INVESTIGATION ON THE EFFECT OF CUTTING PARAMETERS ON MACHINING OF ALUMINIUM USING 5-AXIS MACHINING

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

by

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UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

TAJUK: **Investigation on the Effect of Cutting Parameters on Machining of Aluminium Using 5-Axis Machining**

SESI PENGAJIAN: 2010/2011 Semester 1

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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 Process) with Honours. The members of the supervisory committee are as follow:

……

Main Supervisor

(PROF. DR. MOHD RAZALI B. MUHAMMAD)

……

Co-Supervisor

(DR. MD NIZAM B. ABD. RAHMAN)

DECLARATION

I hereby, declared this report entitled "Investigation on the Effect of Cutting Parameters on Machining of Aluminium Using 5-Axis Machining" is the results of my own research except as cited in references.

Signature	:	…….....
Author's Name	:	SHUKRI ZARIZI B. KAMARUZAN
Date	:	

ABSTRAK

Pengisar ialah bentuk paling biasa dalam memesin, proses pembuangan bahan ini dilakukan bagi mewujudkan pelbagai bentuk dengan membuang jauh bahan yang tidak dikehendaki. Sekarang ini, mesin CNC lima-paksi semakin meningkat naik kerana boleh menyelesaikan sebuah bahagian yang kompleks. Oleh kerana itu, projek ini akan memfokuskan kepada bahagian dinding atau sisi mata alat dengan menggunakan mesin pengisar lima paksi. Membuat model (CAD) dan pengaturcaraan (CAM) telah dibuat menggunakan perisian CATIA. Terdapat tiga analisis utama akan dibawa keluar dan dianalisis. Iaitu kekasaran permukaan, perubahan dimensi dan kehausan mata alat. Bahan mentah akan dipakai ialah Aluminium dan menggunakan mesin DMU 60 MonoBlock. Dalam kekasaran permukaan dan perubahan dimensi keadaan yang akan mempengaruhinya seperti kadar kelajuan pusingan dan kadar suapan akan di analisis menggunakan kaedah Rekabentuk Ujikaji (DOE) dengan cara Permukaan dengan Aturan (Response Surface Methodology). Selain itu, kesan pada mata alat juga akan disiasat selepas pemesinan dibuat. Dalam projek ini terdapat dua jenis alat pemotong akan digunakan yang berbeza panjangnya. Penyebab kehausan mata alat seperti kadar kelajuan pusingan dan kadar suapan setelah menjalankan proses pemesinan juga akan dianalisa. Sementara itu, analisis akan dibuat menggunakan beberapa radas seperti kekasaran permukaan penguji mudah alih (portable surface roughness tester), mesin pengukuran koordinat (CMM), dan microskop optik (optical microscope). Keputusannnya, kadar kelajuan pusingan dan kadar suapan telah member kesan kepada permukaan kekasaran, ketetapan dimensi dan kehausan mata alat.

ABSTRACT

Milling is the most common form of machining; a material removal process in which can create a variety of features on a part by cutting away the unwanted material. Nowadays, CNC machine of five axis machining become popular in order to solve a complex machining of part. Hence, in this project will focus on flank milling using five axis machining. The design modelling (CAD) and the machining programming (CAM) have been developing using CATIA software. There were three main analysis was carried out and analyzed. Namely the surface roughness, dimension variation and tool wear. The raw material used is Aluminium and the machining done using DMU 60 MonoBlock. In surface roughness and dimension variation the influence happen will be analyze using Design of Experiment (DOE) method which is Response Surface Methodology (RSM). Besides that, the effect happen in the tool also has been investigated after the machining done. Meanwhile, the analysis was successfully done using some apparatus such as portable surface roughness tester, Coordinate Measuring Machine (CMM), and optical microscope. As the result, the parameter such as spindle speed and feed rate is given influence to the surface roughness, dimensional accuracy and tool wear.

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DEDICATION

With honest, special thanks dedicated to my beloved parents, my PSM supervisor and UTeM community, and my fellow friends and also to every single person who has provide the opportunities with all your love, patience and understanding.
All your blessing will be granted

Thank You.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

Al	-	Aluminium
ANOVA	-	Analysis of Variance
CAD	-	Computer Aided Design
CAM	-	Computer Aided Manufacturing
CMM	-	Coordinate Measuring Machine
CNC	-	Computer Numeric Controlled
DOE	-	Design of Experiments
FWC	-	Floor-Wall and Ceiling
HSS	-	High speed steel
ISO	-	International Organization for Standardization
MM/MIN	-	Millimetre per Minute
NC	-	Numerical Control
PSM	-	Projek Sarjana Muda
R	-	Cylindrical cutter
Ra	-	Arithmetic average deviation
RPM	-	Revolutions per minute
Rq	-	Root-mean-square-roughness
RSM	-	Response Surface Methodology
V5	-	Version 5
3D	-	Three-Dimensional

CHAPTER 1
INTRODUCTION

1.1 Background

Metal cutting is defined as the removal of metal chips from a work piece in order to obtain a finished product with desired attributes of size, shape, and surface roughness. Metal cutting process can be done by using several processes such as machining, turning, grinding, threading and other. So this metal cutting is the most significant in manufacturing processes. In machining contexts, the milling is some of the processes used to remove material to produce a high quality of product.

Milling is typically used to produce parts that are not axially symmetric and have many features, such as holes, slots, pockets, and even three dimensional surface contours. Others application of milling is the fabrication of tooling for other processes. An example of this is complex three-dimensional (3D) object such as mould making and aircraft turbine making. In Computer Numeric Controlled (CNC), milling is the one from several types of milling machine. This CNC machines now have been used in our industries such as aerospace, automotive, fabrication, instrumentation, machinery, and also mould and die making. Nowadays, this CNC machine from 3-axis and have been improved to 5-axis. Thus, 5 axes milling machine adding two more (A;B) axis in addition to the three normal axis (X;Y;Z). The axis is determined by the modular or combination of axes in the respective machine tools.

Milling is the indicated process when needed to make all the other part that cannot be made on the lathe machining. The demand of low tolerances and better quality product has forced in manufacturing industry to continuously progress in quality

control and machining technology. In 5-axis machining, there are two different methods of tool approach. The first method is by using the face of the tool which occurs in most machining processes and the second method is by using the body, side or shaft of the cutting tool or also known as flank milling.

The 5-axis CNC milling machine is used for produce 3D contours. This machine used typical program alphanumerical data coded. The data represent relative motion position between cutting tool and a work piece. This machine actually flexibility to manufacture a complex or impossible jobs. From this benefit, this machine become widely use in the heavy industry and any application. The major components of this machine are drive units, sliding system, and machine control unit.

This 5-axis milling machine can remove the material to produce a high quality product. The important thing to produce the high quality product is the input parameter and the output characteristics. The factors of input parameter that will influence the final surface roughness; such as spindle speed, feed rate, and depth of cut on control the cutting operation (Boothroyd and Knight, 1989). A product's quality is harder to attain and track than physical dimensions, because relatively many factors affect product surface. Some of these factors can be controlled and some could not.

Nowadays, in the industries, the dimension accuracy and the surface finish need special attention to produce high quality product. In this project, it will investigate about the surface roughness value and dimensional variation on flank cutting condition. Most of the aerospace parts are thin and consist of pockets, flanges, and arc shapes or contours. Flank milling or machining using the body of the tool is very important and needs to focus and concentrate with full attention. After the experiment was done, the effect of tool wear on the face and the body of the tool also can be study. The contour that will be study is the curved shape profile.

1.2 Problem Statement

This 5-axis CNC machine is a new technology for our industries. In getting the high of quality product from this machine is needed to studying about the surface roughness of the product. Most of the works or research so far has focused on the face milling. While the flank milling can provide large productivity gains for such class of surfaces as are found in blades, fans, turbines and other engineering objects. With flank milling the surface can be cut with a single pass, which is more efficient than a point milling method. Thus, this project was initiated to investigate the flank milling machining performance with certain sets of spindle speed, feed rate, and also to investigate the effect on tool wear.

Considering the existing researches in flank milling, most of research spent more attention on the tool path generation, positioning, and optimization of machining accuracy. It is quite difficult to see a research in flank milling that concentrating on the end result of the machining as what had been presented in this project such as effect tool wear, surface roughness and dimensional accuracy. The number of research found for analysis mentioned was done in five axis machining and were used a different parameter setups.

The relationship between parameter and tool is very close, an example tool life increase rapidly as the cutting speed increase. The tool life will be affected when the cutting speed is slow. When the cutting speed is decreases, the force applied on the product is high and the tool wear will effect quickly. Tool life is often involved with the tool wear reaction that affects the product quality especially on the product surface finish. Beside that there are more differences in tool life for different material.

1.3 Objective of Project

The purposes of this project are:

a) To investigate the influence of spindle speed and feed rate on the surface roughness value and dimensional variation to the flank cutting condition.
b) To study the effect of the tool wears on the face and body of the tool when cutting is performed in flank milling for a curved shape profile.
c) Apply the Design of Experiment (DOE) method in terms of spindle speed and feed rate.

1.4 Scope of project

Using the 5 axis CNC milling machine, this project will analyze the surface roughness and dimensional variation of the curved shape part. During machining, will use different value of spindle speed and feed rate. The project will use Design of Experiment (DOE) method where the type of design is Response Surface Methodology (RSM). Before the project started, parameter that wants to use will be identified and the part modelling will be assisted as known as Computer Aided Design (CAD) using CATIA software. Then the modelling will go through to machining programming called Computer Aided Manufacturing (CAM) also using the same software. Machining test for this project was carried out by using DMU 60 MonoBlock multi-axis CNC machine. The material used is Aluminium and the cutting tool use has a 25mm cutting length. After done machining, the machined part will be analysed about the surface roughness using portable surface roughness tester, dimension variation using Coordinate Measuring Machine (CMM), and tool wear using optical microscope. The result from this project will be record and analysed. The flow chart of this project is at the Figure 1.1.

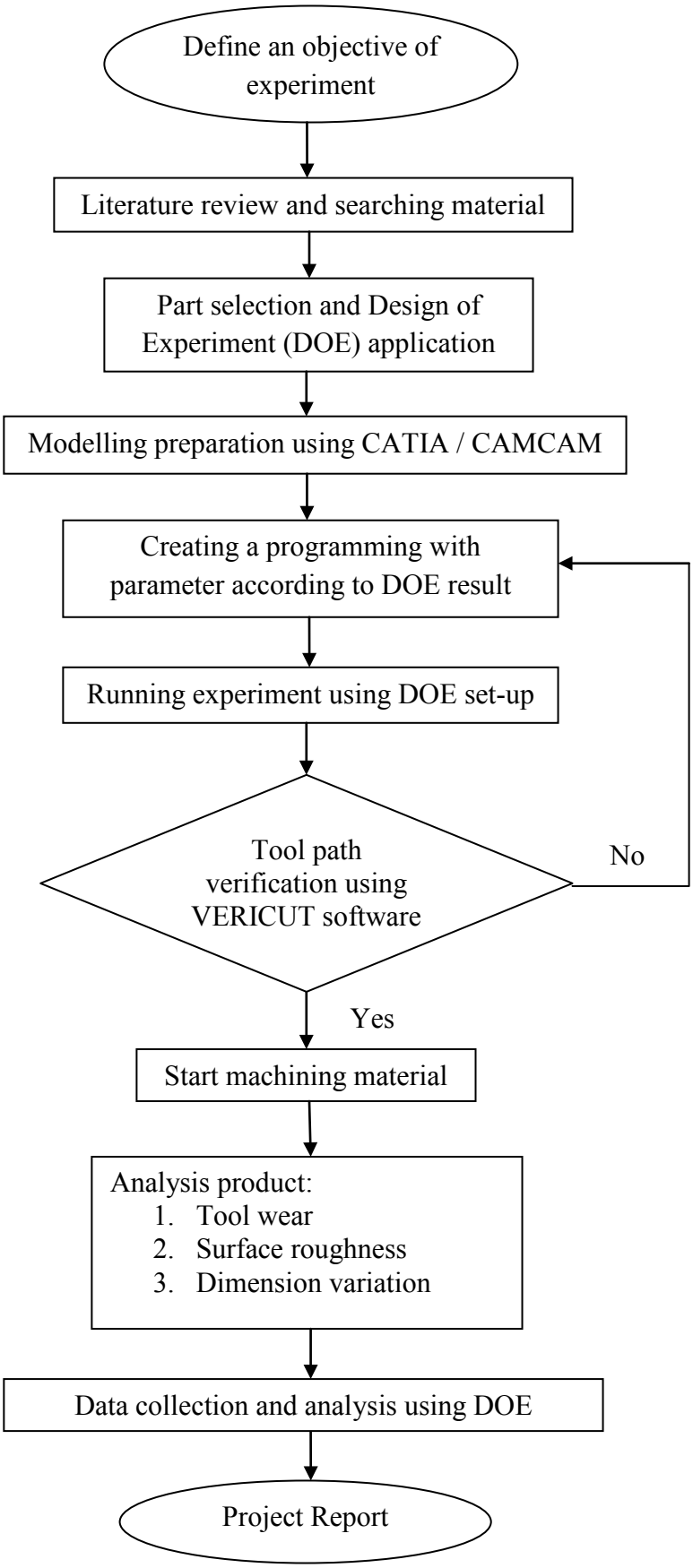

Figure 1.1: Project flow chart.

1.5 Structure of the Report

This report is for completing the 'Projek Sarjana Muda' (PSM) with contain chapter 1 until chapter 6 only. The chapter 1 until chapter 3 was done by last semester and for PSM 2 on this semester consist of chapter 4 until 6.

Chapter 1: This chapter was included about the title of this project, problem statement, objective of this project, and scope of the project. This will be a guideline for complete the PSM. In this chapter, there are three objective of this project that should be study and find.

Chapter 2: This will define about the literature review about the five axis milling machine. All the process parameter using this machine from the journals and books provided. In the end of this chapter is a summary of literature review is also provided.

Chapter 3: Describe an experimental method of this project including Design of Experiment (DOE), experiment flow, experiment set up and equipment, and technique used. Introduction on some method and approach in selecting an optimize parameters for this experimental research also stated in this report. The conclusion of this chapter would interpret as research flow along this research. The method for this project can see in Figure 1.1

Chapter 4: In this chapter was describing about the result from the analysis data. The data got then will use in Design Expert software. This software then will generate the Graph, Summary, Interaction Plot, Main Effect, and Optimization. Meanwhile, the parameter was used in this project such as spindle speed and feed rate can see from the graph and the best setup also can know. Furthermore, this chapter provides interpretation of experiment result.

Chapter 5: Describe about the response such as surface roughness, dimension variation, and tool wear. All the response will discuss in this chapter, and will describe the initial cause. Additionally, the solutions to prevent the cause also have been described.

Chapter 6: This chapter will describe a conclusion of this research including interpretation of overall research flow. The overall research objectives, scope, findings and discussions also conclude in this chapter. Finally, this chapter provides recommendation of future works.

1.6 Activity Planning

This activity planning will show by using the Gantt chart show in Appendix A and Appendix B. This will show about the time and the work that have been done in PSM 1 and PSM 2. This Gantt chart is a planning or scheduling operation involving in this project. By using this chart, it is easy to understand, even though it may contain information.

1.7 Summary

This chapter is important to run this project. This project had described about the problem statement, objective, scope, the structure of this report. The objectives of this project need to achieve after done this project. The objective of this project had three; firstly, investigate about the surface roughness and dimension variation with using defined parameter setup, secondly, investigate about the tool wear and lastly applying the DOE method. Meanwhile, the project also had a scope to focusing in the certain part that has been described.