



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

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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.

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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.

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TABLE OF CONTENTS

DECLARATION	ii
APPROVAL	iii
ABSTRAK	iv
ABSTRACT	v
DEDICATIONS	vi
ACKNOWLEDGMENTS	vii
TABLE OF CONTENTS	viii
LIST OF FIGURES	xi
LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURES	xvii
CHAPTER 1	1
INTRODUCTION	1
1.1 Background Study	1
1.2 Problem Statement	3
1.3 Objectives	1
1.4 Scope	1
CHAPTER 2	2
LITERATURE REVIEW	2
2.1 Five-Axis Machining	2
2.1.1 DMG Mori HSC 70 Linear	4
2.1.2 DMU 60 EVO Linear	6

2.2	Toolpath Generation	7
2.3	CAD/CAM	8
2.3.1	Autodesk PowerMILL	9
2.4	Ball-End Milling Machining	10
2.5	Turbine Blade	12
2.6	Coordinate Measuring Machine (CMM)	14
2.6.1	Coordinate Measuring Machine Probe	15
2.6.2	Measurement strategies	17
2.7	Aluminium	18
CHAPTER 3		21
METHODOLOGY		21
3.1	Project Planning	22
3.2	Phase I	24
3.2.1	Problem Simulation	24
3.2.2	Literature Review to Better Understand the Study.	24
3.2.3	Searching and Draw Suitable CAD Model	25
3.2.4	Import the 3D Model into PowerMILL Software	26
3.3	Phase II	27
3.3.1	Material and Suitable Cutting Tool	27
3.3.2	Preparation of CAM Program	29
3.3.3	Jig and Fixture Preparation	40
3.3.4	Post-Processing	41
3.3.5	Physical machining	42

3.3.6 Dimensional Analysis	43
CHAPTER 4	46
RESULT AND DISCUSSION	46
4.1 Result	46
4.2 Data Analysis for Turbine Blade Machined by DMU 60 EVO	49
4.3 Data Analysis for Turbine Blade Machined by HSC 70	57
4.4 Comparison analysis of Both Machine Part	65
4.5 Machined Part Problem	69
CHAPTER 5	71
CONCLUSION AND FUTURE WORK	71
5.1 Conclusion	71
5.2 Future Work	72
REFERENCES	73
APPENDICES	76

LIST OF FIGURES

Figure 2.1 Cartesian Coordinate system	3
(Adapted from Hurco North America).....	3
Figure 2.2(a): HSC 70 Linear	4
(Adapted from http://en.dmgmori.com)	4
Figure 2.2(b): HSC 70 Linear Controller and Monitor	5
(Adapted from http://en.dmgmori.com)	5
Figure 2.3: DMU 60 EVO Linear	6
(Adapted from http://en.dmgmori.com)	6
Figure 2.4: (a) Original tool orientation (b) tool orientation after optimize	7
(Adapted from (Hu et al., 2016))	7
Figure 2.5(b): Cutter Contact, Cutter location and cutting tool reference point.	8
(Adapted from (K and Lazoglu, 2017))	8
Figure 2.6: shown that iso-scallop for curvature part	9
(Adapted by (Lin et al., 2014))	9
Figure 2.7(a) shown the cutting of Ball End Mill.....	10
(Adapted from (Chao and Altintas, 2016))	10
Figure 2.7(b): Ball-End Mill on the curve	11

(Adapted from (Li et al., 2015))	11
Figure 2.7(c): Extraction of entry/exit angles using arc-surface intersection method.	11
(Adapted from (Li et al., 2015))	11
Figure 2.7(d): Toolpath of cutting impeller	12
(Adapted from (Li et al., 2015))	12
Figure 2.8(a): Blade after roughing without finishing.	13
(Adapted from (Arriaza et al., 2017))	13
Figure 2.8(b): Toolpath for machining mesh of blade	13
(Adapted from (Vavruska, 2016))	13
Figure 2.9(a): The axis of Coordinate Measuring Machine	14
(Adapted (Ferreira et al., 2013))	14
Figure 2.9(b): CMM measuring Table and Coordinate.	15
(Adapted from (Sudatham et al., 2016))	15
Figure 2.10(a): Universal high precision reference spheres, silicon nitride (left) and quartz glass (right).	16
(adapted from (Thalmann et al., 2012))	16
Figure 2.10(b): Probe Direct contact on curve surface	16
(Adapted From (Wang et al., 2017))	16
Figure 2.11: General flow Chart to present work	17
(Adapted from (Rajamohan et al., 2011))	17
Figure 2.12: Designations for alloyed wrought and cast aluminium alloys.	20

(Adapted from http://www.azom.com)	20
Figure 3.1 Flow Chart Methodology	22
Figure 3.2: 3D CAD Model.....	26
Figure 3.2 (a): Block Setting Toolbar	26
Figure 3.2 (b): Cylinder Block	27
Figure 3.3: Detail Regarding Cutting Tool	29
Figure 3.4: List of Tool Used	29
Figure 3.5(a) Setting of Coordinate system	30
Figure 3.5(b) Flow Chart of CAM Machining Processes	31
Table 3.6: Setting of First Roughing Process.....	32
Table 3.7: Setting of Second Roughing Process	33
Figure 3.8(a) : First Roughing	33
Figure 3.8(b) : Second Roughing	34
Figure 3.9: Model Area Clearance Setting.....	34
Figure 3.10: Model Area Clearance.....	35
Figure 3.11: Blisk Area Clearance Setting.....	35
Figure 3.12 Blisk Area Clearance.....	36
Figure 3.13 Hub Finishing Setting.....	36
Figure 3.14 Hub Finishing	37
Figure 3.15: Blade Finishing Setting	37
Figure 3.16: Blade Finishing	38

Figure 3.17 Surface Projection Setting	38
Figure 3.18 Surface Projection	39
Figure 3.19 Surface Finishing Setting	39
Figure 3.20 Surface Finishing	40
Figure 3.21(a): LANG Makro Grip Vice 125	40
Figure 3.21(b): Vice Detail Drawing	41
Figure 3.21(c): Turbine Blade Attached To Vice	41
Figure 3.22: NC Program	42
Figure 3.23 Cylinder Block with the slot.	43
Figure 3.24(a) Applied Spraying Substance on Turbine Blade (HSC 70).....	44
Figure 3.24(b) Applied Spraying Substance on Turbine Blade (DMU 60 EVO)	45
Figure 3.24(c) 3D Scanner Machine	45
Figure 4.1 Result of CAM Program Simulation.....	46
Figure 4.2(a) Physical Machining Result Using HSC 70	47
Figure 4.2(b) Physical Machining Result Using DMU 60 EVO	47
Figure 4.3(a): Result of 3D Scanner for HSC 70	48
Figure 4.3(b): 3D Scanner result for DMU 60 EVO	48
Figure 4.4 Reference Data.....	49
Figure 4.5 Measured Data	50
Figure 4.6 Initial Alignment	50
Figure 4.7 Comparison Accuracy of 3D CAD Model And 3D Scanner Model	51

Figure 4.8: 2D Compare Section	52
Figure 4.9: Point Taken at Section 1.....	52
Figure 4.10 Point Taken at Section 2.....	53
Figure 4.11 Point Taken at Section 3.....	53
Figure 4.12 Gap Thickness of the Blade Surface for Section 1	54
Figure 4.13 Error Bar Chart for Section 1.....	54
Figure 4.14 Gap Thickness of the Blade Surface for Section 2	55
Figure 4.15 Error Bar Chart for Section 2.....	55
Figure 4.16 Gap Thickness of the Blade Surface for Section 3	56
Figure 4.17 Error Bar Chart for Section 3.....	56
Figure 4.18 Reference Data.....	57
Figure 4.19 Measured Data	58
Figure 4.20 Initial Alignment	58
Figure 4.21 Comparison Accuracy of 3D CAD Model And 3D Scanner Model.....	59
Figure 4.22: 2D Compare Section	60
Figure 4.23: Point Taken at Section 1	60
Figure 4.24: Point Taken at Section 2.....	61
Figure 4.25: Point Taken at Section 3.....	61
Figure 4.26: Gap Thickness of the Blade Surface for Section 1	62
Figure 4.27: Error Bar Chart for Section 1.....	62
Figure 4.28: Gap Thickness of the Blade Surface for Section 2	62

Figure 4.29: Error Bar Chart for Section 2.....	63
Figure 4.30: Gap Thickness of the Blade Surface for Section 3	63
Figure 4.31: Error Bar Chart for Section 3.....	64
Figure 4.32: Overall Gap Thickness of DMU 60 EVO Machined Part.....	65
Figure 4.33: Error Bar Chart of Overall Gap Thickness for DMU 60 EVO Machined Part.....	66
Figure 4.34: Overall Gap Thickness for HSC 70 Machined Part.....	66
Figure 4.35: Error Bar Chart of Overall Gap Thickness for HSC 70 Machined Part.....	67
Figure 4.36: Comparison for Both Machined Part	67
Figure 4.37: Comparison Bar Chart for Both Machined Part	68
Figure 4.38: Machined Part Problem for DMU 60 EVO.....	69
Figure 4.39: Hub Finishing and Blade Finishing Tolerance Setting	69
Figure 4.40: Machined Part Problem for HSC 70	70

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).

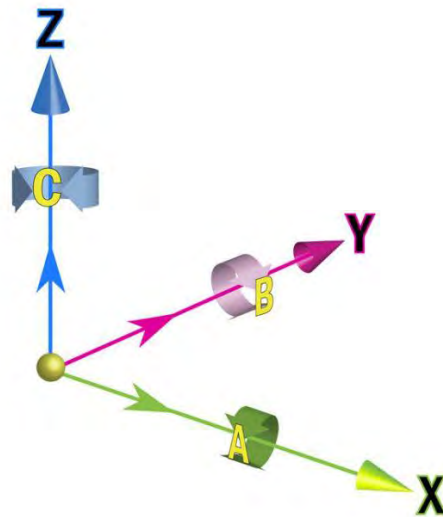


Figure 2.1 Cartesian Coordinate system
(Adapted from Hurco North America)

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 $R_a > 0.15$ 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.