UNIVERSITI TEKNIKAL MALAYSIA MELAKA

EFFECT OF INCLINED BALL MILLING PROCESS ON ALUMINIUM ALLOY

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

By

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UNIVERSITI TEKNIKAL MALAYSIA MELAKA (UTeM)

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I hereby, declared this report entitled "Effect of Inclined Ball Milling Process on Aluminium Alloys " is the results of my own research except as cited in references.

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APPROVAL

This PSM submitted to the senate of UTeM and has been as partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering (Manufacturing Process). The member of the supervisory committee is as follow:

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ABSTRACT

Milling is one of the fundamental forms of machining operation among several industrial machining processes. The inclination of the cutting tool is one of the important factors that influence the surface finish which become a requirements in a variety of manufacturing industries including the aerospace, die-mold and automotive industries where complex surfaces and geometries are machined. The three sectors are stressed most on the quality of the surface finish. Thus, the main objective for this study is to investigate the effect of the inclined ball end milling to the scallop height of the Aluminium Alloys surface. Machining parameters involved in this study are lead angle, tilt angle and step over. The material used to test its scallop is Aluminium Alloys. Full factorial design of DOE by using the Design Expert software was applied in order to determine the test run for the experiment. It also used to analyze the data obtained from the experiments. There were two method used in this study in order to get the accurate result which are Simulation modeling using CATIA software and Experimental machining using the 3-axis CNC milling machine. The result for both processes showed that the scallop height was decreased when the tilt angle increased.

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ABSTRAK

Proses kisar adalah salah satu bentuk asas operasi pemesinan antara proses pemesinan yang terdapat dalam industri. Kecondongan mata alat merupakan salah satu factor penting yang mempengaruhi permukaan akhir produk yang menjadi keperluan dalam pelbagai industri pembuatan termasuklah sector ruang angkasa,'die-mold'dan automotif. Ketiga-tiga sektor ini sangat menekankan terhadap kualiti permukaan yang terhasil. Oleh itu, objektif utama kajian ini adalah untuk mengkaji kesan peningkatan sudut mata alat dalam 'ball end milling' terhadap kekasaran permukaan bahan kerja. Pembolehubah yang terlibat dalam kajian ini adalah sudut 'lead', sudut 'tilt' dan 'step over'. Bahan yang akan digunakan untuk menguji kekasaran permukaannya adalah aloi Aluminium. Kaedah "full factorial" menggunakan 'Design Expert' digunakan untuk menentukan bilangan ujikaji perlu di jalankan. Ia juga akan digunakan kemudian bagi menganalisis data yang akan diperolehi. Dua jenis ujikaji telah dilakukan untuk mendapat hasil yang lebih tepat telah digunakan iaitu Model simulasi dari 'CATIA' dan experiment mesin menggunakan 3 paksi mesin CNC. Pencapaian yang didapati melalui kedua-dua uji kaji tersebut menunjukkan ketinggian lekukkan di permukaan adalah berkuarang apabila sudut 'tilt' bertambah.

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DEDICATION

To my beloved parents Mat Zali bin Junoh and Azizah Ismail, thank you for your continuous support and thanks for everything. My sisters and brothers, thank you for encouraging me to do well in this writing.

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LIST OF ABBREVIATION

AA	-	Arithmetic Average
ANOVA	-	Analysis Of Variance
CATIA	-	Computer Aided Three-dimensional Interactive Application
NC	-	Numerical Control
CLA	-	Centre Line Average
CNC	-	Computer Numerical Control

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CHAPTER 1

INTRODUCTION

1.1 Background of the Study

Manufacturing of parts with complex surfaces brings additional challenges such as tool accessibility and contouring. Five- axis milling provides much better accessibility with the help of increased tool orientation capability. However, 5-axis milling also brings extra difficulties due to the complicated process geometry and mechanics. Lead and tilt angles determine orientation of cutting tool and the engagement region, and affect the mechanics and dynamics of the process. Local chip thickness, cutting force coefficients, dynamic forces and stability are affected by lead and tilt angles. Improper tool orientation may result in decreased productivity and part quality due to higher cutting forces, surface form errors and process instability. Thus, lead and tilt angles are very important parameters in 5-axis milling processes. Effects of lead and tilt angles on the process are not known very well, and cannot be easily estimated unlike parameters such as feed rate and cutting depths. Lead and tilt angles have effects on different factors such as tool tip contact with the work piece, scallop height, cutting forces, torque, form errors and stability. (Ozturk et al.,2009)

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1.1.1 Ball End Milling

A ball end mill is well suited to milling many types of materials, from plastics to steel alloys and titanium. The toughness and durability of the cutting edge is very high in ball end mills because of the rounded edge design. This fact is actually just a by product of the rounded cutting edge. Originally it was rounded for a specialized purpose, namely for milling grooves with a semi-circular cross-section. This type of groove is an important part of the metal bearings used in many machines.

Another benefit of the way the ball end mill is designed is that it can handle very high feed rates, meaning it can mill the material very quickly. This gives it great productivity for use in today's milling machines. The smooth geometry of the cutting tip also translates into lower cutting forces, giving the cutter added strength under pressure. Since it is less likely to break under normal forces, the ball end mill is also highly cost-effective for the applications to which it is suited.

Ball end mills are almost always made of tungsten carbide, a high-strength metallic compound containing tungsten and carbon. Tungsten carbide powder is pressed into rods, which are then ground and sharpened to various specifications. A typical ball end mill will often be manufactured with a protective coating. These coatings usually contain titanium mixed with other elements such as carbon and aluminium.

1.1.2 The Effect of the Inclined Ball Milling Process

As already it has been researched, various cutting process conditions are very important in the developed surface roughness of machined surface. One such cutting condition with important effect in the quality of surface is the inclination angle between the cutting tool and the work piece, during the cutting process. The placement of cutting tool can be differentiated, depending on the inclination angle

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between the tool and the processed surface and the feed direction. These result in different milling strategies that consequently lead to different surface quality. The reasons for this behaviour are the different cutting speed of the cutting edge, the different shapes of chips per case and the variability of the developed cutting forces.

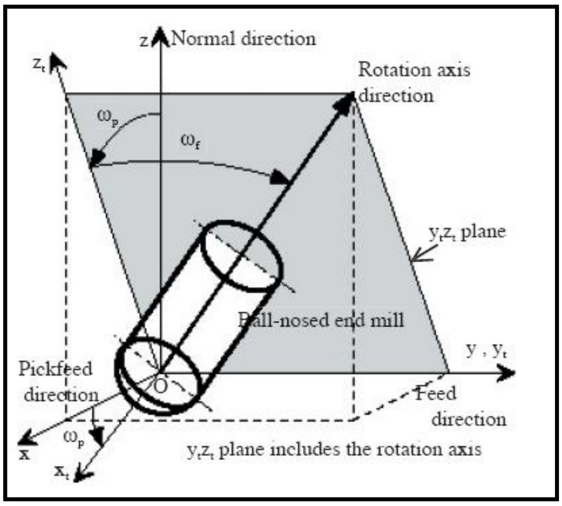

Figure 1.1: Definition of tool orientation and inclination.(Terai et. al.)

Fig.1 illustrates the definition of the tool orientation. Z axis is the normal direction of the surface of the work piece in machining. Y axis is the direction of feeding the tool. So, x-axis is the direction of pick feed. On this coordination 2 defined for the tool orientation. One is the angle between z axis and a plane including the tool rotation axis and y axis. It is called “the angle of pick feed direction ω_p”. In this case we define another coordination $x_t y_t z_t$. This coordination is inclined ω_p around y axis. So y_t z_t plane include the tool rotation axis. In this plane the angle between the tool rotation axis and z_t axis is called “the feed direction angle ω_f”. (Terai et. al.)

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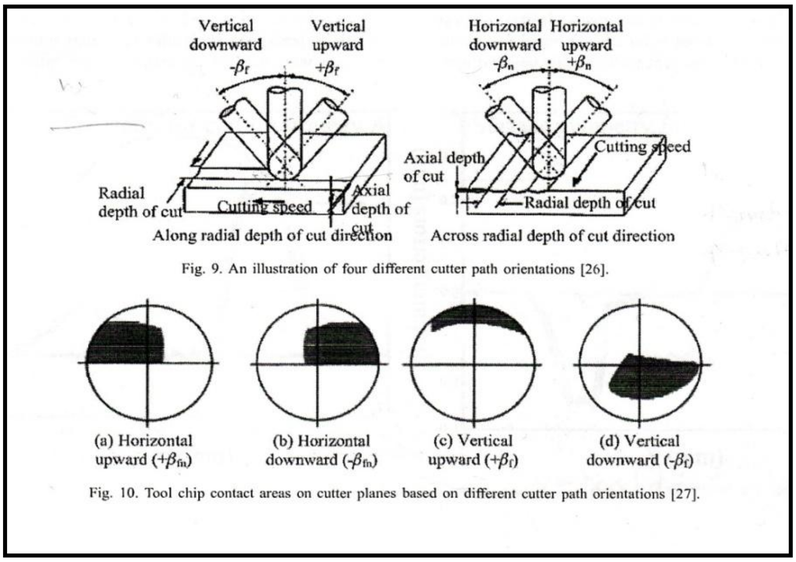

Figure 1.2: An illustration and tool chip contact areas of four different path orientations. (C.K. Toh)

1.2 Problem Statement

The finish milling on the plane surface using ball end milling generally results in poor tool life since the effective cutting speed at its tip is zero and the effective cutting speed is very small. The different contact area of the cutting tool will lead to the different cutting speed of the machining process. Step over also will influence the scallop height produce on the surface. The different of inclination angle and cutter path orientation will result the different surface finish. This experimental study is purposely to investigate the inclination angle as well as the cutter path orientation in order to get the best surface.

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1.3 Objective

The purposes of this study are:

i. Investigation using the CATIA simulation
ii. To investigate the effect of the inclined ball end milling to the scallop height of the Aluminium Alloys surface.
iii. To compare the results between the experimental machining with the CATIA simulation machining

1.4 Scope of Project

This study is mainly about the experimental test of the Ball end milling process to study the effects of the inclination of Ball End Milling process on the Aluminium Alloys. The study will include the effect of the inclination to the surface roughness of the Aluminium Alloys using four different cutter path orientation of the cutting tool. Different inclination angle of the Ball end milling machine will result different surface roughness. Hence, this study is to discover the suitable inclination angle to produce the best surface roughness of Aluminium Alloys. The study takes into account the orientation of the cutting tool, with respect to the work piece, offering the possibility to alter the tool inclination angles. The study is focus primarily on the Ball End Milling Process on Aluminium Alloys to identify the effect of the inclination angle of the process on the Aluminium Alloys. The study is considered in three aspects which are inclination angle of the cutting tool (30°), speed of the cutting tool, and also the cutter path orientation consist of horizontal upward, horizontal downward, vertical upward, vertical downward. The method use in the study are calculation, modelling of the process using CATIA, basic machining of 5-axis Milling Machine, and measurement for the surface roughness which using surface profilometers. Above all, this study uses the Design of Experiment (D.O.E) method in analyzing the result.

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1.5 Structure of Project

Generally, this report is divided into two parts which are Projek Sarjana Muda (PSM) I and PSM II. In total, this report contains of five main chapters. These chapters are separated into two parts which the first part contains three chapters which are introduction, literature review and methodology whereas the second part conducts the two more chapters, results and discussion and finally, conclusion and recommendation of this study.

In the first chapter, Introduction, briefly explain the background of the study about the Effects of Inclined Ball end Millings process and introduction on the ball end milling generally. It also contains of the problem statement, objectives, scope and structure of this project. All theories were taken and referred to the articles, journals, and some books related to the study are explain in detail in Chapter 2, Literature Review.

In chapter 3, Methodology, all methods that have been use are explained specifically in term to achieve the objectives and obtain the result of the study. On the other hand, in Chapter 4, for the results and discussion, this report are focus primarily on the data that been collected and identify the influence factor that achieve the result. Besides, suggestion for improvement on the Ball end Milling process also been given in this chapter.

In the last chapter, Chapter 5, Conclusion and Recommendation which conclude this study and also included some suggestion in order to improve this study for future.

Finally, all the chapters are compiled separately in sequences in order to give a clear view to the readers. The flow chart below shows the general flow of the Projek Sarjana Muda (PSM) that will be held in two semesters.

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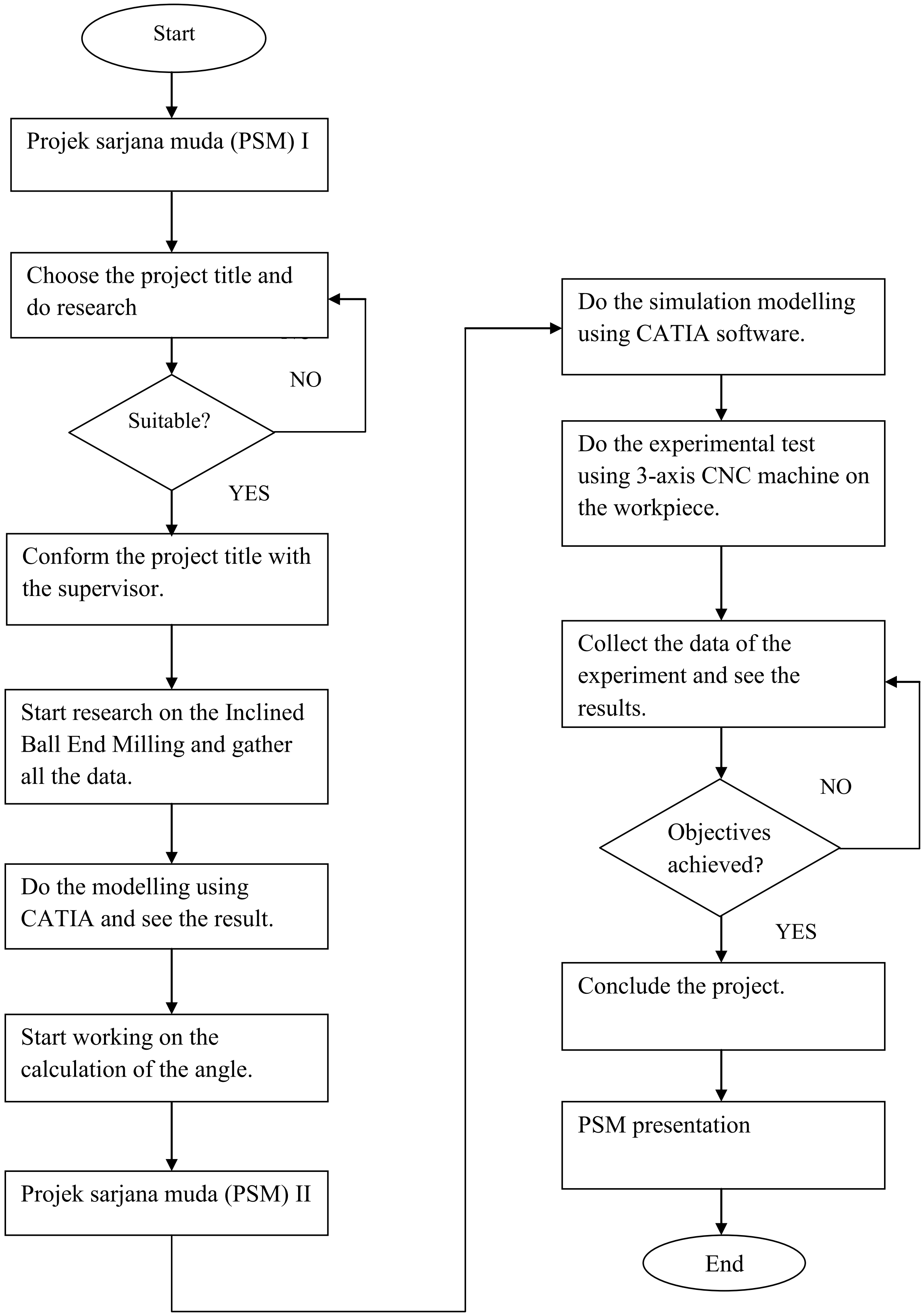

Figure 1.3: The Process Flow Chart of the PSM I and PSM II

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1.6 Gantt Chart

Table 1.1: Gantt chart for PSM1

No	Yeat	2009																			
	Activity	July				Aug				Sept				Oct				Nov			
1	PSM title confirmation																				
2	Problem statement identification																				
3	objective and scope of study																				
4	Finding literature review																				
5	PSM 1 report writing																				
6	PSM 1 report review																				
7	PSM 1 report submission																				
8	Preparation for PSM 1 presentation																				
9	PSM 1 presentation																				

Planning

Actual

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Table 1.2: Gantt Chart for PSM II

No	**Year**	**2009**																			
	Activity	**Jan**				**Feb**				**Mar**				**Apr**				**May**			
1	Improvement on PSM 1																				
2	Finding literature review																				
3	Simulatio Modelling using CATIA																				
4	Machining and material preparation																				
5	Machining process																				
6	Surface roughness measurement																				
7	Data Analysis using Design Expert																				
8	PSM 2 report writing																				
9	PSM 2 review																				
10	PSM 2 submission																				
11	Preparation for PSM 2 presentation																				
12	PSM 1 presentation																				

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