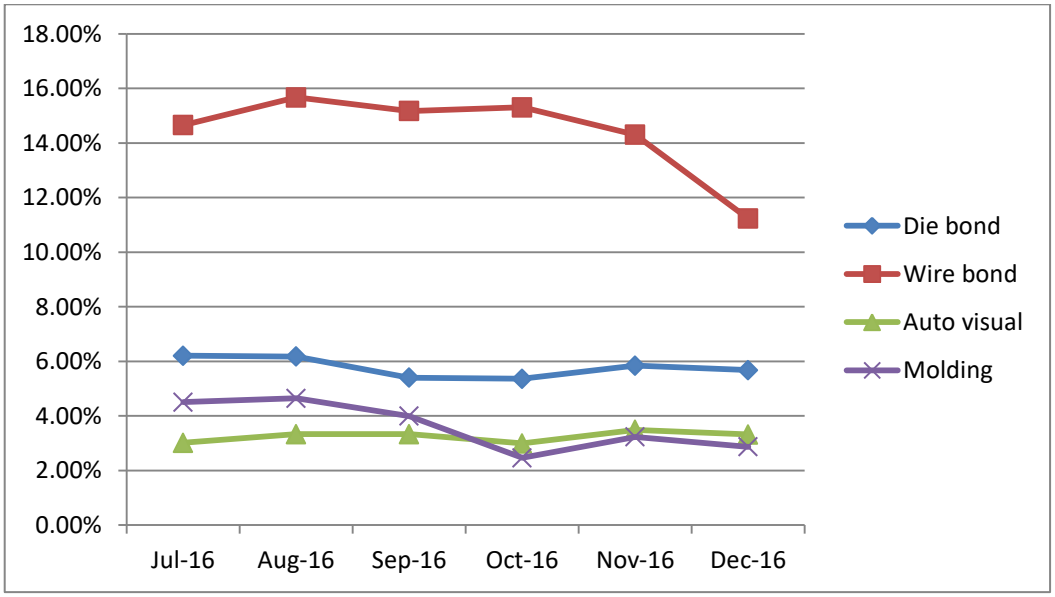

Figure 1.1: Percentage of the setup and changeover time over six months

MOST is one of the effective tools used to determine the ideal time and ideal working procedure of the worker to complete a task. MOST is a predetermined motion time system that allowed user to identify or predict the standard time before they start to work on the process. As per Pandey et al. (2016), MOST can enhance the productivity of the manpower by proper working methods and standard time, utilize the existing resources and balance the work among the workstation. As mentioned by Puvanasvaran et al. (2016b), MOST is capable to identify the hidden losses available in the OEE calculation and improve the OEE level of the machine or process by eliminate the waste. However, they are using MOST as a tool to improve the OEE level but not integrate the MOST into the OEE calculation in order to monitor the performance of the machine without neglecting of hidden losses in the OEE in traditional approach. Therefore, a framework that integrate MOST in the OEE calculation is needed to assist user to identify hidden improvement potentials and visualise the losses in the production.

1.3 Research Questions

i. How the Overall Equipment Effectiveness integrate with other tools?
ii. Why the Overall Equipment Effectiveness calculation need to be modified?
iii. How to develop a new Overall Equipment Effectiveness framework to integrate Maynard Operation Sequence Technique into Overall Equipment Effectiveness calculation?
iv. How to evaluate the effectiveness of the new Overall Equipment Effectiveness framework?

1.4 Objectives

i. To identify the integration of the Overall Equipment Effectiveness with other tools and modification of the Overall Equipment Effectiveness calculation.

ii. To develop a new Overall Equipment Effectiveness framework to integrate Maynard Operation Sequence Technique into Overall Equipment Effectiveness calculation.

iii. To evaluate the effectiveness of new Overall Equipment Effectiveness framework in visualise losses by comparing with general Overall Equipment Effectiveness.

1.5 Scopes of Study

The focus of this study is the integration of MOST in the OEE calculation method by develops a new modified OEE formula along with the framework to apply in the studied company. The intention to modify the OEE formula is to raise up the attention to the setup losses which mainly point to working behaviour of manpower and frequency of the setup or changeover process available in the daily production. MOST is a predetermined motion time study that can used to overcome this issue by involved in the OEE calculation.

A semiconductor company located at Malacca is struggle to achieve better OEE performance to utilize the resources, reduce losses and reduce manufacturing cost. They faced problem in identifying the losses in effective way, which able to find the hidden potential improvement. To overcome this issue, wedge wire bond machine in the production is chosen as the studied subject in this study. As shown in the Figure 1.1, the wire bond processes recorded with 11 % to 16 % of setup and changeover time, where it is the highest among the other three main processes of the case company. The data is