UNIVERSITI TEKNIKAL MALAYSIA MELAKA

FIVE AXIS TOOL PATH PROGRAMMING UTILIZING CATIA V5 FOR SINGLE BLADE

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

BY

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DECLARATION

I hereby, declared this report entitled “FIVE AXIS TOOL PATH PROGRAMMING UTILIZING CATIA V5 FOR SINGLE BLADE” is the results of my own research except as cited in references.

Signature : ………………………

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Date : ………………………

APPROVAL

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

……………………………….

(Project Supervisor)

ABSTRAK

Disebabkan perniagaan aeronautic semakin dimemperluaskan, pembuatan enjin aero dengan menuntut produktiviti dan kualiti merupakan satu cabaran bagi bidang pembuatan. Kajian ini membentangkan pergerakan mata alat dengan menggunakan CATIA V5 untuk menghasilkan aeroangkasa bilah tunggal. Pemesinan lima paksi digunakan secara lebih meluaskan dalam pemesinan permukaan yang kompleks. Bahan mentah yang telah digunakan dalam kajian ini adalah aluminium yang telah biasa digunakan dalam pembuatkan komponen pesawat. Deckel Maho DMU 60monoBLOCK adalah pemesinan komputer lima paksi yang kawalan berangka digunakan dalam kajian ini. Secara umumnya, strategi pemesinan utama yang digunakan adalah multi-paksi heliks pemesinan. IMS post processor digunakan untuk menukarkan fail APT ke dalam fail .H. Sementara itu, cara untuk menyelesaikan masalah yang dihadapi semasa kajian ini akan dibincangkan dengan secara teliti. Untuk hasilan analisis, mesin mengukur koordinat digunakan untuk mengukur ketepakan dimensi dengan kaedah fizikal dan secara langsung. Keputusan telah dibincangkan dengan lebih lanjut dengan beberapa faktor yang berkemungkinan menyumbangkan kepada penyebab ketepatan. Antara beberapa faktor yang berkemungkinan adalah berkaitan dengan ketegaran bahan kerja dan getaran semasa proses pemesinan

ABSTRACT

The expanding of the aeronautics business represents a challenge in aero engine manufacturing because of demanding productivity and quality of manufacturing increase. This research presents a tool path utilizing CATIA V5 for aerospace single blade. Five axis machining is widely used in machining of complex surfaces. Raw material used aluminium 6061 as this material is typically use in manufacturing aircraft components. DMG DMU 60 monoBLOCK which is one computer numerical control (CNC) machines is use in this research. Generally, the main machining strategy applied was multi-axis helix machining. IMS post processor to convert APT file into .H file. Meanwhile the way to troubleshoot was further discussed in detail this research. To analysis result, Coordinate Measuring Machine (CMM) is use to measure the dimensional accuracy by physical and directly probing method. The results were further discussed with few possible factors that contributed to result accuracy. Few possible factors mention in this research were strongly believed due to relate with rigidity of work piece and vibration during machining process.

DEDICATIONS

I would like to dedicate to my beloved parents because of encourage me to do better in my life. Not to forget to my friends because of support and help me by giving information and opinion during the study.

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

CNC	-	Computer Numerical Control
CAD	-	Computer Aided Design
CAM	-	Computer Aided Manufacturing
CATIA	-	Computer Aided Three-Dimensional Interactive Application
CMM	-	Coordinate Measuring Machine
CMCs	-	Composite Matrix Composites
NASA	-	National Aeronautics and Space Administration
ALCOA	-	Aluminium Company of America
NC	-	Numerical Control
WPC	-	Work Piece Coordinate

CHAPTER 1
INTRODUCTION

1.0 Introduction

This chapter presents about project background of the proposed research. It also discusses problem statements, objectives, scope and organization.

1.1 Background

Aeronautic is a business in still developing sector and no doubt aircraft is an expensive process. The difficulty of manufacturing complex geometry aircraft parts especially engine part makes most of the components costly. Worldwide air traffic level prediction foresees a quick continuous development, expecting the number of planes to increase at a normal of more than three percent by 2030. The expanding of the aeronautics business represents a challenge in aero engine manufacturing because of demanding productivity and quality of manufacturing increase. (Kappmeyer et al., 2012) Blisk (Figure 1.1) is a turbo machine component that combine of both rotor disk and blades. There is also a design where disk and blades are fabricated in a single piece.

Figure 1.1: Assembled blade

These sharp edge (Figure 1.2) are required to be replace in case there are any damage to the blades beyond minor dents. Blisk can be fabricated by machining from a forged part, cast part or by welding blades to a disk. However, these techniques are usually not suggested in critical application by concern fatigue (Broomfield, 1986). The right way to manufacture components for the aerospace industry is critical, CNC machining allowing for the manufacture of perfect parts within special designed aerospace machining center. Aircraft engines are high technology product, the manufacture of which involves creative techniques. Aero-engines face up to the need of continuous improving of its technical capabilities in terms of achieving higher efficiencies with regard to lower fuel consumption, enhanced reliability and safety.

Figure 1.2: Blisk Blade

1.2 Problem Statement

CAM systems offer a variety of five axis tools path. The general problem with five axis machining is that five axes simply offer too much freedom. Selection of strategies for five axis tool paths is the challenge. The two degrees of freedom for the axis tilts result for any tool path position in an infinite number of correct tilt values which are still collision free but completely different. Finding the optimum angles is important. As a consequence, any CAM system needs parameters by the user in putting constraints to the tool path creation process (Endl and Jaje, n.d.). In addition, even when the combination of machine and control is operating very precisely, there would be contour deviations on the surface if no further measures were taken. Quality control is required to ensure blisk reliable performance. It is a big challenge to obtain high accuracy single propeller blade. Since propeller blades are machined first on one side and then on the other side, it is necessary to flip the propeller. Flipping propeller model on the machining fixture is not accurate enough. Small errors in position and orientation can result in very large errors at the tip and poor alignment between blade face and back surface. Therefore, initial set-up and alignment of rotary table is great importance for five axis machining.

To obtain high accuracy machined part and the way of programmer tailor CAM programming for machined part is a challenge for CAM users. The choice of five axis machining strategy depend on the material, machine, available tools, and holders. Additionally, the limited of the different rotation axes of milling machine should be considered when creating five axis tool path. However, five axis tool path may not run optimal on any machine by default setting.

1.3 Objectives

The objectives of this research are as follows:

a) To create and validate the five axis machining tool paths utilizing CATIA V5 for a single blade.
b) To investigate the effect dimensional accuracy on machined part to be compared to the CAD model.

1.4 Scope

This topic focus on getting the tool paths generation in order to produce at least a single blade utilizing CATIA V5 as the main CADCAM software. Aluminum is the material identified to be used in validating the tool paths for the physical machining. Only aluminium alloy being used in this research, other material not in consideration. Deckel Maho DMU 60 MonoBLOCK five axis machining centre used to perform the machining.

The measurement of machined part had undergo dimensional accuracy analysis to be compared to the original CAD model. Surface finish not be discuss in this research.

CHAPTER 2
LITERATURE REVIEW

2.0 Introduction

Literature review discuss about the relevant information and survey the literature in relevant area of study. At early stage of the studies, gather the reference books, research journals, online article, and magazine as the main sources of thesis guides. Followed by critically analyses the information to ensure that are relevance of this research by showing limitations of theories and points of view. This section included the principle of five axis machining, machining strategies, multi axis helix, multi axis flank machining, dimensional accuracy, and aluminum.

2.1 Five axis Machining

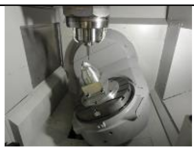
CNC milling machines are usually classified by the number of axis of motion. Literally, a three-axis milling machine able to perform machining process by moving a cutting tool along X, Y, and Z three linear axes. With use of end mill and unique fixture devices the three-axis milling machine can be very flexible and can be used to manufacture various kind of parts. While five axis milling machine is a combination of three linear axes plus two additional rotary axes (either a rotary axis with rotary table, compound rotary table, or a dual rotary axis) and provides flexibility and efficiency that three axis milling machine cannot be achieved. In other words, five axis milling machine able to produce much more complex shape by using a single set up without special cutting tools or fixtures with greater accuracy. Even the twisted impellers, turbine blades and compressor blade found in aircraft turbine engines can be produce by five axis machine. However, to produce a complex geometry parts is still a difficult task although the five axis machining have a lot of advantages and new possibilities. (López, 2005)

It is a challenging task for machining mechanical parts such as turbine blades, impeller and compressor blade with high dimensional accuracy and high geometrical complexity. In order to obtain ideal dimensional accuracy, the incline angle must be keep within the limits. Three-axis CNC are always falls out of the limits, therefore it is much harder to achieve required accuracy. Five axis CNC machining center can be easily corrected the tool position which need extra maintenance and cost. The extra cost can be cover by the benefits of lower tool wear, shorter planning and the quality of work is improved. In addition, five axis machining able to maintain constant cutting forces along the tool path by setting the feed rate which able to reduce machining time significantly. (Layegh et al., 2012).

2.1.1 Five axis CNC Milling Machine Configurations

Basically, machine tool has six degrees of freedom and can by moving tool at any position, while milling machine structure has five degrees of freedom. There are some common machine configuration for five axis that are available in current market. The most common types of five axis machining center are table-table, table-tool, table-tool (turn-mill), and tool-tool.

Table 2.1: Types of five axis machines

i) Table-Table BC type	ii) Table-Tool BC type	iii) Table-Tool BC type (turn-mill)	iv) Tool-Tool AC type
			

The first type of five axis machine is two rotary axes located on the table. B axis tilts around Y axis and C axis rotates around Z axis of the part. While the head is always stationary and linear motion is driven by the head. Its offer better undercut capabilities than other machine configuration.

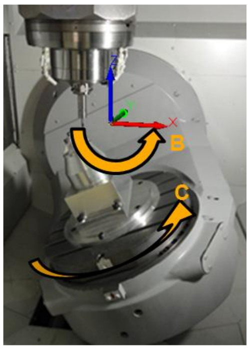


Figure 2.1: Table-Table BC type

The table still rotate in C axis but the head of machine can be tilt.

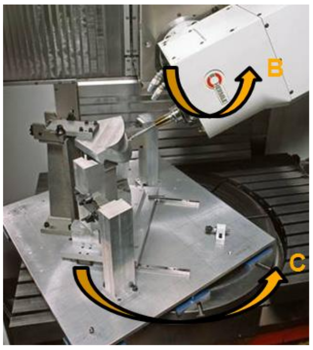


Figure 2.2: Table-Tool BC type

Turn-mill is the combination of milling machining center and turning machining. The turning spindle become the C-axis to rotate the part and the tilting of the tool is driven by the B-axis. The linear axis are located on lathe, with the Z- positioned horizontally along the spindle axis instead of vertically along the tool axis.

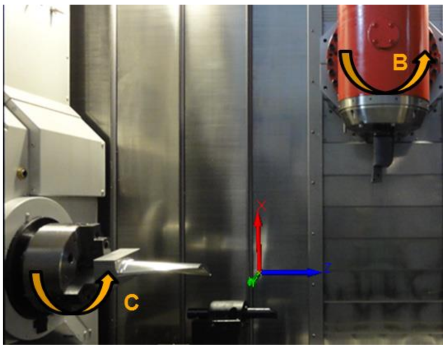


Figure 2.3: Table-Tool BC type (turn-mill)

Both rotary axes are located on the milling head to rotate and tilt the tool into desired position, while the table is stationary for AC type five axis milling machine center. This design allow to machine heavier parts compared to table-table type of machine. Because the table does not tilt, and is suitable for a very rigid setup for larger parts. Furthermore, the rotating head allows to use the shorter length tooling because the tool can enter or rotate around the part. With this, can greatly reduce the vibration of tool and increase the accuracy of parts.

Figure 2.4: Tool-Tool AC type

Every each of them has their own strength that makes them stand out among the choices. Other than the features such as maximum feed rate, spindle speed, automatic tool changers are important as in three axis machines, there are three main issues must considered for machine selection which are rigidity, work volume and accuracy. Rigidity is the need in all milling machining center due to able it to improve the positioning accuracy and higher material removal rates. For the most part, a more rigid machine will be more costly. Large size and hard material required higher rigidity of machine in order to perform well. The working volume of the machine is one of the important issue that define by the range of joint motions. Range of motion determines the maximum size of part and the ability of the cutting tool to access some functions on the part. Accuracy is very critical to machine performance. The phenomenon of positioning errors makes difficulty to predict the accuracy of a machined part.

2.1.2 Advantages of Five axis Milling Machining Center

With expanding the demand for the performance design, mechanical element having complex shape and accuracy are needed to be manufactured in tight tolerances. In manufacturing high end designs, the complex part has to be created by maintaining the dimensional accuracy with minimum number of setups which required tool positioning and contouring capability. Five axis milling has been widely used in automotive, aerospace and die-mold industries. These shapes are known as free form surfaces, which cannot expressed analytically with ease. Precision casting, forming, forging, injection, blowing, pressing and other are the production technologies that can effectively fabricated free form surfaces parts. Today, these complex shapes are possible to produce a complete part with five axis milling centres aided of CADCAM system by only one clamping (Pokorný et al, 2012).

2.2 Machining Strategies

There are several of tool path strategies selection in CAM systems and each of them are appropriate place in five axis. For a particular application, the suitable tool path strategies can be vary. It is depend on programmer experience, lesson learned from the past project and the actual machine configuration will playing the big role in selection. Therefore, different programmers to program a same part, the outcome will be likely to totally different machining strategies. Available tooling and specified material could play a critical role in selection of tool path strategies process.

The selection of machining strategy is very critical in achieving the aim of the research. Machining of turbine engine compressor, there are few universal strategies such as flank milling, point milling and plunge milling, while some local strategies such as zig, zig-zag, helical, raster and trochoidal milling. Munar summarized that five axis operation can be divided into two which is point milling or flank milling. Point milling is remove material by using the tip of the tool and usually applied to machine complex surface. The drawbacks of point milling is time consuming and the surface might require secondary process in order to remove the scallop height. The flank milling is removes material by