UNIVERSITI TEKNIKAL MALAYSIA MELAKA

A STUDY ON MACHINING STRATEGIES FOR THIN-WALLED FIVE-AXIS POCKETING PROFILE; AERO-STRUCTURAL PARTS

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

By

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DECLARATION

I hereby declared this reported entitled “PSM Title” is the result of my own research except as cited in references.

SIGNATURE: ……………………………………

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DATE: 9^{th} DECEMBER 2016

APPROVAL

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

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ABSTRACT

The aerospace industry have growth rapidly and doubled compare to the past decade because of its several advantages to machine parts such as the complexity and intricate aerospace components. Multi-axis flank contouring was the main machining process used in Catia V5 software. The aerospace wing beam with slanted thin-walled was selected to be machined by five-axis CNC machine with two types of machining strategies, namely Combin Parelm and Combin Tanto in Multi-axis flank contouring process. In this study flank milling was the main focused in performing the physical machining instead point milling. Aluminium 6 series (Al 6063) is chosen to be the main material in producing the pocketing profile for slanted thin-walled. The effect of surface roughness and dimensional accuracy were two main analyses carried out at the end of this research. Analysis was carried out by using Mitutoyo surface roughness machine and Contura Carl Zeiss G2 Coordinate Measuring Machine (CMM). From the result obtained, Combin Parelm indicate the best strategy to machine slanted thin-wall pocketing profile due to its dimensional accuracy obtained during the result. The main factors to contribute the Combin Parelm was the tool trajectory while machining thin-wall. The implication of the outcome and suggestion for future work are presented. This article presents an exemplary review in this field study and propose a future development.

Abstrak

Industri aeroangkasa telah membangun dengan pesat dan bercambah dua kali ganda berbanding sedekad yang lalu kerana beberapa kelebihan yang terdapat dalam memesin komponen yang rumit. Kepelbagaian paksi pemotongan sisi merupakan proses permesinan utama yang digunakan di dalam perisian CATIA V5. Rasuk di bahagian sayap aeroangkasa berdidnding nipis serta mempunyai kecondongan telah dipilih untuk dimesin oleh CNC mesin berpaksi lima dengan dua jenis strategi permesinan iaitu, Combin Parelm dan Combin Tanto didalam proses kepelbagaian paksi pemotongan sisi. Di dalam kajian, pemotongan sisi merupakan fokus utama dalam melakukan permesinan fizikal dan pemotongan hujung bukanlah fokus utama. Aluminium 6 siri (Al 6063) merupakan bahan utama yang dipilih untuk menghasilkan profil berpoket berdinding nipis serta mempunyai sudut kecondongan. Kesan kekasaran permukaan dan ketepatan dimensi dua analisis utama yang dijalankan pada akhir kajian ini. Analisis telah dijalankan dengan menggunakan mesin Mitutoyo kekasaran permukaan dan Contura Carl Zeiss G2 Penyelaras Mesin Mengukur (CMM). Dari keputusan yang diperolehi, Combin Parelm menunjukkan strategi terbaik untuk memesin profil berpoket berdinding nipis serta mempunyai sudut kecondongan kerana ketepatan dimensi yang diperolehi semasa keputusan. Faktor-faktor utama yang menyumbang Combin Parelm adalah, trajektori alat semasa pemesinan untuk dinding nipis tersebut. Implikasi keputusan dan cadangan untuk kerja-kerja masa depan dibentangkan. Artikel ini membentangkan kajian teladan dalam kajian lapangan ini dan mencadangkan pembangunan masa hadapan.

DEDICATION

This thesis is dedicated to my beloved father, for earning an honest living for us and supporting and encouraging me to believe in myself and become who I am right here and now.

It is dedicated also to my beloved mother, a strong and gentle soul who taught me to keep trust in Allah S.W.T, believe in hard work will eventually make me success in the future.

I would like to give my deepest gratitude to my kindest supervisor, Mr Syahrul Azwan Bin Sundi@Suandi for his endless support, mentorship and kindness to me throughout in completion of this thesis.

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LIST OF ABBREVIATIONS SYMBOLS AND NOMENCLATURE

CNC	-	Computer Numerical Controller
CAD	-	Computer Aided Design
CAM	-	Computer Aided Manufacturing
CATIA	-	Computer Aided Three Dimensional Interactive Application
CMM	-	Coordinate Measuring Machine
AL	-	Aluminium
CU	-	Copper
AG	-	Silver
LI	-	Lithium
ZR	-	Zirconium
MG	-	Magnesium
ZN	-	Zinc
FE	-	Iron
SI	-	Silicon
CE	-	Cerium
CR	-	Chromium
V	-	Vanadium
MCU	-	Machine Control Unit
DPU	-	Data Processing Unit
CLU	-	Control Loop Unit
EDM	-	Electric Die Machine
V5	-	Version 5
Ra	-	Arithmetic Mean Value
Ry	-	Root Mean Square
Rz	-	Ten point height of irregularities
Rq	-	Maximum roughness height
PC	-	Personal Computer
2D	-	Two dimension

UV	-	Ultra Violet
R	-	Radius
R_1	-	Radius 1
R_2	-	Radius 2
C_a	-	Cutting length
C_p	-	Type of cutting tool
r/min	-	rotation/minutes
mm/min	-	millimetre/minutes
mm	-	millimetre
mm/tooth	-	millimetre/tooth
m/min	-	metre/minutes
rpm	-	rotation per minute
fz	-	feed per tooth
z	-	insert number
vf	-	table feed
n	-	main axis spindle speed
NC	-	numerical controller
Vs	-	versus

LIST OF SYMBOLS

δ = Elastic Deformation of the wall

T = Allowed machining tolerance

µm = Micrometre

σ = Sigma

^{o} = degree

CHAPTER 1

INTRODUCTION

1.0 Introduction

Nowadays, manufacturing a complexity and intricate component by using Computer Numerical Controller (CNC) machining are in a high demand for many industries such as aerospace, automotive, ship maker, die-mould and etc. Jim Adams et al. (2016) stated, commercial aerospace business was inflation due to the backfire in global economies and acceleration of emerging regions. Furthermore, the five-axis milling are the best machine because it tool have two rotational degrees of freedom and other several advantages such as; high accuracy in manufacturing, low in production time, high manufacturing flexibility, adept in contour machining (two to five-axis machining) and decreased human error.

On the other hand, by using five-axis CNC machining, the component to be produced can be achieved it dimensional accuracy and smooth surface roughness. The crucial thing to achieving dimensional accuracy and smooth surface roughness are depended on machining strategies, machining parameters, tools used and etc. There are several type of machining strategies such as flank milling, point milling, and plunge milling. Flank milling, used the side of the tool or body to remove the material, while for point milling, it used the tip or end of tool cutter to perform cutting the material.

The selected machining strategy used in this research was Multi-axis Flank contouring in order to machine slanted thin-walled pocketing profile and achieving dimensional accuracy, smooth surface finish for that particularly slanted thin-walled.

Figure 1.0: Five-axis machining performed for complicated part.

1.1 Background

Five-axis machining has been widely used in aerospace industries for years. Five-axis machining, have been greatly giving advantages to aerospace, automotive and die-mould industries. The advantages of using five-axis machining are shorter production time, better surface finish and able to machining complex part.

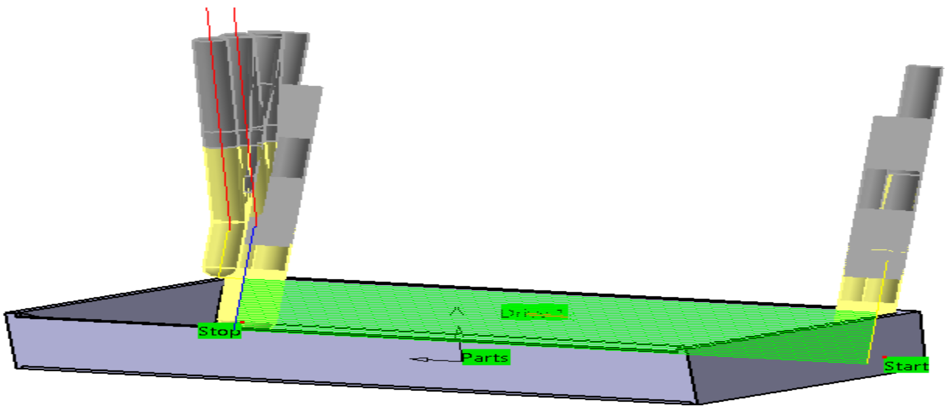

Figure 1.1: Combi Tanto tool paths on slanted thin-wall.

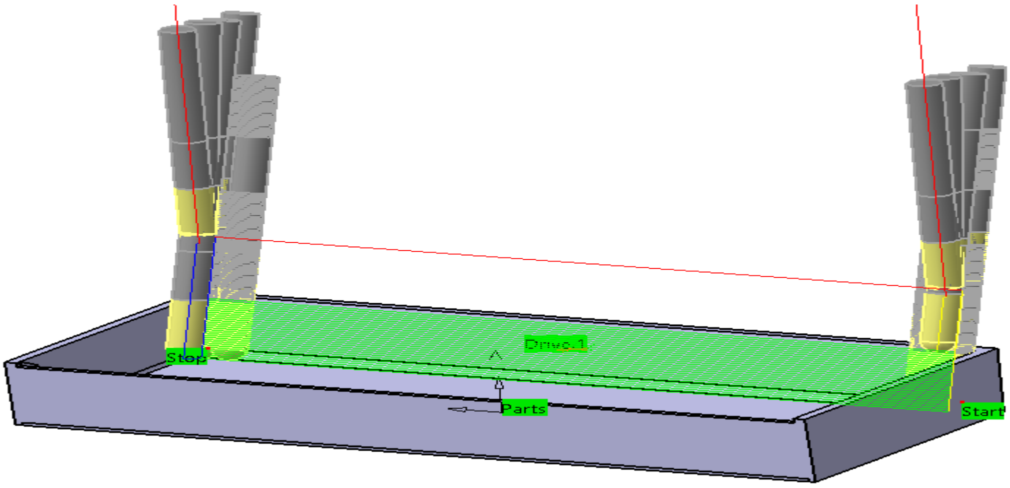

Figure 1.1a: Combine Parelm tool paths on slanted thin-wall.

Five-axis flank milling or contouring have been widely practiced to machine thin-walled components. By using five-axis flank milling, the machined surface quality, and machining efficiency can be improved greatly compared to point milling as known as end milling. Reported studied by Hu Gong et al. (2011), the machined part not required polishing processes after applying flank milling operation and machine efficiency may improve a lot. In this research, the focused machining strategies used to produce the slanted thin-wall component are Combine Parelm and Combine Tanto.

1.2 Problem Statement.

The aerospace industries continue to grow rapidly and doubled compare to the past decades. Moreover, the aerospace part can be categorized as the most difficult part to be machined. Furthermore, thin-wall machining is a great challenge due to its characteristics such as low rigidity and complex shape according to Huang et al. (2012). Other than that, it is due to minimize the trial and error machining that can increase the cost.

There are also many defects occurs during fabricate thin-walled that will eventually affect the dimensional accuracy and surface finish of the slanted thin-walled parts such as chatter marks occurs when milling a thin-walled parts. Research studied by Arnaud et al. (2012) on evaluating the modelled of machining vibrations of thin-walled aluminium work-pieces at high productivity found, the regenerative vibration while machining thin-walled or rigidity parts created chatter that will eventually lead to the poor surface finish.

According to Harik et al. (2013), flank milling mostly used on ruled surfaces, because the shape of cutting tools are mostly in cylindrical and conical surfaces, which is ruled surfaces. Basically most of the previous researcher focusing on machining a thin-walled with 90° and straight wall by using three-axis CNC machining. However in this study, five-axis CNC machine was used in order to produce slanted thin-walled pocketing profile. There are a lot of machining strategies given by multi-axis flank milling such as Tanto Fan and Combi Tanto.

1.3 Objective of Research

The aims of this research are,

i. To investigate the effect of the surface finish and dimensional accuracy on the machine part of aluminium 6 series (6063), for various machining strategies applied in the five-axis flank milling.
ii. To observe any differences occurred when applying various machining strategies in the flank milling five-axis machining.
iii. To make a recommendation of the best machining strategy.

1.4 Scope of Research

This research focused on utilizing five-axis CNC milling machine to produce the slanted thin-walled part that concentrated only on closed pocket profiles such as circular and rectangular shape only. CNC machine was chosen because it ability to machine complexity and intricate shape and parts. The type of CNC machine used in this research was DMU-60 Mono-block. The CAD/CAM software, CATIA V5 software was used in manipulating the CAD modelling shape and prepared the CAM programming.

For the thin-walled material, the aluminium 6 series (6063) is used. The aluminium 6063 is suitable to use because it was architecture alloy and have a good machinability with good surface finish. Aluminium 6063 alloy was commonly used in aircraft or manufacturing aerospace parts.

For the machining strategy selected was flank milling also known as Multi-axis Flank Milling or Contouring. The Multi-Axis Flank Milling was suitable because it can decreased manufacturing time, enhanced quality and reduced costs for fabricating the thin-wall or aerospace parts. The machining strategies also focused on the type of tool approaches for the thin wall, there is three type of approaches, which is overlap, three wise and water line type. The tool axis in the Multi-axis Flank milling will only focused on Combine Parelm and Combine Tanto. The parameter for machining will not be covered in this research study. The suitable parameter have been used that met the criteria to produce of the thin-walled components.

To determine and analyse the dimensional accuracy for the thin-walled part, the Carl Zeiss Coordinate Measurement Machine is used. The CMM advantages are high precision, high accuracy and accurate dimensions can be obtained by knowing the coordinates and distance between two reference points. On the other hand, Mitutoyo surface roughness machine test is going to be used in determining the surface finish of the machine thin-walled parts.

The slanted thin-walled part are from any of aerospace part. In this research study, the part is G.E Beam in aerospace industries. The part has slanted wall with 105° and 85° angle. This research will only focus on slanted wall, to investigate the dimensional accuracy and surface roughness for the particular slanted wall.