Faculty of Manufacturing Engineering

REFURBISHMENT OF PLATING MACHINE UNLOADER 304 STAINLESS STEEL TRACK BY DMAIC APPROACH

Mohamad Rasyidi Bin Nazir Ali

Master of Manufacturing Engineering

(Manufacturing System Engineering)

2019

REFURBISHMENT OF PLATING MACHINE UNLOADER 304 STAINLESS STEEL TRACK BY DMAIC APPROACH

MOHAMAD RASYIDI BIN NAZIR ALI

A thesis submitted
in fulfilment of the requirements for the Master of Manufacturing Engineering
(Manufacturing System Engineering)

Faculty of Manufacturing Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2019

DECLARATION

I declare that this thesis entitled "Refurbishment of Plating Machine Unloader 304 Stainless Steel Track" 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	:	Mohamad Rasyidi bin Nazir Ali
Date	:	30 / 8 / 2019

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 Manufacturing Engineering (Manufacturing System Engineering)

Signature	:	…………………………………...
Supervisor Name	:	Ir. Dr. Mohamad Bin Minhat
Date	:	30 / 8 / 2019

DEDICATION

To my beloved mother and late father

Late Nazir Ali Bin Shangkotti

Noor Begum Bte Mohd Said

ABSTRACT

This project focused on improving the performance of Meco electroplating machine. The project was done using six sigma DMAIC approach. Remarkably, the historical data on the six sigma DMAIC approach showed that the unload pusher error have significant contribution in affecting the machine stability performance. Through brainstorming and 5 why analysis, the real root cause of this issue were found to be due to high worn out rate of unloader track. Based the data collected for 2 weeks in production line, several severe worn out were observed. Therefore the improvement was done by focusing on refurbishing the original 304 stainless steel material that was originally used in fabricating the unloader track. There were two materials proposed in order to overcome this issue, the 439 stainless steel and powder metallurgy 39. Selection of these two material was done due to their high wear resistance ability. After finalizing, the prototype was completed and delivered with 1 month lead time. The two different material were then installed at two Meco electroplating machine while other parameter remains constant that are product type and pusher speed. Based on the worn out result obtained, both material showed significant improvement for 76% which is from 0.65mm worn out to 0.15mm within duration of four week. For future work, it is suggested the monitoring duration to extend from 12 weeks up to 26 weeks to have obtain maximum lifespan. This project also contribute significantly in improving the unscheduled downtime from 4.66 % to 1.77 % which is significant in improving OEE stability.

ABSTRAK

Projek ini memberi tumpuan kepada peningkatan prestasi mesin penyaduran Meco. Berdasarkan pendekatan DMAIC, data menunjukkan ralat penolak mempunyai sumbangan penting kepada prestasi kestabilan mesin. Dengan sesi memberi idea dan analisa 5 Why, penyebab utama masalah ini adalah disebabkan oleh kadar kehausan trek yang tinggi. Dari data yang dikumpulkan selama 2 minggu pada tapak pengeluaran, kehausan yang teruk dapat diperhatikan. Dari sini tumpuan penambahbaikan untuk membaikpulih bahan keluli tahan karat 304 yang digunakan untuk pembuatan trek. Terdapat dua cadangan bahan untuk mengatasi isu ini berdasarkan kertas jurnal iaitu keluli tahan karat 439 dan metalurgi serbuk 39. Pemilihan kedua-dua bahan ini kerana keupayaan rintangan terhadap haus yang tinggi. Selepas memuktamadkan 2 bahan ini, pembina sampel diteruskan dan dihantar dan disiapkan dalam masa 1 bulan. Kedua-dua bahan dipasang di dua mesin penyaduran Meco dengan kawalan parameter jenis produk dan kelajuan pusher. Berdasarkan penemuan hasil, bahan baru menunjukkan peningkatan yang ketara. Projek ini juga berhasil memyumbang kepada masa henti tidak berjadual daripada 4.66 % to 1.77 % yang penting dalam meningkatkan kestabilan Kecekapan Peralatan Keseluruhan.

ACKNOWLEDGEMENTS

First and foremost, I would like to take this opportunity to express my sincere gratitude towards my supervisor Ir. Dr. Mohamad Bin Minhat from Faculty of Manufacturing Engineering, Universiti Teknikal Malaysia Melaka (UTeM) for his essential supervision, support and encouragement towards the completion of this thesis. A special thanks are also dedicated to my late father, beloved mother and siblings for the unconditional support during my studies. Next, would like to thanks my Infineon working team member for consistence support during this project. Lastly, thanks you to everyone who had been to the crucial part of realization of this project.

TABLE OF CONTENTS

PAGE

DECLARATION
APPROVAL
DEDICATION
ABSTRACT **i**
ABSTRAK **ii**
ACKNOWLEDGEMENTS **iii**
TABLE OF CONTENTS **iv**
LIST OF TABLES **vii**
LIST OF FIGURES **viii**
LIST OF APPENDICES **xi**
LIST OF ABBREVIATIONS/SYMBOLS **xii**

CHAPTER
1. INTRODUCTION **1**
1.1 Background 1
1.2 Problem Statement 2
1.3 Objectives 3
1.4 Scope of Research 4
1.5 Research Planning 4
1.6 Significant of Study 4
1.7 Organization of Chapters 5
1.8 Summary 6

2. LITERATURE REVIEW **7**
2.1 Company Background 7
2.2 Plating Background 8
2.3 Meco Electro Plating Line (EPL) Machine Background 10
2.4 Meco Electro Plating (EPL) Machine Design and Sequence 15
2.4.1 Fiber Optic Sensor 15
2.4.2 Bottom Roller 16
2.4.3 Pusher cylinder 16
2.4.4 Unloader track 17
2.5 Characteristic of Stainless Steel Material 17
2.6 Worn out research and approach to perform improvement 18
2.7 Researches on Stainless Steel 439 material 19
2.8 Researches on Powder Metallurgy material 21
2.9 Advantages of Molybdenum for wear resistance. 23
2.10 General Problem solving tool based on Journal 24
2.11 Define, Measure, Analyze, Improve and Control (DMAIC) 25
2.12 Summary 29

3. METHODOLOGY **30**

3.1 Planning Setup by Flow Chart 30
3.2 Research Tools 32
3.3 Research Task 32
3.4 Define Phase 32
3.4.1 Bar chart of overall process machine stoppages 33
3.5 Measure Phase 34
3.5.1 Pareto Chart principle 34
3.5.2 Pareto Chart Analysis on Plating Machine stoppages 35
3.6 Analyze Phase 36
3.6.1 Ishikawa Diagram 36
3.6.2 Brainstorming session on Ishikawa diagram 37
3.6.3 Analysis of potential root cause with Cause and Effect diagram 38
3.6.4 Elimination of non-potential root cause by Why-Why analysis 40
3.7 Data collection plan for worn out measurement 45
3.7.1 Worn out measurement procedure setup 45
3.8 Improve Phase 47
3.8.1 Original track Stainless Steel 304 Material Composition 47
3.8.2 Proposal on Stainless Steel 439 & Powder Metallurgy 30 48
3.9 Installation of new refurbish unloader track 48
3.10 Summary 49

4. RESULT AND DISCUSSIONS **51**

4.1 Initial Information 51
4.2 Worn out data collection on original track SS304 51
4.3 Objective 1 - Discussion on worn out correspond to root cause of high machine stoppages 53
4.4 Chemical composition of refurbish version 55
4.5 Worn out data collection on refurbishment track SS439 for 12 weeks 56
4.6 Worn out data collection on refurbishment track PM30 for 12 weeks 57
4.7 Objective 2 - Discussion on performance evaluation lifespan and worn out improvement of SS439 and PM30 for 12 weeks 58
4.8 Monthly Visual Inspection under microscope for SS439 59
4.8.1 SS439 SEM result at worn out area 60
4.9 Monthly Visual Inspection under microscope for PM30 62
4.10 Pareto Chart after improvement 63
4.11 Objective 3 – Validation on machine OEE specific to unscheduled downtime before and after implementation 64
4.12 Control phase 65
4.12.1 Control Plan & Method 65
4.12.2 Update Failure Mode and Effect Analysis (FMEA) 66
4.12.3 Update Quarterly Preventive Maintenance Procedure 67

4.13 Summary 67

5. CONCLUSIONS AND RECOMMENDATIONS 69

5.1 Conclusions 69
5.2 Recommendations for future research 70
5.3 Closure 71

REFERENCES 72

APPENDICES 78

A Gantt chart

LIST OF TABLES

TABLE	TITLE	PAGE
2.1	Chemical compositions of the 304 and 439 stainless steels (Huntz et al., 2007)	20
2.2	Quality technique usage (Jamaluddin et al., 2011)	26
2.3	Rational construction of DMAIC (Smętkowska and Mrugalska, 2018)	28
3.1	Cause and effect matrix table	39
3.2	Summary of hypothesis elimination	44
3.3	Data collection plan	45
3.4	Chemical composition in stainless steel 304 (Meco Equipment Engineers, 2015)	47
3.5	Comparison of material composition for improvement	48
4.1	Measurement of worn out depth at SS304 unloader track	52
4.2	Comparison of track material composition between stainless steel (Meco Equipment Engineers, 2015)	55
4.3	Measurement of worn out depth at SS439 unloader track	56
4.4	Measurement of worn out depth at PM30 unloader track	57
4.5	SS439 monthly surface inspection monitoring under microscope	60
4.6	SEM image for SS439	61
4.7	PM30 monthly surface inspection monitoring under microscope.	62

LIST OF FIGURES

FIGURE	TITLE	PAGE
1.1	Comparison between good and worn out unloader track surface (Infineon Technologies, 2019)	3
2.1	General production process flow (Infineon Technologies, 2019)	7
2.2	SEM image of leadframe surface after plating with dendrite growth (Infineon Technologies, 2019)	8
2.3	Side view of dendrite growth at 100nm of magnification scale (Infineon Technologies, 2019)	9
2.4	Meco Electroplating Machine (Infineon Technologies, 2019)	11
2.5	Meco Electroplating schematic (Meco Equipment Engineers, 2015)	12
2.6	Meco Electroplating Machine (Meco Equipment Engineers, 2015)	14
2.7	Meco unloader station (Infineon Technologies, 2019)	15
2.8	Roller 1 and roller 2 unloader station(Infineon Technologies, 2019)	16
2.9	Steps of TOPSIS method (Bhosale et al., 2018)	23
2.10	Phases for DMAIC approach (Tenera and Pinto, 2014)	27
3.1	Flow chart of the project	31
3.2	DMAIC research tool sequence	32
3.3	Machine stoppages trend for overall process (Infineon Technologies, 2019)	33

3.4 Pareto chart template (Infineon Technologies, 2019) 35
3.5 Analysis on the Pareto chart of Plating Machine stoppages (Infineon Technologies, 2019) 36
3.6 Ishikawa diagram template (Jia et al., 2018) 37
3.7 Ishikawa diagram brainstorming on potential causes based on 5M criteria 38
3.8 Worn out of unloader track surface 40
3.9 Jig install under the translator 41
3.10 Jig install at magazine lifter 41
3.11 Comparison for good and fail magazine 42
3.12 Parameter offset and trigger warning to notify machine owner 43
3.13 Mitutoyo digital Vernier Caliper to measure worn out depth 46
3.14 Measurement of worn out on the track surface 46
3.15 AutoCAD drawing of the new refurbishment track 48
3.16 SS439 and PM30 refurbish unloader track received 49
4.1 SS304 Worn out depth versus calendar week 52
4.2 Product movement on unloader track 53
4.3 Pusher error generation when worn out keep increasing 54
4.4 SS439 Worn out depth versus calendar week 57
4.5 PM30 Worn out depth versus calendar week 58
4.6 Analysis on the Pareto chart after improvement of Plating Machine stoppages (Infineon Technologies, 2019) 63
4.7 Unscheduled downtime before and after project implementation 64
4.8 Control Method based on effectiveness (Infineon Technologies, 2019) 66

4.9	FMEA document updated for plating machine (Infineon Technologies, 2019)	66
4.10	Quarterly Preventive Maintenance procedure on track inspection	67

LIST OF APPENDICES

APPENDIX	TITLE	PAGE
A	Gantt Chart	78

LIST OF ABBREVIATIONS/SYMBOLS

CTQ	-	Critical to Quality
CNC	-	Computer Numerical Control
DMAIC	-	Define, Measure, Analyse, Improve, Control
DPAK	-	Product Name
EDS	-	Energy Dispersive Spectrometer
EDX	-	Energy Dispersive X-ray
EPL	-	Electro Plating Line
ESR	-	Equipment Safe Release
GA	-	Genetic Algorithm
MSA	-	Methane Sulphonic Acid
OEM	-	Original Equipment Manufacturer
PM	-	Powder Metallurgy
SEM	-	Scanning Electron Microscope
SMED	-	Single Minute of Die Exchange
SS	-	Stainless Steel
TOPSIS	-	Technique for Order of Preference by Similarity to Ideal Solution
TPM	-	Total Productive Maintenance
WIP	-	Work In Progress
WRIWP	-	Wear Rate Initial Wear Period
WRUWP	-	Wear Rate Uniform Wear Period

CHAPTER 1

INTRODUCTION

1.1 Background

Nowadays, semiconductor manufacturing has become a viable business. Due to rapid globalization and technology breakthrough from year to year, this business keeps on improving and expending as the major market share around the world. In order to produce maximum product output with high quality, the management are now focusing on improvising the stability of material, man, machine and method (Duran et al., 2015).

Plating is one of the important process in the semiconductor industries. The electro-chemical plating process helps to enhance the pre-mould lead frame by introducing a layer of epoxy mixture which is mechanically strong and sturdy. This process is carried out by using an alkaline base solution that will then induce a strong epoxy layer known as dendrite on the surface of the lead frame. Dendrite is considered to be important as it helps to improve the adhesion of lead frame during moulding process. To be more precise, adhesion properties helps in reducing and overcoming the delamination issue of each units during high temperature throughout the plating process (Infineon Technologies, 2019).

In term of machine, generally electro-chemical plating machine are divided into 3 main components that are loader station, machine body and unloader station. Basically, machines are fully automated in order to achieve better throughput and productivity. In the process of plating, machine stoppage at unloader station is very critical as it led to higher number of product scrap that is usually formed due to over immersion in chemical. Therefore, the challenges faced by the industries of semiconductor in reducing their loss were basically through the sustainability and improvement of machine stoppages.

Besides, every single machine stoppage had become the main culprit in production line as it affect the machine downtime performance which will then led to the reduction in output produced during each shift. On the other hand, the bad performances of machine stoppages had also directly impacted the delivery schedule and hence led to the increment of cost due to product scrap during plating process.

1.2 Problem Statement

In this project, the focus is at the unloader track area whereby the worn out behavior of machine was apprehended in order to improve machine performances hence reducing the jamming rate. Several materials have been chosen and evaluated in order to achieve maximum life span and minimum worn out rate. Based on the historical data on 2018, from week 30 until week 45, plating machine showed a higher number of stoppages in term of performance. The low performance of machine had impacted much to the high unscheduled downtime during plating process.

One of the biggest challenges faced along this sustaining process is the lifespan issue. It is a nature of every process to have product move in and out of the machine. During the movement of the product, a contact is formed in between the product with the surface area of track which will generates friction. Although there might only be a small resistance produced through this contact, but if it occurs continuously along the track, energy will be created, thus causing the product to be worn out due to the friction. Figure 1.1 shows the comparison between the good and worn out unloader track under microscope view whereby the worn-out unloader track was clearly seen with a new slot created on the surface.

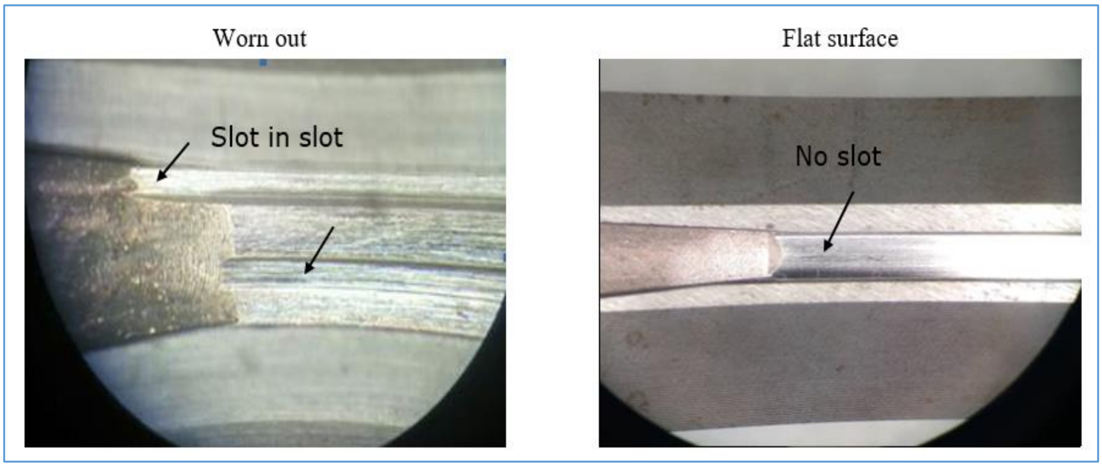

Figure 1.1 : Comparison between good and worn out unloader track surface (Infineon Technologies, 2019)

1.3 Objectives

Aim of this project is to improve material lifespan of the unloader track hence improving the machine performance. The objectives of this project are:

i. To investigate the root cause that contributes to high machine stoppages by using problem solving tool.

ii. To evaluate the performances of two type of material in term of improving their life span and to reduce worn out rate.

iii. To validate overall equipment efficiency of unscheduled downtime before and after implementation.

1.4 Scope of Research

This project will be conducted at Meco electroplating machine which run DPAK packages in Infineon Technology Melaka. Measurement of worn out depth at original SS306 track were performed by using digital Vernier caliper in order to understand the worn out rate. The improvement in this project will be focusing on the evaluation performance of refurbishment track using SS439 and PM30 material. DMAIC approach was applied as a method to solve this issue.

1.5 Research Planning

The research planning and outline were shown in the Gantt chart as attached in Appendix A.

1.6 Significant of Study

In order to stay competitive in global market, it is important for the company to ensure all the supporting machine and tool to function at a maximum level of efficiency. In this project, the focus is to conduct improvement to enhance machine performances in order to operate it under maximum efficiency. This was important to ensure that the capital investment on the equipment and tool can be reduced by improving the equipment efficiency and through development of machine stability. In addition, having a machine without stoppage could also be helpful in minimizing the quality and safety issue.

1.7 Organization of Chapters

This report will be divided into 5 main chapters. Chapter 1 which is also known as the introduction chapter will basically explains on the background of the study, objectives, aims and the scope of the project. There is also an explanation on the significance of this project which were done by tackling the worn out issue and its contribution towards the Infineon Technology.

Next, chapter 2 begins with a brief explanation on the plating process and their importance to the product. In addition, the Meco Electroplating machine design and functionality were also introduced in this chapter. This chapter also elaborates the detail of this project which will then be implemented and monitored at the plating machine. The details of machining operation such as the machining parameters, characteristics and the work piece materials were discussed in this chapter. All of the information were basically obtained through the analysis done from journal paper, article, patent and others research sources as a research purpose.

Chapter 3 consists of the flow chart which explains the experimental method of the work done in order to achieve objectives of this project. The methodology started by performing data collection on the machine stoppages trend. This data were then further analysed in term of machine, method, man and material. Next, the chapter discussed on the refurbish plan of new unloader track using high wear resistance ability.

Chapter 4 compiles the data monitoring process which specifically focus on the two new materials of 439 stainless steel and powder metallurgy 39. This chapter also consist of the detail discussion on both material. Next, the control plan were then setup in order to sustain the performances of new material. Last but not least, chapter 5 also provides the conclusions to decide the final material selection. Recommendations were also proposed in order to highlight pain point and area for improvisation in case if there is study related to this project in future.

1.8 Summary

This chapter has provided a synopsis on the background of the project. It also had clearly indicated the objectives and scope of this project which were important in improvising the material lifespan.

CHAPTER 2

LITERATURE REVIEW

2.1 Company Background

Infineon Malacca plant is one of the biggest productions plant which consists of 9100 workers from 4 main departments of Power Logic Assembly (PLA), Power Logic Test (PLT), and Sensor & Discrete segment. In this project, the area of improvement will be focusing on the front of Line of A2 Plating process in Power Logic Assembly Segment (PLA). In the Back End Manufacturer, Infineon Malacca production flow begins from Pre Assembly Wafer Saw process up to the test process and until the product was shipped to customer (Infineon Technologies, 2019).

Figure 2.1 shows the general production process flow in Infineon Malacca plant. The start and end process were linked by integrated automated processes which were named as Front of Line (FOL) & End of Line (EOL) production process area. After the last process at EOL, each unit will then undergoes a testing process in order to ensure that every single product were good and robust.

Figure 2.1 : General production process flow (Infineon Technologies, 2019)