UNIVERSITI TEKNIKAL MALAYSIA MELAKA

INVESTIGATION ON THE EFFECT OF MACHINING PARAMETERS IN EDGE TRIMMING OF CARBON FIBRE REINFORCED PLASTIC (CFRP) MATERIAL

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor"s Degree in Manufacturing Engineering Technology (Product Design) with Honours.

by

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ABSTRAK

Penggunaan Plastik Reinforced Fiber Carbon (CFRP) telah digunakan secara meluas dalam industri aeroangkasa sepanjang tahun kerana kekuatan tinggi dan berat ringan. Hayat komponen sangat bergantung kepada kualiti pemesinan. Penyiasatan eksperimen mengenai kesan parameter pemesinan dalam pemangkasan tepi bahan CFRP dijalankan. Operasi pemesinan yang digunakan adalah pemangkasan tepi bahan. Tujuan eksperimen ini adalah untuk menentukan parameter pemesinan yang dioptimumkan iaitu kelajuan gelangsar dan kadar suapan dalam mengurangkan kerosakan semasa mengurangkan bahan CFRP tertentu. Objektif kedua kajian ini adalah untuk melihat fenomena kehausan mata alat pada alat jenis penghala di tepi pemangkasan bahan CFRP tertentu. Kaedah DoE digunakan dalam kajian ini, orthogonal Taguchi L9 digunakan. Pemangkasan tepi CFRP dijalankan dengan menggunakan paksi 3 paksi CNC Gantry Haas GR-510. Pengukuran kekasaran permukaan yang diambil menggunakan Mitutoyo Surftest SJ-410. Nilai daya pemotongan dicatatkan menggunakan Kistler Dynamometer. Kehausan pada mata alat diperhatikan dengan mengunakan mikroskop MM-800. Semua data ini dikumpul dan dianalisis menggunakan kaedah ANOVA. Menggunakan parameter pemesinan terbaik dan optimum membantu mengurangkan kerosakan CFRP di tepi pemangkasan. Hasil daripada kajian ini menunjukkan bahawa parameter pemesinan optimum menggunakan kelajuan rendah gelangsar (2526 RPM) dan kadar suapan sederhana (379mm/min). Kajian ini juga membuktikan bahawa kelajuan suapan dan kelajuan gelangsar mempengaruhi kekasaran permukaan dan daya pemotongan.

ABSTRCT

The usage of Carbon Fibre Reinforced Plastics (CFRP) has been widely used in aerospace industry over the year for their high strength and lightweight. Service life of a component is highly dependent on the quality of machining. An experimental investigation of the effect of machining parameters in edge trimming of CFRP material is conducted. Machining operation used is edge trimming. The aim of this experiment is to determine the optimized machining parameters namely spindle speed and feed rate in reducing damages during edge trimming specific CFRP material. The second objective of this study is to observe tool wear phenomenon on routers type tool in edge trimming of specific CFRP material. DoE method was used in this research. Taguchi L9 orthogonal arrays were used. Edge trimming of CFRP is conducted using 3- axis CNC Gantry Router Haas GR-510. Surface roughness measurement is taken using Mitutoyo Surftest SJ-410. Cutting force value is recorded using Kistler Dynamometer. Tool wear is observed using measuring microscope MM-800. All this gathered data analysed using ANOVA method. Using the best and optimum machining parameters help to minimize the damages of CFRP in edge trimming. The results from this research reveal that the optimum machining parameter is using low spindle speed (2526 RPM) and moderate feed rate (379mm/min). This research is also proven that feed rate and spindle speed does affect surface roughness and cutting force.

DEDICATION

To my beloved parents Mr & Mrs Kumaran Saminathan

My supportive supervisor Mr Muhammad Syafik Bin Jumali

Co-supervisor Mr Syahrul Azwan Bin Sundi @ Suandi

My faithful panels, lectures, and staffs of FTK

My BMMD Cohort 5 classmates

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TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF SYMBOLS

D,d	-	Diameter
W	-	Centre thickness of CFRP
W_{max}	-	Maximum thickness of CFRP
N	-	Spindle Speed
Vf	-	Feed Rate
Fz	-	Feed Per Tooth
T	-	Tool Type
R	-	No of Run

LIST OF ABBREVIATIONS

CFRP	-	Carbon Fibre Reinforced Plastics
GFRP	-	Glass Fibre Reinforced Plastics
DoE	-	Design of Experiment
CNC	-	Computer Numerical Control
RPM	-	Revolutions Per Minute
EDM	-	Electrical Discharge Machining
AWJ	-	Abrasive Water Jet
SEM	-	Scanning Electron Microscope
CAD	-	Computer Aided Drawing
CAM	-	Computer Aided Manufacturing
ANOVA	-	Analysis of Variance

CHAPTER 1

INTRODUCTION

1.1 Introduction

Carbon Fibre Reinforced Plastics (CFRP) are increasingly used as a major and important material in aerospace industry. It is not only used in aerospace, instead, it is being widely used in aircraft, automobile and sports goods for it‟s due to few advantages such as their lightweight, highly modulus, highly specific strength and high resistance to corrosion. Over the year the consumption and the trend of CFRP materials have shown gradual increases. For example, Boeing 777, which enters services in 1995, contains only 10% of composite structure by weight but in year 2010, aircraft AB-350XBW is started to use almost 50% of composite structure (Hashish, 2013). This result obviously shows the demand and attention toward the usage of CFRP by aerospace industries. During the manufacturing component of CFRP materials, it is usually necessary to carry out machining after curing in order to meet the required tolerances and to manufacture fitting and joining surfaces. One of the very common machining processes is edge trimming. This operation can be carried out using either conventional machining or in some cases, by using abrasive water jet cutting. Mechanical edge trimming is also a standard procedure in sample preparation for mechanical testing for composite material (Shahid, 2013). However, due to inhomogeneous nature of CFRP, some factors like delamination will be occur on the machined surface.

1.2 Problem Statement

There are several problems faced based on finding ways to determine the best machining parameters for edge trimming of CFRP material. This problem arises as many questions which the solution is needed to be found.

Typical problems which normally found in machining CFRP are related to surface finish and integrity (Shahid, 2013). Common integrity issues are fibre pull out, fibre breakage, and matrix smearing. The surface quality resulting from finish machining of CFRP is characterized by surface finish and surface damage. Surface texture is often defined in term of geometric surface roughness parameters such as the arithmetic mean roughness (Ra), Maximum peak (Ry) and ten-point mean roughness (Rz). Higher value of surface roughness will affect the quality of the CFRP when in assembly process in the aerospace industry where it couldn‟t bind two panels together.

On the other hand, other problem that can occur is tool wear. Tool wear will frequently and actively found in the flank or nose area of cutting tool. The nature and character of CFRP which is abrasive will reduce the tool life. High tool flank wear happens due to the incomplete machining at a faster transverse. The major cause of this factor because of increase of feed rate during machining. In addition, the depth of cut also plays a minor role in tool wear (Halim et al. 2017).

1.3 Objectives

The main aim of this research is to obtain the optimized machining conditions in edge trimming CFRP material. In order to make this project successful, the objectives which are the guidance of the project has been declared where it must be achieved in completing this project:

i. To determine the optimized machining parameters namely spindle speed and feed rate in reducing damages during edge trimming specific CFRP material.

ii. To observe tool wear phenomenon on routers type tool in edge trimming of specific CFRP material.

1.4 Scope

The scope of this project is defined by the objectives or research targets set earlier which going to be emphasis on the cutting parameters in reducing damages during edge trimming of specific CFRP. In addition, surface roughness, tool wear and cutting force analyzed. Design of experiment (DoE) is the method used for the overall experimental process planning. Taguchi method focused on this project. The study is based on research done on finding the best and optimum parameter while doing edge trimming. The research includes research, testing and observing data obtained on a different value of cutting speed and feed rate. Completing the project includes testing and analysing to make sure the material will not have any surface integrity damages such as fibre pull out fibre breakage, and matrix smearing. The cutting tool used in this project is 6.35 mm burrs tool. The CFRP panel is stacked with unidirectional proportion. Edge trimming performed using 3- axis CNC Gantry Router Haas GR-510. Surface roughness carried out using Mitutoyo Surftest SJ-410. Cutting force focused on Fx & Fy and the data taken using Kistler dynamometer. Tool wear observed using Nikon measuring microscope MM-80.

1.5 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 results obtained to the hardware being made.

Chapter 5:Conclusion

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

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this chapter, exploration and evaluation of previous research that is related to this project is discussed. The information gathered will become an additional source for the project in studying and developing the project to be more successful. To have a brief understanding of the researches related to the project, a few literature reviews had been done.

2.2 Composite Materials

Composite materials are material which has the combination of two or more materials which usually have different chemical or physical property from one another. The combination of this material will give a very distinctive property. Composites would not either dissolve or blend into each other. The major advantage of composite materials, it can be moulded into complex shapes. There are two ways of making composites. Firstly via matrix, secondly through binder. Reinforced composites are made from fragments of different material or bind and surround together fibres. However, using only CFRP materials will be main focus of this research.

2.2.1 Glass Fibre Reinforced Plastics (GFRP)

GFRP known as the first modern composite material. Plastics are used as its matrix and the glass is the reinforcement that has been made into fine threads and woven into thin sorts of cloth. The plastic matrix protects and holds together the glass fibre from damage sharing out the forces acting on it. The usage of GFRP has gradually being used in different engineering field such as aerospace, oil, gas, and process industries due to its unique material properties which has impressive high fracture strength and toughness, admirable thermal and corrosion resist, and not to forget about its high ratio of strength to weight (Sreenivasulu , 2013).

Figure 2.1: GFRP plate used in engineering field (Sreenivasulu, 2013)