# UNIVERSITI TEKNIKAL MALAYSIA MELAKA

## COMPARISON STUDY BETWEEN HSC 70 WITH DMU 60 EVO USING POWERMILL SOFTWARE ON SIMULTANEOUS 5-AXIS MACHINING PART

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

by

**MOHAMAD FARID BIN MAHADI**

**B071410673**

**930922-03-5391**

FACULTY OF ENGINEERING TECHNOLOGY

2017

# DECLARATION

I hereby, declared this report entitled “Comparison Study between HSC 70 with DMU 60 EVO Using PowerMILL Software on Simultaneous Five-Axis Machining Part” is the results of my own research except as cited in references.

**Signature** **:………………**

**Name** **: MOHAMAD FARID BIN MAHADI**

**Date** **: ………………………**

# APPROVAL

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

………………………………

(MR. MUHAMMAD SYAFIK BIN JUMALI)

# ABSTRAK

Dalam kajian ini, maklumat, jurnal dan artikel mengenai tajuk yang "Kajian Perbandingan antara HSC 70 dengan DMU 60 EVO Menggunakan Perisian PowerMILL pada Bahagian Pemesinan Lima-Paksi Serentak" telah dicari dan digunakan untuk pengetahuan dan pemahaman yang lebih baik. Dalam penyelidikan selanjutnya terdapat masalah yang berlaku pada bahagian pemesinan kerana strategi pemesinan dan pasca pemproses. Objektif kajiannya adalah menghasilkan kipas turbin menggunakan dua mesin CNC dan memeriksa ketepatan kipas turbin telah diselidiki. Model kipas turbin CAD telah dipilih dari laman web GrabCAD. Malangnya, model CAD mesti diubahsuaian kerana had mesin CNC dan alat mesin. Kemudian, kipas turbin itu telah direka bentuk menggunakan perisian Solidwork untuk memenuhi had mesin. Aluminium 5053 digunakan sebagai bahan mentah untuk pemesinan kipas turbin. HSC 70 dan DMU 60 EVO digunakan dalam pemesinan kipas turbin dan program pemesinan telah dibuat menggunakan perisian PowerMill. Dalam perisian PowerMill, strategi pemotongan digunakan untuk pemesinan sebahagiannya adalah kasar, pelepasan kawasan model, pelepasan kawasan blaster, penghujung hab, penamat bilah, unjuran permukaan dan penamat permukaan. Selepas proses pemesinan fizikal, kipas turbin itu telah diperiksa menggunakan mesin pengimbas 3D dan metodologinya. Data imbasan dari Pengimbas 3D akan ditukar dalam model 3D. Perbandingan model 3D dan model 3D imbasan telah dibandingkan menggunakan perisian Geomagic Control X. Sesetengah cadangan telah dibuat untuk memperbaiki kajian ini pada masa akan datang. Cadangan adalah batasan kaedah dan kaedah analisis.

# ABSTRACT

In this study, information, journal and articles regarding the title which is “Comparison Study between HSC 70 with DMU 60 EVO Using PowerMILL Software on Simultaneous Five-Axis Machining Part” have been searching and used for better knowledge and understanding. In further research, some problem occurred on machining part due to machining strategy and post-processor. The objective of this study is producing impeller using two CNC machine and inspect the accuracy of the part machined have been investigated. Impeller CAD model has been selected from GrabCAD website. Unfortunately, the CAD model must be made major modification due to the limitation of the CNC machine and machine tools. Then, the impeller has been designed using Solidwork software to fulfill the limitation of the machine. Aluminium 5053 is used as raw material to machine impeller. HSC 70 and DMU 60 EVO is used in machining impeller and the machining program been created using PowerMill software. In PowerMill software, cutting strategies been used to machine the part is roughing, model area clearance, blisk area clearance, hub finishing, blade finishing, surface projection and surface finishing. After physical machining processes, the part has been inspecting using 3D Scanner machine and its methodology. The scan data from 3D Scanner be converted in the 3D model. The comparison of 3D model and scan 3D model been compared using Geomagic Control X software. Some recommendations have been made to improve this study in future. The recommendations are limitation of tools and analysis method.

Keyword: Impeller, CNC machine, PowerMill, 3D CAD model.

# DEDICATIONS

I dedicate my dissertation work to my family and all my friends, A special feeling of gratitude to my loving parents, Mahadi Bin Ishak and Maskah Binti Saleah whose word of encouragement and always give positive vibes whenever I in depress. My brother Mohamad Faizal Bin Mahadi that always support and give encouragement to proceed with the thesis. I also dedicate my dissertation to all my friends that support and contributed some of the ideas for this research. Thank you for everything.

# ACKNOWLEDGMENTS

I would like to express deepest gratitude to my supervisor Mr. Muhammad Syafik B. Jumali for her full support, expert guidance, understanding and encouragement throughout my study and research. Without her incredible patience and timely wisdom and counsel, my thesis work would have been a frustrating and overwhelming pursuit. In addition, I express my appreciation to Mr. Syahrul Azwan Bin Sundi@Suandi for becoming the co-supervisor. His thoughtful question and comments were valued greatly.

Thanks also go to my fellow friends at the Faculty of Technology Engineering of University Technical Malacca. Special thanks go to them who helped me throughout this academic exploration.

Finally, I would like to thank my parents, sisters, and brother for their unconditional love and support during the last two years. I would not have been able to complete this thesis without their continuous love and encouragement.

# TABLE OF CONTENTS

# LIST OF FIGURES

# LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURES

| | | |
|---|---|---|
| CAM | = | Computer Aided Manufacturing |
| CAD | = | Computer Aided Design |
| 3D MODEL | = | Three-Dimensional Model |
| 2D | = | Two-Dimensional |
| NC | = | Numerical Control |
| CNC | = | Computer Numerical Control |
| IGES | = | Initial Graphic Exchange Specification |
| STEP | = | Standard Exchange of the Product Model |
| STL | = | Standard Triangle Language |
| UTEM | = | Universiti Teknikal Malaysia Melaka |
| CMM | = | Coordinate Measuring Machine |
| MPF | = | Media Package File |

# CHAPTER 1

# INTRODUCTION

## 1.1 Background Study

In the era of technology rapidly developing, many machines have been created to fulfill a human need, reduce human efforts and improve production efficiency and productivity. Machining operation was divided into two type that is conventional machining and non-conventional machining. Many industries today using a machine that can be controlled by computers. This is because to reduce defects products and produce high quality of products. But, these machines are very costly. It also needs high skill workers to operate this machine. This machine advantage is it can reduce production time, reduce defects, and can have a high accuracy of machining parts.

Advanced manufacturing typically offers competitive wages, contributes handsomely to regions gross regional product, and offers job opportunity for workers with a wide variety of education and skills including many middle-skill jobs. Because of that, professionals on workforce development, economic development, and higher education are fighting to make their community well suited for advanced manufacturing. Advanced Manufacturing technology is a family of activities that depend on the use and coordination of information, automation, computation, software, sensing, and networking, and make use of cutting-edge materials and emerging capabilities enabled by the physical and biological sciences, for example, nanotechnology, chemistry, and biology.

Computer Numerical Control (CNC) is an automation machine which is been controlled by NC-code program. NC code is computer language that the CNC machine can understand and execute. This language was developed originally to machine parts directly to what that has been settings by the programmer. This code will be created using CAD/CAM software. CNC is the complexity of high accuracy in the minimum that commonly used in the today's world. CNC also can be controlled in term of feed rate, spindle speed and the axis of this machine.

CAD/CAM software stands for Computer Aided Design/ Computer Aided Manufacturing are very important in advanced manufacturing today. CAD is a software to design products such as electronic, aerospace parts and automobile parts. From CAD design, the 3D computer model data will be converted to appropriate CAM format. CAM is a software to create tool paths and NC code to run a CNC controlled machine. In CAM software, the cutting strategy can be settings to reduce tools wear and avoid cutting marks on the machined part.Nowadays, these are an example of CAD and CAM software that commonly used in manufacturing such as CATIA and SolidWorks by Dassault Systemes. Another example is Inventor and PowerMill by Autodesk.

Turbine Blade or Impeller has a complex geometry that cannot be machined by using only 3-axis machining or any other method of machining. An impeller usually made from of iron, steel, bronze, brass, aluminium and plastic. The traditional process to create an impeller is using casting process. The metal has been melted to a high temperature to be in molten state. The molten metal will be poured into the mold that has formed to shape an impeller. However, the fabrication of turbine blades by investment casting is a very complex process, and the shrinkage during casting is highly nonlinear (Yiwei et al., 2017).

Aluminium is used in huge variety of products such as cans, foil, kitchen utensil, window frames and aerospace industries. This is because aluminium has high thermal conductivity and high corrosion resistance. Aluminium is soft and ductile that can be easily machined. Aluminium is the most abundant metal in the Earth's Crust more than 8.1% but rarely found uncombined in nature. It usually found in minerals such as bauxite and cryolite is called aluminium silicates. Aluminium is anti-rust or corrosion resistance and lightweight are very suitable for aerospace and ship production.

## 1.2 Problem Statement

Nowadays, technology became one of the country economy or worldwide business. A product that is created from manufacturing technology being import or export to increase country economy. So that, many machines to create these product has been imported. There are so many five-axis machines be created these days such as Mazak, Kitamura Five-axis machine, and DMG Mori. Most of the people know about the existence of this machine, but they do not know truly how many they were created. Five-axis machine has several of the models that have a different configuration and different machining command.

Turbine blades or impeller has a very complex geometry that hard to be machined. The blade has very thin layer and curvature from bottom to top. Although this impeller can be made using casting process, it has a bad surface finish. It also has crack and porosity because of the casting process. Many processes have to be done to make the perfect product of impeller. It will increase production time and cost.

This project is to determine the better machine to machine impeller. The machine that has been selected is HSC 70 and DMU 60 EVO. Both of machine is five-axis machine or multi-axis machine that have high accuracy machining. But, there has a different configuration in term of machining axis. So that, comparison to determine which machines produce better results in term of dimensional accuracy for an impeller.

## 1.3 Objectives

The project objective that has been determining are:

1. To machine impeller using HSC 70.
2. To machine impeller using DMU 60 EVO.
3. To compare the dimensional accuracy of both machines.

## 1.4 Scope

Scopes for this project is based on objectives that have stated and there are the several scopes that will be carrying out:

1. The machine that will be compared is DMU 60 EVO and HSC 70 linear.
2. Programming (CAM) will be done using PowerMILL Software with customized postprocessor.
3. Machining part is impeller machined on Aluminium.

# CHAPTER 2

# LITERATURE REVIEW

In this chapter are about all finding that been obtained from many sources such as a journal, article, books, the internet and the topic that related to this study. The finding is the guideline to complete this study. This section includes the five-axis machining, aluminium and turbine blade.

## 2.1 Five-Axis Machining

Five-axis CNC machine tools perform precision machining of complex features in automotive, aerospace and power generation industries to cope with strict quality requirements(Nojehdeh and Arezoo, 2016) Nowadays, many companies such as aerospace and automobile were using five-axis machining for production. Although it is bit expensive, it much worth in term of time, product quality and production quantity. This project is to study the configuration or post-processor for the five-axis machine. This study also is to approve the accuracy and good surface finish on the selected machining part that is turbine impeller with the design product. Many researchers have a study to improve the behavior of five-axis machining in term of machining quality. CNC machineability is to move a part or a tool on five different axes at the same time. Three-axis machining centers move in two directions (X and Y), and the tool moves up and down (Z). Five-Axis machining centers can rotate on two additional rotary axes (A, B and C) which help the cutting tool approach the part from all directions.

Descartes was lying in bed (as mathematicians and philosophers are wont to do) when he observed a fly buzzing around his room. Descartes recognized that he could describe the fly's position in the room's three-dimensional space using just three numbers, embodied by the variables X, Y and Z. (Rene Descartes, 1569-1650).

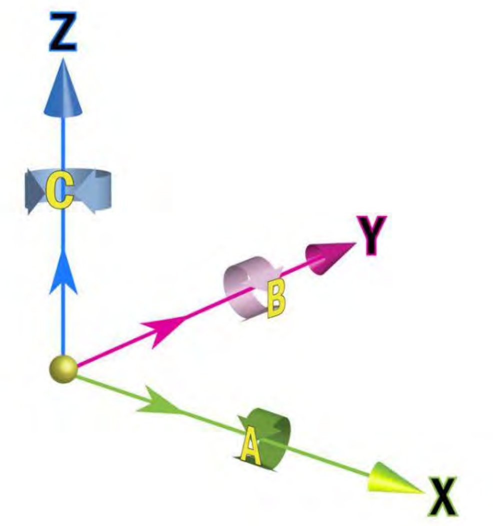


Figure 2.1 Cartesian Coordinate system
(Adapted from Hurco North America)

Five-axis machining can machine a complex geometry part such an impeller or propeller. Five-axis machine can almost machine the part in all direction. The tool can be programmed to lead and tilt to cut curvature part. The focus of five-axis machining machine is to improve productivity and product quality. It also fully auto machine that can be set up by the operator. The NC-code of the part to be machine can be created using CAD/CAM software. In a traditional way to make a complex geometry is using conventional machine or process such as casting, forging, and metalworking. Even though it cheap, casting has a rough surface finish and not achieve the product target. It also takes the time to make many products. To make the smooth surface, the operator will use another machine such as milling machine and many another machine. So that, it will increase product expenses.

### 2.1.1 DMG Mori HSC 70 Linear

HSC 70 linear is the five-axis that is created to reduce human effort and easy to machine a single part in less time. The machine is more precision and has better surface quality for the die and mold industry. The thermo symmetric machine bed in bridge type design forms the basis for highest long-term accuracy. This will be further amplified by the innovative cooling concept. New HSC spindles with shaft, flange and jacket cooling ensure thermal stable process conditions and an up 70 % lower axial tool expansion.

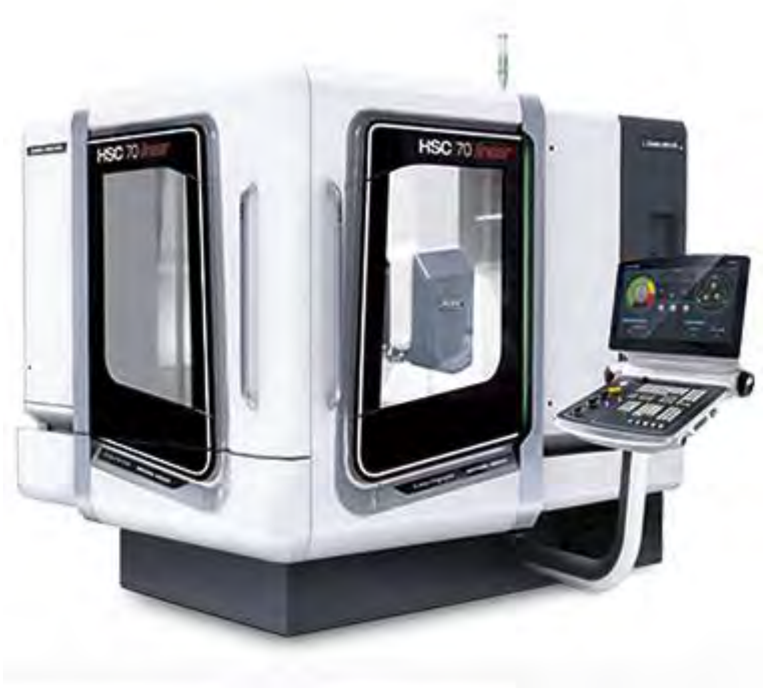


Figure 2.2(a): HSC 70 Linear
(Adapted from http://en.dmgmori.com)

The machine has highest long-term accuracy less 15 µm innovative cooling concept and thermo symmetric design. The machine also has better surface quality Ra > 0.15 by HSC spindles with the shaft, flange, and jacket cooling. HSC 70 has linear motors in all axes in the standard version for highest dynamics and precision. (Adapted from http://en.dmgmori.com) The machine also has NC table and pivoting spindle is the integrated five-axis solutions.