EVALUATION OF MILLING/TRIMMING PERFORMANCES FOR CFRP MATERIAL UTILIZING VARIOUS BURR/ROUTER TOOL GEOMETRICAL FEATURES

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DECLARATION

I declare that this Choose an item. entitled "Evaluation Of Milling/Trimming Performances For CFRP Material Utilizing Various Burr/Router Tool Geometrical Features" is the result of my own research except as cited in the references. The Choose an item. has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature	:	
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Date	:	18/1/2022

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 degree of Bachelor of Manufacturing Engineering Technology (Process and Technology) with Honours

Signature	:	
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Date	:	18/1/2022

DEDICATION

Alhamdulillah praise to Allah for the strength, guidance and knowledge that was given by Allah for me to complete this study. A special appreciation, I dedicate this thesis to my beloved parents, Mohd Hasni Bin Bakar and Ruhaizah Binti Ramli. Finally, for my supervisor Mr Syahrul Azwan Bin Sundi@Suandi, a lot of thanks to him for guidance and advices in completing this thesis

ABSTRACT

Carbon Fiber Reinforced Polymer (CFRP) has found significant application in a variety of industrial sectors, particularly in the aerospace and automotive industries, due to its superior mechanical properties such as high strength, light weight, and corrosion resistance. The objective of the experiment was to study the optimum router tool geometry for the specific CFRP materials. The second objective of this research is to investigate the effect of the surface quality and the tool wear when various tool geometry of router type is used during edge trimming of CFRP material. Finally, to propose the most optimal burr/router tool geometry for trimming a specific CFRP material. The selected study material was a CFRP panel with a thickness of 3.25 mm and a total of 28 plies. Three different types of tool geometries manufactured of tungsten carbide material with the same diameter, 6.35 mm, while varying in the number of flutes and helix angle were successfully studied. The Model Pro II MDX-540 was used to trim the CFRP edges. The surface roughness of panel material is measured with the Mitutoyo Surftest SJ-410. A Kistler Dynamometer type 9257B was used to measure the cutting force. A Nikon MM-800 measuring microscope was used to evaluate tool wear. Following the conclusion of three cutting tool processes, all data gathered was evaluated. To prevent CFRP damage during edge trimming, an ideal set of machining parameters is used. A spindle speed of 5938 RPM, a cutting speed of 118.47 m/min, and a feed rate of 297mm/min are the optimal machining setup. For each tool, the machine mode is down and up cutting. Cutting tool 1 (T1) provided the least amount of surface roughness when compared to the overall mean value in both machining directions, according to the data. The cutting tool 2 (T2), on the other hand, has the highest surface roughness value. In the meantime, cutting tool type 3 (T3) is halfway between the other two tool types. In comparison to T1, when the tip of the pyramid cutting edge tool is really obviously smooth, tool wear observations show evident fractures at T2 and T3.

ABSTRAK

Polimer Bertetulang Gentian Karbon (CFRP) telah menemui aplikasi penting dalam pelbagai sektor perindustrian, terutamanya dalam industri aeroangkasa dan automotif, kerana sifat mekanikalnya yang unggul seperti kekuatan tinggi, ringan dan rintangan kakisan. Objektif eksperimen adalah untuk mengkaji geometri alat penghala yang optimum untuk bahan CFRP tertentu. Objektif kedua penyelidikan ini adalah untuk menyiasat kesan kualiti permukaan dan haus alatan apabila pelbagai geometri alat jenis penghala digunakan semasa pemangkasan tepi bahan CFRP. Akhir sekali, untuk mencadangkan geometri alat burr/penghala yang paling optimum untuk memangkas bahan CFRP tertentu. Bahan kajian yang dipilih ialah panel CFRP dengan ketebalan 3.25 mm dan sejumlah 28 lapis. Tiga jenis geometri alat yang berbeza yang dihasilkan daripada bahan tungsten karbida dengan diameter yang sama, 6.35 mm, manakala variasi dalam bilangan seruling dan sudut heliks berjaya dikaji. Model Pro II MDX-540 digunakan untuk memangkas tepi CFRP. Kekasaran permukaan bahan panel diukur dengan Mitutoyo Surftest SJ-410. Kistler Dynamometer jenis 9257B digunakan untuk mengukur daya pemotongan. Mikroskop pengukur Nikon MM-800 digunakan untuk menilai kehausan alatan. Berikutan kesimpulan daripada tiga proses alat pemotong, semua data yang dikumpul telah dinilai. Untuk mengelakkan kerosakan CFRP semasa pemangkasan tepi, satu set parameter pemesinan yang ideal digunakan. Kelajuan gelendong 5938 RPM, kelajuan pemotongan 118.47 m/min, dan kadar suapan 297mm/min adalah persediaan pemesinan yang optimum. Untuk setiap alat, mod mesin adalah ke bawah dan ke atas memotong. Alat pemotong 1 (T1) memberikan jumlah kekasaran permukaan paling sedikit jika dibandingkan dengan nilai min keseluruhan dalam kedua-dua arah pemesinan, mengikut data. Alat pemotong 2 (T2) pula mempunyai nilai kekasaran permukaan yang paling tinggi. Sementara itu, alat pemotong jenis 3 (T3) berada di tengah-tengah antara dua jenis alat yang lain. Berbanding dengan T1, apabila hujung alat canggih piramid benar-benar licin, pemerhatian haus alat menunjukkan keretakan yang jelas pada T2 dan T3.

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A million thank to my lovely family for giving me support. I cannot find the appropriate words that could properly describe my appreciation for their support and faith in our ability to success. Lastly, I would thanks to all who are involved directly or non-directly in my project. I surely cannot forget your kindness and only Allah can repay you all. Thank you.

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LIST OF SYMBOLS

D,d	-	Diameter
V_f	-	Feed Rate
F_z	-	Feed Rate per Tooth
N	-	Spnidle Speed
T	-	Tool Type
W	-	Centre thickness
a_e	-	Cutting Width
V_c	-	Cutting Speed
$(^{O})$	-	Angle

LIST OF ABBREVIATIONS

AFRP	-	Aramid Fibre Reinforced Polymer
AWJM	-	Abrasive Water Jet Machining
CNC	-	Computer Numerical Control
CFRP	-	Carbon Fibre Reinforced Polymer
FRP	-	Fibre Reinforced Polymer
GFRP	-	Glass Fibre Reinforced Polymer
HAZ	-	Heat Affected Zone
HSM	-	High-Speed Machining
RUM	-	Rotary Ultrasonic Machines

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CHAPTER 1

INTRODUCTION

1.1 Background

Over the last decade, the usage of Carbon Fibre Reinforced Plastic (CFRP) composites in aerospace applications such as primary and secondary aircraft components has risen sharply. These lightweight composites have excellent physical and mechanical qualities, such as better corrosion resistance, high specific strength or stiffness, and good dimensional stability, as well as the ability to form complicated forms. (El-Hofy *et al.*, 2017). Polymer composites are displacing standard aluminium as the most often used material in aircraft to implement the change. Besides, Carbon Fibre Reinforced Plastic (CFRP) fuselage structures or aircraft's main body structure were first used in civil aviation with the debut of the BOEING 787 Dreamliner in October 2011 and the AIRBUS A350-XWB in January 2015. (Kupski and Teixeira de Freitas, 2021). As a matter of fact, the usage of CFRP materials in the aerospace sector is becoming more widely adopted.

Furthermore, machining operations such as trimming or milling to the final shape, as well as drilling, are commonly required to facilitate component assembly due to the workpiece's surface roughness. Surface roughness and dimensional accuracy are directly related. Therefore, identifying a fine surface finish to ensure an acceptable tolerance in the finishing process is usually required. Tolerance and strength requirements place a restriction on the maximum allowable roughness in many practical design applications. (Sundi *et al.*, 2019).

Next, the tool materials for machining composites should be strong to sustain the abrasiveness of the fibres and debris produced during the machining process. The tool geometry should have a sharp edge capable of shearing the fibres cleanly. The router or burr tool's tool geometry would seem to reduce defects on the trimmed surface. The main factors identified affecting the mass of harmful particles were the tool geometry and the cutting parameters that effected the formation of the chip thickness (Sundi *et al.*, 2020).

1.2 Problem Statement

Several problems have been analyzed based on a method for choosing the optimum machining parameters for CFRP materials edges. This problem occurs because many issues need to be resolved.

Typically machinery issues are related to the surface of quality, especially in CFRP materials (Jawahir *et al.*, 2011). CFRP materials are known for being hard to cut, which may lead to a range of micro- and macro-geometric material failures such as delamination, uncut fibres, burning matrices, fibre pull-outs, cracking, and micro-cracking. (Geier, 2020). In industries such as aerospace or aircaft, it places great emphasis on accuracy and dimensionality in the process. Moreover, it is to produce a quality product. The challenge is to get better Surface Roughness, Ra which is to get the lowest value of surface roughness during the final test. Therefore, the highest value will have a detrimental effect on the surface quality.

In addition, the problem that will arise during the machining of this CFRP material is the wear of tools. The impact of workpiece processing and integrity does not differ from standard alloys in general. In this respect, the effect such as increased speeds of cutting and wear results in increased cutting temperatures and a high chance of damage of the matrix. (Jawahir *et al.*, 2011). The facts are that increasing the cutting speed and decreasing the feedrate will cause in tool wear. In order to overcome faults identified during machining of CFRP composites, cutting tool design and material selection are important (Ozkan *et al.*, 2019).

Therefore, whether obvious or not, the tests carried out in the research investigations will undoubtedly face some challenges and difficulties. The characteristics and tools utilised to avoid or eliminate difficulties are the focus of this research. Furthermore, research might give an overview and subsequently a suggestion for change.

1.3 Research Objectives

The main goals of this study is to find the best tool geomtery during edge trimming of CFRP material. There are guidelines that have been given in finishing this project in order to properly achieve the objectives:

i. To study the optimum router tool geometry for the specific CFRP materials.
ii. To investigate the effect of the surface quality and the tool wear when various tool geometry of router type is used during edge trimming of CFRP material.
iii. To propose the most optimum burr/router tool geometry for trimming a specific CFRP material.

1.4 Scope of Research

The scope of the project is defined by the research target objectives established at the start of the project, which are focused on the chosen geometry and the type of router used to cut the CFRP material. This research also looked at cutting force, tool wear, and surface roughness. This study employs three different types of router devices, each with its own set of geometries, namely the number of flutes and helical angles. The cutting condition is used continuously for all three tools in accordance with the machine speed. The use or operation of trimming on CFRP materials has resulted in a variety of results on the material's surface. As a result, it is possible to determine which cutting tools are the best and most efficient for machining operations.

1.5 Research Significant

Machining fibre reinforced composites is a crucial activity for maximising the use of these modern materials in engineering disciplines. Extreme cutting impacts must be avoided during machining to avoid waste product in the last stages of the manufacturing cycle. Mechanical and thermal qualities are critical for machining FRP. The fibre employed in composites has a significant impact on the cutting tool selection during cutting edge material, shape, and machining parameters. It is critical to verify that the tool chosen is appropriate for the material. (Sorrentino and Turchetta, 2014).

This study has a significant influence on industry, academia, and the community. As machining in industry, needs a tight balance between productivity, item quality, and tool selection, it is critical to have the correct feed and speed. If machines and cutting tools are pushed too aggressively, the time it takes to change tools will eat up any productivity increases, and machinists will burn their tools out too rapidly. Machines, on the other side, may cut appliance costs at the price of productivity, and time is money in the parts-making sector. That is why it is so important to discover the perfect spot for maximum tool life.

Impact in academia, as well as the able to discuss new environmental and social problems, is a distinct benefit for students. This may be used to justify study and to contribute to current knowledge. As a result, students' capacity to openly approach these new concerns, handle the challenges of new fields of research, and produce literature for the subject area is highly regarded, and therefore it is a significant addition to knowledge. Developed by the Malaysian Ministry of Education as a result of the Malaysia Education Blueprint (MEB) 2013 to 2025, it governs all national education issues, from preschool to higher education. The ministry, led by the Minister of Education, aims to provide all Malaysians with equal access to quality education, educate highly skilled, knowledgeable and united Malaysians and indirectly create employment opportunities. Therefore, entrepreneurship education in Malaysia creates entrepreneurial students as part of the National Action Plan for Higher Education as an initiative to drive economic innovation and change to create new wealth and job creation (Kamaruddin *et al.*, 2017).

1.6 Thesis Outline

The reports are divided into the following chapters as below:

Chapter 1: Introduction

The introduction to this project's research is more direct in this chapter. Background, problem statement, study purpose, and research scope are explanations of elements.

Chapter 2: Literature Review

Based on the project title, this chapter focuses more on the research and applicable theory.

Chapter 3: Methodology

This section discusses the methods for determining the subject of study and research depending on the objectives.

Chapter 4:Results and Discussion

This section covers the project's output, from the results collected to the hardware being created.

Chapter 5:Conclusion

This section will cover the project's overall overview and conclude based on the project's outcome and improvements that can be done to make the project better for future use.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter highlights the current state of knowledge and theory in carbon fibre reinforced polymer machining research (CFRP). The information acquired will provide an extra source for the project in researching and growing it to be more effective, since it will be used in creating assessments and analyses based on past research. A few literature studies were conducted in order to gain a general understanding of the project's research.

2.2 Composite Materials

Composite materials are made up of mixing two or more materials that do not dissolve or merge into one other with relatively diverse properties. The various composite materials work together to produce the composite unique characteristics. The combination of this matrix and separated phases provides composites with a large difference in characteristics from either component (Jacoby, 2004). These composite mixtures come in a variety of shapes and sizes, and they're used in a variety of sectors. The design and mix are determined by the material's demand and application. However, in this research, a specific CFRP material shall be the focus material to be studied.

2.2.1 Aramid Fibre Reinforced Polymer (AFRP)

Aramid fibre reinforcing polymer (AFRP) is a fibrous composite material made of synthetic fibres. This material's features include high tensile strength, low thermal expansion coefficient, and light weight. It is been widely employed in aerospace, national defence, and military applications (Yang, Song and Zhang, 2015). Next, aramid fibre is a composite material that is not heat resistant and robust. ARFP is a hard, coarse material with a long