MACHINABILITY STUDY OF ROUGHING MACHINING STRATEGIES FOR POCKETING FEATURES OF AN AEROSPACE

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**A thesis submitted
in fulfillment of the requirements for the degree of
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DECLARATION

I declare that this Choose an item. entitled " Machinability Study of Roughing Machining Strategies For Pocketing Features of an Aerospace "is the result of my research except as cited in the references. The chosen item has not been accepted for any degree and is not concurrently submitted in the candidature of any other degree.

Signature	:	
Name	:	MUHAMAD MAHFIZ BIN SABARDAN
Date	:	15/1/2023

APPROVAL

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the Bachelor of Manufacturing Engineering Technology (Product Design) with Honours.

Signature :

Supervisor Name : TS. DR. SYAHRUL AZWAN BIN SUNDI @ SUANDI

Date : 22/02/2023

DEDICATION

This report is the

outcome of many long and

difficult journy. Those people who represent

an encouragement thanks to the

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proudly acknowledged in

this work. For ***parents***

and families to colleagues

and friendship circles who stood in

toaid when problems emerged during

this project. To my devoted parents and relatives,

who was always my closest companions

and who have educated me on this

level. This endeavor

would not have been

possible if it hadn’t been for their

love and support.

ABSTRACT

Computer-aided manufacturing (CAM) is the efficient application of computer technology in manufacturing planning and control. Aerospace, biomedical engineering, optics, and MEMS all require the fabrication of parts with high dimensional precision and surface profile, making production difficult. The main aim of this research is to evaluate the effect of roughing strategies namely concentric and helical (multipass mode) on the surface roughness and tool wear in machining pocketing profiles of an example aero structural component. and to determine pand ropose the most optimum roughing strategy to machine pocketing profiles of an example aero structural part using an actual aerospace standard material (Aluminum 6061 series) with respect to the surface roughness and tool wear analysis utilizing roughing operation offered by CATIA V5. Surface roughness is an important property that indicates workpiece quality during the milling process. Meanwhile, dimensional accuracy is a crucial aspect that determines the acceptance of each machined part. The type of cutting tool used in the milling machining process, tool geometry selection, and cutting parameters are all important factors in achieving good surface finishing and meeting part tolerances. In this research, there are two main machining strategies that will be focused on: multipass and helical. In Catia V5, users could choose the direction of the tool path. There were some elements that required the tool path to be carefully considered during the machining process. As a result, selecting the proper cutting or machining strategy is critical to ensuring the end result of machining. This project will utilize a CNC milling machine with a 3-axis to perform the physical machining. In this project, there are two types of measurement involved, which are surface roughness and tool wear. The tool wear was studied using microscopy analysis on a rough image of the tool that was obtained via a Nikon MM-800 optical microscope. Measurement is a method of measuring something using additional equipment. Ra, Ry, and Rz are the three parameters derived by surface roughness testing. The value of Ra was investigated as a parameter for surface roughness. However, because Ra is utilized as a global measurement of the roughness amplitude on a profile, only it was studied. Ra is the mean roughness of a piece of standard length sampled from the roughness chart's mean line. Aside from that, the pieces were divided into two halves, one circular and the other rectangular.

ABSTRAK

Pembuatan bantuan komputer (CAM) ialah aplikasi teknologi komputer yang cekap dalam perancangan dan kawalan pembuatan. Aeroangkasa, kejuruteraan bioperubatan, optik dan MEMS semuanya memerlukan fabrikasi bahagian dengan ketepatan dimensi tinggi dan profil permukaan, menjadikan pengeluaran sukar. Matlamat utama penyelidikan ini adalah untuk menilai kesan strategi pengasaran iaitu sepusat dan heliks (mod berbilang laluan) ke atas kekasaran permukaan dan haus alatan dalam pemesinan profil poket contoh komponen struktur aero. dan untuk menentukan pand ropose strategi roughing yang paling optimum untuk profil poket mesin contoh bahagian struktur aero menggunakan bahan standard aeroangkasa sebenar (siri Aluminium 6061) berkenaan dengan kekasaran permukaan dan analisis haus alatan menggunakan operasi roughing yang ditawarkan oleh CATIA V5. Kekasaran permukaan adalah sifat penting yang menunjukkan kualiti bahan kerja semasa proses pengilangan. Sementara itu, ketepatan dimensi adalah aspek penting yang menentukan penerimaan setiap bahagian mesin. Jenis alat pemotong yang digunakan dalam proses pemesinan pengilangan, pemilihan geometri alat, dan parameter pemotongan adalah semua faktor penting dalam mencapai kemasan permukaan yang baik dan memenuhi toleransi bahagian. Dalam penyelidikan ini, terdapat dua strategi pemesinan utama yang akan difokuskan: multipass dan helical. Dalam Catia V5, pengguna boleh memilih arah laluan alat. Terdapat beberapa elemen yang memerlukan laluan alat untuk dipertimbangkan dengan teliti semasa proses pemesinan. Akibatnya, memilih strategi pemotongan atau pemesinan yang betul adalah penting untuk memastikan hasil akhir pemesinan. Projek ini akan menggunakan mesin pengilangan CNC dengan 3 paksi untuk melaksanakan pemesinan fizikal. Dalam projek ini, terdapat dua jenis ukuran yang terlibat, iaitu kekasaran permukaan dan haus alatan. Haus alat dikaji menggunakan analisis mikroskopi pada imej kasar alat yang diperolehi melalui mikroskop optik Nikon MM-800. Pengukuran ialah kaedah mengukur sesuatu menggunakan peralatan tambahan. Ra, Ry, dan Rz ialah tiga parameter yang diperolehi oleh ujian kekasaran permukaan. Nilai Ra telah disiasat sebagai parameter untuk kekasaran permukaan. Walau bagaimanapun, kerana Ra digunakan sebagai ukuran global amplitud kekasaran pada profil, hanya ia dikaji. Ra ialah min kekasaran bagi sekeping panjang standard yang diambil daripada garis min carta kekasaran. Selain itu, kepingan itu dibahagikan kepada dua bahagian, satu bulatan dan satu lagi segi empat tepat.

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LIST OF ABBREVIATIONS AND SYMBOLS

D,d	-	Diameter
mm	-	Milimeter
CAM	-	Computer aided manufacturing
CAD	-	Computer aided design
Al	-	Aluminum
CMM	-	Coordinate Measuring Machine

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CHAPTER 1

INTRODUCTION

1.1 Background

This chapter will detail the project's goals and objectives history as well as the problem statement for the process machinability on roughing and pocketing features of an aerospace part. The project’s objective, scope, and limitations are also included in this chapter.

Mechanical milling is a frequently utilized technology in the industrial sector because to its adaptability and precision in product manufacture. (Edem & Balogun, 2018). Over the last thirty years, machining processes that can form a wide range of work, part shapes, and special geometry features have made increasingly rapid advances. Machining is an important process in the manufacturing process. It is defined as the removal of material in the form of chips from a workpiece. Manufacturing components with high dimensional precision and surface profile is tough in aircraft, biomedical engineering, lasers, and MEMS.(Ahmed et al., 2021).

Milling is an important step in the manufacturing industry since it ensures high productivity and quality are constantly in demand. In their research, Reddy and Prajina looked into the cutting process. (Titu et al., 2021). The surface roughness for mechanical components has a considerable influence on their performance and cost. For creating the needed part for the final assembly while keeping required geometrical forms and dimensional tolerances, the machining variables and methods for composites are crucial. (Nurhaniza et al., 2016). The type of cutting tool used in the milling machining process, tool geometries selection, and cutting parameters are all important factors in achieving good surface finishing and meeting part tolerances.

In the current context, the manufacturing industry is being forced to adopt modern technologies in order to maintain item quality while lowering production costs and increasing production volume. Pocket milling is a common machining technique used in the production of dies and moulds. The roughness of the pocket's surface determines its quality. Characteristic of the product's functioning qualities. (Rajyalakshmi & Rao, 2021). Pocket milling, which involves removing all material within a closed boundary, employs CAM-generated tool paths to remove material to a predetermined depth. Because of their ability to machine complex geometries with high dimensional accuracy, computer numerical control (CNC) machines have grown in popularity in modern manufacturing. These days, the trend in now's, the goal of computer-aided manufacturing (CAM) development of the system is to build a variety of CAM systems that can identify the precise elements that make up a part's 3D model and then generate the most significant machining method and parameters based on geometric form recognition.(Kariuki et al., 2014).

The CADCAM is a hybrid of CAD and CAM. From idea through documentation, computer-aided design (CAD) generally described as use of computers or graphical software to help or enhance product design. This efficient use of computer technology in industrial planning and control is known as computer-aided manufacturing (CAM). This combination allows information to be transferred from the designing phase to the planning step for product manufacture without need to physically reenter part geometry data. CATIA V5 is a CADCAM software package. This software would be used to both alter and prepare the CAM programmed for the component.

In both the literature and industry, 3-axis roughing remains the dominant approach due to easy programming and collision control, and also a generally faster implementation.

(Jousselin et al., 2019). For milling freeform surfaces, parallel contour and orientation courses are the most popular. The regular and parallel pathways of the borders are ideal for cleaning machining processes.

A direction parallel route has parts that are parallel to a designated line (Figure 1.1). This line might be perpendicular to or equal to the surface's border, or perpendicular to the coordinate system's axis. The length of the resulting trajectory is directly influenced by the reference line's selection. The zigzag route is a form of path that runs parallel to the axis and is widely used for roughing in commercial CAM systems.(Vila et al., 2019). The contour parallel route is created using the surface's limit curves. Each path represents a shift of the surface border towards the center or away from it (Figure 1.1b). The symbol f stands for the distance between two successive Cutting Contact (CC) sites, whereas the letter w stands for the separation between two adjacent pathways (Figure 1.1c).

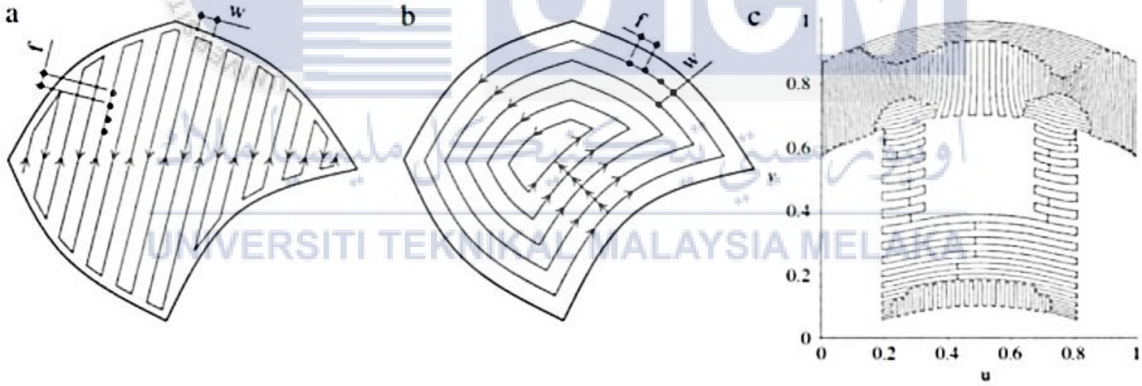

Figure 1.1 (a) Direction parallel. (b) Contour parallel. (c) Adaptive Curvilinear space-filling curve. (Vila et al., 2019)

Finally, In the aerospace industry, tool wear can be a significant concern due to the demanding nature of the machining processes used to produce aerospace parts. These parts are often made from high-strength, high-performance materials that are difficult to machine and can cause rapid tool wear. In addition, the tight tolerances and high-quality requirements of the aerospace industry make it critical to maintain the accuracy and performance of the cutting tools throughout the machining process. There are several approaches that can be taken to manage tool wear in the aerospace industry, including the selection of appropriate tool materials and coatings, the use of advanced cutting technologies such as cryogenic machining or high-speed machining, and the implementation of tool wear monitoring and control systems.

By understanding the factors that contribute to tool wear and implementing strategies to mitigate its effects, it is possible to optimize the machining process and improve the efficiency and quality of the finished parts in the aerospace industry.

1.2 Problem Statement

Nowadays, the mass-produce of material in the matching industry brought strategies that can optimize the surface finish of the material that important. Whenever it relates to pocketing profiles, the cutting strategy is crucial in determining the machining outcomes. Nowadays, there is a high demand for high-quality pocketing features for surface roughness because appearance, function, and reliability are all important in any product. With these considerations, surface finish and tool wear are critically maintained in the production of industry. For Aero-structural parts, pocketing profile is the main design in rib and spar sections due to its ability in improving the strength of the overall aircraft wing structure. Rapid tool wear is a significant issue in our manufacturing process, leading to increased tooling costs and reduced efficiency. It is important to identify the root causes of tool wear and implement strategies to mitigate its effects in order to optimize the machining process and improve the quality of the finished parts.

1.3 Research Objective

The primary objectives of this study are stated below:

- To evaluate the effect of roughing strategies namely concentric and helical (multipass mode) on the surface roughness and tool wear in machining pocketing profiles of an example aero structural component.
- To determine propose the most optimum roughing strategy to machine pocketing profiles of an example aero structural part using an actual aerospace standard material (Aluminum 6061 series) with respect to the surface roughness and tool wear analysis utilizing roughing operation offered by CATIA V5.