Faculty of Mechanical and Manufacturing Engineering Technology

COMPARISON STUDY ON THE EFFECT OF ROUTER TOOL GEOMETRICAL FEATURES ON MACHINING PERFORMANCE FOR EDGE TRIMMING OF CFRP MATERIAL

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Bachelor of Manufacturing Engineering Technology (Product Design) with Honours

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ABDUL THAQIF BIN MOHD AMIN

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Date : ………………………………………….

DEDICATION

This dissertation is dedicated to my father, Mohd Amin bin Afuan, whose financial support and passionate encouragement made it possible for me to complete this project. Also, to the memory of my late mother, Saripah Rahah binti Saiyid Harun, who passed away after a year I started my degrees studies. I had promised to made my mother proud by the achievement of this academic goal and I hope that I have fulfilled that promise.

ABSTRACT

Carbon fibre reinforced polymer (CFRP) gave a huge impact on today's companies such as automotive, shipping and aerospace due to their high quality and light weight. Even though CFRP are manufactured to their closest shape, but they have to undergo a process called secondary machining. In this study, the edge trimming machining of CFRP will be performed by utilizing three types of router tools with different surface geometry. The three router tools are categorized into fine, medium and coarse toothing. Experiment are conducted in varying spindle speed and feed rate but radial depth of cut will be remained constant. The main objective of this study is to investigate the effect of tool geometrical feature of router tools on the surface roughness of trimmed surface for a specific CFRP material such as surface roughness and in addition, cutting force as well as tool wear. Surface roughness measurement of trimmed CFRP was taken using Mitutoyo Surftest Sj-410. The observation of tool wear for those three types router tool was taken under optical microscope Nikon MM-800, as well as the trimmed surfaces of CFRP. The finding provide evidence that fine toothing is the suitable tool for edge trimming of CFRP with respect to overall averaged surface roughness value.
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ABSTRAK

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Polimer bertetulang serat karbon (CFRP) memberi impak besar kepada industri hari ini seperti automotif, perkapalan dan aeroangkasa kerana kualiti dan berat ringannya. Walaupun CFRP dihasilkan ke bentuk yang paling dekat, tetapi ia perlu menjalani proses pemesinan sekunder. Dalam kajian ini, pemotongan tepi pada panel CFRP akan dilakukan dengan menggunakan tiga jenis mata alat yang mempunyai permukaan geometri berbeza. Tiga mata alat router ini dikategorikan sebagai halus, sederhana dan kasar. Eksperimen dijalankan dengan kelajuan gelangsar dan kadar suapan yang berbeza namun kedalaman radial adalah tetap. Objektif utama kajian ini adalah untuk mengkaji hubung kait antara permukaan geometri yang berbeza pada alat pemotong router dengan kesan kekasaran permukaan permukaan yang di potong pada panel CFRP beserta kesan tekanan yang terhasil ketika proses pemotongan tepi CFRP. Mesin yang di gunakan untuk mengukur kekasaran permukaan CFRP yang dipotong adalah Mitutoyo Surftest Sj-410. Pemerhatian ke atas kesan kehausan mata pemotong untuk ketiga-tiga jenis alat router serta permukaan yang dipotong pada panel CFRP di lihat di bawah mikroskop optik Nikon MM-800. Di akhir kajian ini mendapati bahawa mata alat yang halus merupakan mata alat yang sesuai untuk pemotongan tepi panel CFRP dengan mengambil kira aspek keseluruhan purata data permukaan kasar.

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

CFRP	-	Carbon Fibre Reinforced Polymers
GFRP	-	Glass Fibre Reinforced Polymers
DoE	-	Design of Experiment
CAM	-	Computer-Aided Manufacturing
CAD	-	Computer-Aided Design
CNC	-	Computer Numerical Control
Vf	-	Feed Rate
Fz	-	Feed per Tooth
Vc	-	Cutting speed

CHAPTER 1

INTRODUCTION

1.0 Background

Carbon Fibre Reinforced Plastics (CFRP) is one of the high demand composites in the aerospace and automotive manufacturing industry. This is due to the strength and stiffness to weight ratio material and the ability to replace aluminium without changing the material properties by 40% of the mass production in aerospace application. Thus, by using CFRP as main material in some application, it can reduce the usage of fuel consumption due to its heavy reduction in weight. In composite manufacturing, CFRP is easier to produce in various forms or in other words, freedom in shape design. However, to meet the product dimensional tolerances and quality requirement, the composite have to undergo an edge trimming process in order to remove excess material from previous operation (Halim et al., 2017).

CFRP still need a finishing operation to achieve the requirement in dimensional state for assembly process with other part even though the composites are produced near net shape. The finishing process consist of trimming, drilling and turning and there will be problem may occur to the surface of machined part such as delamination, spalling and splintering due to the inhomogeneous nature of fibre reinforced composites. Thus, this can conclude that the quality of machines surface is related to its service life (Urban, 2005). The aim of this research is to find out the finest geometrical features of routers tool which can improve the quality of edge trimming on carbon fibre reinforced polymer (CFRP) composites. To obtain this goal, three types of router tool will be focused are fine, medium and coarse toothing. The experiment is carried out with different router tool geometry and spindle speed, feed rate and with similar depth of cut.

1.1 Problem Statement

During this research, there are some problems that need to be emphasized in order to figure out the effect geometrical features of router tool towards machining performance for edge trimming CFRP material.

The selection of cutting tools and cutting condition is very important in the machining process (Ferreira et al., 1999). Cutting tools have various of geometry such as fine, medium and coarse and this may give a differ outcome in machining process like trimming.

Last but not least, tool wear can give big impact on the result of surface finish due to machining parameters (feed per tooth and cutting speed). Due to this factor, CFRP panel will have some surface integrity problem such as matrix degradation and fiber pull-out.

1.2 Objective

To make this project more define, there is some guideline and structure of the research project have been made. The objectives of this research are listed as below:

i. To investigate the effect of tool geometrical feature of router tools on the surface roughness of trimmed surface for a specific CFRP material
ii. To observe the effect of tool wear for the three types of router tool in trimming specific CFRP material; fine, medium and coarse toothing.
iii. To propose the best router tool geometrical feature in trimming specific CFRP material, either fine toothing, medium toothing or coarse toothing that will be determine on surface finish and tool wear.

1.3 Scope

The scope of this project is to study the surface finish as well as tool wear and cutting force while doing the process of edge trimming towards Carbon Fibre Reinforced Plastics (CFRP). Three type of carbide uncoated router tool with different geometrical feature (fine, medium and coarse toothing) are used in order to determine which is the best geometrical features of routers tool in edge trimming of CFRP. The specimen of CFRP is unidirectional with 28 number of plies in total which consist of 2 glass plies (bottom & top) act as protector of the outer surfaces of the panel. Design of experiment method will be used in the research. Specifically, Taguchi orthogonal method (L4) are used. This study is done based on research done finding the best tool geometry among the three types of router tools as mention earlier for edge trimming of CFRP material.

1.4 Thesis Outline

The reports consist of the few chapters as below:

Chapter 1: Introduction

This chapter will simply introduce about the project. This chapter covers introduction, problem statement, objective and scope of the project.

Chapter 2: Literature Review

This chapter emphasis on the research and studies made relevant to the project title.

Chapter 3: Methodology

This part includes the method used in which area of research and studies made based on the project objective.

Chapter 4: Results and Discussion

This chapter discusses about the output of the project from the result obtained to the hardware being made.

Chapter 5: Conclusion and Recommendation

This chapter will discuss about the summary of the overall project and conclude based on the output obtained from the project and improvements can be made to make the project better for future purp

CHAPTER 2

LITERATURE REVIEW

2.0 Composite Material

A composite material usually consists of a quite strong, stiff fibers in a tough resin matrix. Example of natural composite material are wood and bone which wood contains of cellulose fibers in a lignin matrix and bone contains of hydroxyapatite particles in a collagen matrix. In contrast with man-made composite material that are carbon fiber reinforced polymers (CFRP) and glass fiber reinforced polymers (GFRP) which is widely used in aerospace and other industries nowadays. Even though they both are stiff and strong (in their density), but they had several weaknesses such as brittle in a polymer matrix. But by combining material with complementary properties can make a composite material in high strength, stiffness, toughness and low density with just a few or none of weakness in individual component materials.

There are several benefits of using composite material which are they can be formed into complex shape rather than their metallic counterpart. The main reason composite material is widely used in industries is because of they can reduces the number of parts making up a given component, thus can reduces the weight of the part, but also in usage of fasteners and joints can be minimize. In this case, fewer fastener and joint may lead to shorter assembly time (Quilter, 2004).

2.0.1 Glass Fiber Reinforced Polymers (GFRP)

In recent years, variety of engineering application such as oil, gas, process industries and aerospace have been widely used glass fibre reinforced polymers (GFRP). Filament winding hand lay-up and many more are the fabricated process for component of GFRP. For tolerance and measurement purpose, they require further machining in order to control their dimensional for easy assembly and function aspect. Its state that GFRP has an anisotropic behaviour and the machining of the component is differed from conventional materials. This composite material is a great alternative to save cost where it can replace stainless steel and other materials that easily corrosive (Palanikumar, 2008) due to their high ratio of strength to weight , high fracture strength and toughness , excellent thermal and corrosion resistance (Sreenivasulu, 2013).

2.0.2 Glass Fiber Reinforced Polymers (GFRP)

In aerospace industries, Carbon Fiber Reinforced Polymers (CFRP) have been recognized even wider, this is due to their mechanical and physical properties in high strength-to-weight ratio and high modulus-to-weight ratio. Complex interaction between matrix and reinforcement happen during machining because of CFRP composite consists two phases of materials with significantly distinguished mechanical and thermal properties. Reinforcement is carbon fiber and the matrix are polymer resin by its nature like epoxy. Polymer resin act as binder to the reinforcement which provides the strength (Rangasamy Prakash et al., 2016). CFRP also known by their ability in molding where they can be molded to near net shape. This make the process of wings and fuselage panels production easier. But other machining such as trimming, milling and drilling are still required to make the CFRP part to their final shapes and sizes (Slamani et al., 2016). These operations must be