UNIVERSITI TEKNIKAL MALAYSIA MELAKA

ACCURACY STUDY OF IMPELLER ON FIVE-AXIS AND NINE-AXIS MACHINE BY USING POWERMILL AND CATIA

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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FACULTY OF ENGINEERING TECHNOLOGY
2017

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

TAJUK: **Accuracy Study of Impeller on Five Axis and Nine Axis Machine by using PowerMILL and CATIA**

SESI PENGAJIAN: **2017/18 Semester 1**

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ABSTRAK

Pada zaman yang moden ini, pelbagai jenis mesin CNC dapat diperoleh dalam pasaran dan mesin CNC terbaru adalah mesin CNC dengan sembilan paksi. Tujuan membuat kajian ini adalah untuk mengkaji ketepatan mesin CNC lima paksi dan mesin CNC sembilan paksi dengan menghasilkan produk yang sama dalam parameter yang sama tetapi dengan cara pemesinan dan perisian CAM yang berbeza. Cara untuk membuat kajian ini adalah menggunakan perisian CAM yang berbeza sebagai pengantaraan. PowerMILL adalah digunakan untuk mesin CNC lima paksi manakala CATIA adalah digunakan untuk mesin CNC sembilan paksi. Pendesak yang mempunyai permukaan geometri yang kompleks telah dihasilkan oleh kedua-dua mesin. Mesin 3D scanner digunakan untuk menganalisis dimensi pendesak yang dihasilkan. Keputusan yang diperolehi telah ditafsirkan dan perbandingan prestasi ketepatan antara kedua-dua keputusan telah dibuat. Berasaskan keputusan perbandingan yang didapatkan, ketepatan PowerMILL program adalah 75.80% dalam toleransi manakala ketepatan CATIA program adalah 36.80% dalam toleransi.

Kata Kunci: Ketepatan; Pendesak; Mesin CNC Lima Paksi; Mesin CNC Sembilan Paksi; Perisian CAM;

ABSTRACT

Today there are many type of CNC machines in the market and the latest CNC machine is nine-axis turn/mill machine. The purpose of this paper is to study the accuracy on five-axis and nine-axis CNC machine by produce a same part with same parameter but different cutting strategies and CAM software. The method use to study accuracy of machine is by using different CAM software as the post processor. PowerMILL is used for the five-axis machine while CATIA is used for the nine-axis machine. Impeller, which has a complex geometry surfaces is produce by both machines. 3D scanner machine is use to analyse the accuracy of impeller produced. The result obtained is interpret and comparison accuracy of both results are made. Based on the comparison, the accuracy of the CAM program of PowerMILL, which is 75.80% in the range of tolerance, is more accurate than the CAM program of CATIA, which is 36.80% in the range of tolerance.

Keywords: Accuracy; Impeller; Five-axis machine; Nine-axis machine; CAM software;

DEDICATION

To my beloved parents

ACKNOWLEDGEMENT

Firstly, I would like to thanks to my university, University Teknikal Malaysia Melaka (UTeM) giving me the opportunity to do this project. I had gained much of knowledge when doing this project.

Next, I would like to thanks to my supervisor, Mr Muhammad Syafik Bin Jumali, who help me much when doing this project. When I had confuse in my project, my supervisor had guide me and motivated me to do the project in the right way.

I also like to take this opportunity to thank to all lab assistance in UTeM. With the help of the lab assistance, I had complete my project smoothly.

Lastly, I would like to thank to my beloved family and friends that always encourage and support me toward this project.

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CAD	-	Computer-Aided Design
CAM	-	Computer-Aided Manufacturing
CATIA	-	Computer Aided Three-dimensional Interactive Application
CL	-	Cutter Location
CMM	-	Coordinate Measuring Machine
CNC	-	Computer Numerical Control
DWG	-	Drawing
DXF	-	Drawing Exchange Format
IGES	-	Initial Graphics Exchange Specification
NC	-	Numerical Control
STEP	-	Standard Exchange of the Product Model
STL	-	Standard Triangle Language

Chapter 1
Introduction

1.0 Introduction

In this chapter, it discussed the background of the CNC machines and CAM software used, the problem meet during the research, the objective of the project, and the scope of the project.

1.1 Background

Nowadays, CNC machines have wider range of used in most industries, from small workshops to big factories. Industries that used CNC machine widely are metal removal industry, fabrication industry, mechanical industries and others. CNC in CNC machine stands for Computer Numerical Control, which mean the machine need a computer to control it.

At present, there are many CNC machine manufacturer in the market. One of the famous CNC machine manufacturer is DMG Mori. DMG Mori Company is one of the largest manufacturer of metal cutting machine and top manufacturer of CNC-controlled Turning centres and Milling machines. Products introduce by DMG Mori are CNC machine equipped with latest technology like lathes, milling machines, advanced technologies, Software Solutions and Systems.

Five-axis and nine-axis CNC machine have wider range of used in mechanical industry. This is because of the ability of the machines to produce the parts with complex geometries well and obtain better dimensional accuracy. The motion for five-axis and nine-axis CNC machine is almost same but nine-axis CNC machine have the additional spindle and tailstock, which allow movement of A-axis, Z2-axis, X2-axis and C2-axis. Both of the programming of machine need a CAM software as a

postprocessor to convert the Cutter Location (CL) data to machine control data (NC data).

Model of five-axis CNC machine available in UTeM is HSC 70 linear invent by DMG Mori. HSC represent high-speed precision cutting centres and it provide a new dimension of high-speed machining. Linear refer to linear drives in all axes that provide maximum dynamic and thermal stability while enabling minimum machining times, desired surface quality with Ra less than 0.15 µm and the highest dimensional accuracy. Further to highly dynamic linear drives and the new performance spindles with shaft, flange and jacket cooling, the thermo-symmetrical design and unique cooling measures ensure maximum precision and productivity. The new HSC range also attempt the greatest manufacturing solution for every application while maintaining high standards of quality. The new-look design of the machines from DMG Mori allows the perfect visual backdrop for show casing that help produce perfect components.

Model of nine-axis CNC machine available is NTX 1000 invent by DMG Mori. NTX 1000 is a "all-rounder" machine with high accuracy, high efficiency machining of complex shaped work piece in the aircraft, medical equipment, automotive, die and mould, and precision equipment industries. The excellent combination of turning centre and a machining centre in the machine provides process integration for various machining from high- mix, low-volume production to mass production, and bringing a great profit to industrial.

Today, many commercial available CAM software for five-axis machining such as CATIA, Delcam's PowerMILL, Mastercam and Open Mind's hyperMILL. For nine-axis machining, CAM software available are CATIA, EdgeCAM, SolidCAM and Mastercam. Even through there are many CAM software in the market, but there are no one of the software can use for every CNC machine. For example, Delcam's PowerMILL as its name PowerMILL, it only can use for CNC milling machine but cannot for CNC turning machine.

PowerMILL is CAM software developed by Delcam Plc. It is one of the world leading CAM software in two-axis, three-axis and five-axis machine for complex shapes, allowing advanced machining strategies to minimize machining time and maximize finish quality. There are some ease provided by PowerMILL for five-axis programming which are 3+2 machining, simultaneous five-axis machining strategies,

and five-axis rest finishing. According to Rick Hecker, Eifel, he says that PowerMILL is the best because with PowerMILL and its features, he able to machine undercuts in far less setups and save a lot of machining time.

CATIA is the world's engineering and design leading software developed by Dassault Systèmes. CATIA stands for Computer Aided Three dimensional Interactive Application and the first release of CATIA is 1977. CATIA allows user to do 2D and 3D design, allows manufacturing processes to be designed for 3D model manufacture, and allows verification through analysis of 3D models. Currently, the latest version of CATIA is level 6 or known as CATIA V6. CATIA brings significant additional functionality for each version. The fundamentals to the design process were developed in between V4 and V5 while the handling of data changed in between V5 and V6.

Impellers are commonly used in energy generator, aerospace crafts, and petrochemical equipment and so on. The shape of an impeller is too complicated for three-axis machining due to the collision between tool axis and impeller blades. Therefore, five-axis machining is the best choice to machine impeller because the five-axis machine able to adjust the tool twisting angle to proper location and prevent the collision with the impeller blades. (Liang et al. 2008)

1.2 Problem Statement

Currently, five-axis CNC machine is mostly use in industry compare to other machines such as three-axis and four-axis CNC machine. The new invent technology, which is nine-axis had been launch in the market and some improvement had made in nine-axis CNC machine. The capabilities of five-axis and nine-axis are almost the same. Both of the machines are five-axis simultaneously machining. The difference are five-axis machine is in milling while nine-axis machine is in turning base. Besides, nine-axis machine has the additional axes, which are X2, Z2, A, and C2 axis.

Impeller is used as the prototype because of the complex shape of the impeller. In previous study, impeller is machined by three-axis machine but it cause the collision of the tool axis with the blade of impeller. Therefore, to machine an impeller, five-axis machining is needed.

1.3 Objective

The objective of this project are:

i. To study the accuracy on five-axis and nine-axis machine by produce a same part with same parameters but different cutting strategies and CAM software, which are PowerMILL and CATIA.

ii. To compare the accuracy of the impellers in transferring the programs from PowerMill and CATIA to the actual parts.

1.4 Scope

In this project, things included and excluded for the research are discuss. This project is mainly focus on the accuracy of CNC machine by using different CAM software, which are PowerMILL and CATIA. Impeller as the part produced by both machine with same parameter to compare the accuracy of machines. Things that not included are the cutting strategies and cutting tools. The CAD model of impeller is create and check by adviser to ensure the smallest dimension of impeller are able to be machine with suitable cutting tools. The material of the stock is aluminium. Two stocks, which are aluminium block and aluminium cylinder, are use for different machine for machining process. The dimension of the impellers are analyse by using 3D Scanner after physical machining. The results obtained are analyse and accuracy dimension of both impeller are compare.

Chapter 2

Literature Review

2.0 Introduction

In this chapter, the key word in the title, which are accuracy, impeller, five-axis machine, nine-axis machine, and CAM software will be describe with some information from journals, books, articles, and websites. With the information collected, the understanding about the title is more clearly.

2.1 Accuracy

In general, accuracy defined as the degree of agreement of the measured dimension with its true magnitude. While in CNC machine, accuracy classified as positioning accuracy, repeat accuracy, and resolution. Positioning accuracy in CNC machines defined as how accurately the machine can be positioned with respect to a certain coordinate system. Repeat accuracy is defined as the closeness of acceptance of repeated movement in the same operating conditions of the machine. Resolution also called as sensitivity is the smallest difference in dimension of the machine components. Besides, there are some important factor in achieving dimensional accuracy, which are stiffness of the machine tool, and backlash in gear drives and lead-screws. (Kalpakjian and Schmid, 2014)

A study about condition monitoring of CNC tool accuracy with Renishaw equipment is conducted by Naveen Kumar et al. (2013). Based on the study, the accuracy machining is affected by the computer numerically controlled (CNC) machine tools. In early years, the machine tool builder have been improve the machine tool and provided a higher contouring accuracy for multi-axis CNC machine tool. To access the quality and capability of machine tool, calibration is the only comprehensive

indicator. Besides, the accuracy parameter will extremely affects all criteria of machine performance including quick acting, energy efficiency, metal consumption, reliability and durability. From the study, the ways use to improve the accuracy of machine tool are laser calibration and ballbar test. In laser calibration, Renishaw Laser interferometer system are used for accurate calibration of machine tools, coordinate measuring machines and other position-critical motion systems. The movement of CNC machine in direction X, Y, and Z-axis is perform by using the Renishaw laser system. For ballbar test, Quick Check 10 ball, a linear displacement sensor based tool that provides a simple and rapid check of CNC machine tool's positioning is used to measure geometric errors in CNC machine tool and detect inaccuracies cause by its controller and drive system. Figure 2.2 and Figure 2.3 clearly stated the result of quality and productivity after condition monitoring the CNC machine. The finding of the study is the performance of the machine have been improve after condition monitoring and the quality and productivity of process has increased.

Parameters	Particulates
Radius	150.0000mm
Sample rate	19.23Hz
Feedrate	1000 mm/min
Run direction	**CCW/ CW**
Plane under test	**XY**
Start angle	0°
End angle	360°
Overshoot angle	180°

Figure 2.1 Test Parameter of Ballbar Test.

(Naveen Kumar et al. (2013))