UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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IMPROVEMENT OF CUTTER GEOMETRY TO ENHANCE MACHINING PERFORMANCE FOR TRIMMING CFRP COMPOSITES

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing Engineering (Manufacturing Process)

by

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APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering (Process) (Hons.). The member of the supervisory is as follow:

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(DR. RAJA IZAMSHAH BIN RAJA ABDULLAH)

ABSTRAK

Semasa proses pembuatan komponen dari bertetulang gentian karbon plastik (CFRP), langkah selepas pemesinan dilakukan serta toleransi diperlukan untuk memenuhi dan untuk membuang permukaan mounting dan penyatuan.Proses pengeluaran seperti pengilangan kebanyakannya digunakan untuk proses ini. Semua jenis proses pengeluaran yang melibatkan CFRP komposit, kerosakan dalam bentuk delamination boleh berlaku. Kecacatan dalam pengeluaran komposit CFRP adalah lazim di lapisan atas lamina itu kerana ia hanya disokong di satu pihak.Titans atas dan bawah pita multiaxial CFRP adalah lebih kritikal berbanding kain tenun, di mana gentian disokong sepanjang trek. Gentian dipotong oleh alat dengan cara yang undefined , memesongkan bawah tindakan kelebihan dan seterusnya delamination berlaku dalam bentuk serat dan serat pelarian overhangs tepi dipotong. Kerosakan itu harus dielakkan, kerana ini memerlukan masa yang lama untuk proses pemesinan dan memerlukan kos yang tinggi untuk membaiki serta dalam beberapa kes membawa kepada penolakan komponen. Kebanyakan kajian yang sedia ada mengenai pemesinan komposit CFRP hanya menumpukan semata-mata kepada perancangan proses dan sering mengabaikan kesan pemotong geometri yang merupakan faktor penting dalam pemesinan. Sudut heliks yang berbeza pada alat geometri mempengaruhi prestasi pemotongan dan perlu dipertimbangkan secara serius dalam pemesinan CFRP komposit. Kajian ini bertujuan untuk meningkatkan dan membina ciri geometri iaitu sudut heliks terhadap prestasi pemotongan CFRP bahan komposit. Kesan yang ditubuhkan tidak akan digunakan untuk menghasilkan alat berprestasi tinggi khususnya untuk pemangkasan bahan CFRP komposit.

ABSTRACT

The application of carbon fiber reinforced plastic (CFRP) in industry has increased significantly over the last decade. It is necessary for carrying out post-machining step after curing in order to meet the required tolerances and to manufacture fitting and joining surfaces during machining CFRP composites. Production processes such as milling are mainly use for this. Every process involving CFRP Composites, delamination can occur. This characteristic production defect in CFRP composite is often occur in the top layers of the laminate as these are only supported on one side. This is because top and bottom plies of a multiaxial CFRP tape are even more critical than those of woven fabric, where crossing fibers are mutually supported. Fiber will be cut using the tool in an undefined way, deflect under the action of the cutting edge and consequently delamination occurs in the form of fibres overhang and fibre breakout at the cut edges. Damage to the sample should be minimized, because it takes a long his rehabilitation process and involves high costs and may result in the rejection of components. Most of the existing research in machining CFRP composite concentrates merely on process planning and often neglects the effects of cutter geometric feature which is significantly important. Tool geometric features such as number of teeth and helix angle have direct influence on the cutting performance and should be seriously considered in machining of CFRP composite. This research aims to improve the geometrical cutter feature namely number of teeth and helix angle on the cutting performance of CFRP composite material. The established effects will be used for the development of high performance cutting tool, specifically for trimming CFRP aero composite material.

DEDICATION

First and foremost, I would like to express my greatest appreciation to Universiti Teknikal Malaysia Melaka for giving me the opportunity to undergo my final year "Projek Sarjana Muda". Special thank you goes to my supervisor Dr. Raja Izamshah Bin Raja Abdullah for his dedication and guidance during the period of undergoing my project and also to technician En. Hanapiah for her guidance. Last but not least, I want to thank my mom and dad for their support as well as to all my friends Cik Nur Rashidah Binti Mohmad Daud who never give up encouraging me to complete this report.

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LIST OF ABBREVIATION, SYMBOLS AND NOMENCLATURE

CFRP	-	Carbon Fiber Reinforced Plastic
CTRM	-	Composites Technology Research Malaysia
DOE	-	Design of Experiment
RSM	-	Response Surface Methodology
FRP	-	Fiber Reinforced Plastic
CBN	-	Cubic Boron Nitride
3D	-	3 Dimension
MG	-	Micro Grain Carbide
CNC	-	Computer Numerical Control
Ra	-	Surface Roughness
kW	-	Kilowatt
µm	-	Micro meter
Fd	-	Delamnination Factor
Wmax	-	Maximum width of the observed delamination
W	-	Width of the observed delamination
ANOVA	-	Analysis of Variance

CHAPTER 1

INTRODUCTION

This chapter briefly describe the introduction of the project includes the application and demand of CFRP composites, problem statement, objective and scope of the study.

1.1 Background

Carbon Fiber-Reinforced Composites (CFRP) are widely used in todays industry such as aerospace, shipping and automotive because of their high specific strength and high specific stiffness.

Composites offer a great advantages as a material for aircraft. It has a high strength to weight ratio which significantly reduced the aircraft weight and thus are fuel save (Aviation, 2005). Modern improved composite materials and matured processes have encouraged commercial aircraft companies to increase the use of composites in primary and secondary structures. Driven by the demand for fuel-efficient, light-weight and high-stiffness structures that fatigue durable and corrosion resistance, the Boeing 787 Dreamliner is designed with more than 50 percent composite structure, marking a striking milestone in composite usage in commercial aviation.

Meanwhile, the Airbus A350 commercial airplane is being designed with a similar percentage of composite materials in its structure. Figure 1 shows the use of composites in several commercial aircraft applications (Aniversario et al 1982).

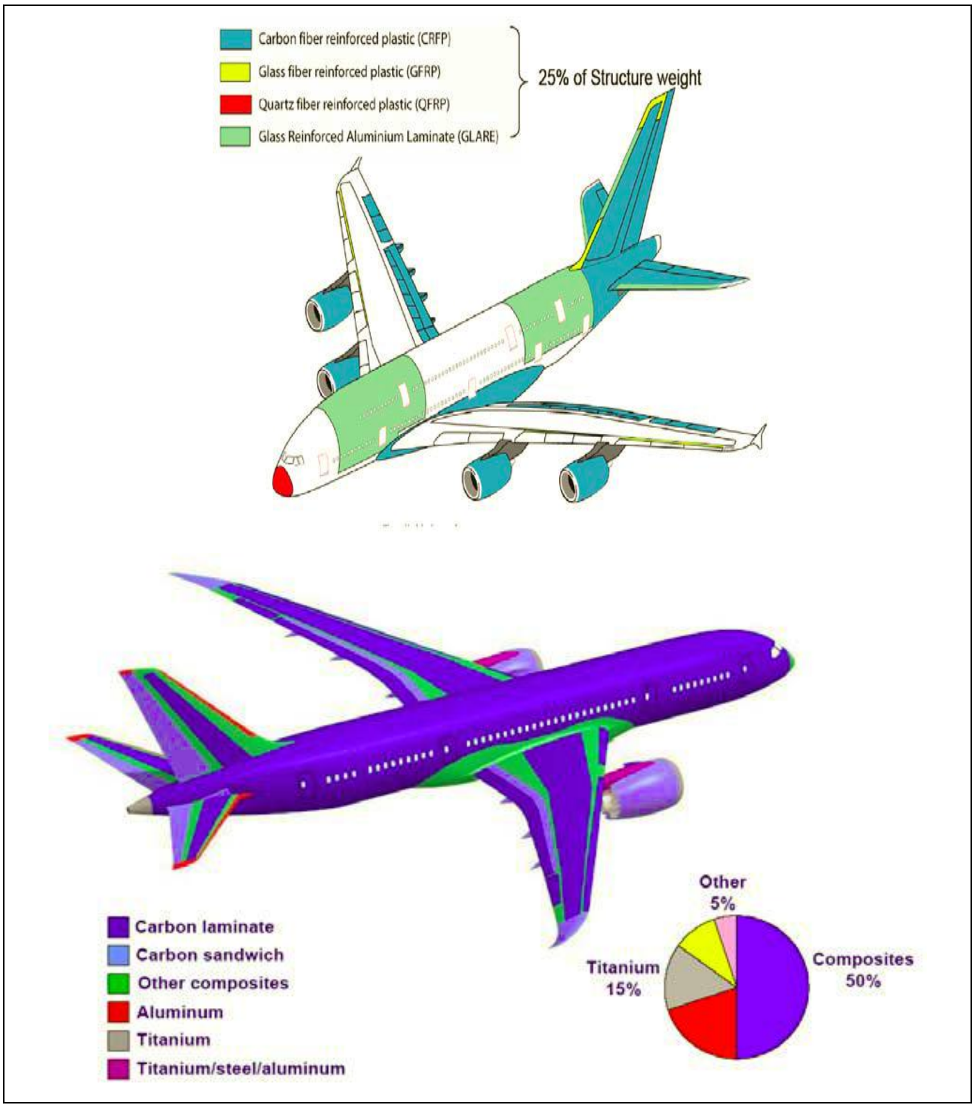

Figure 1.1. Composite Materials Applications in Commercial Aircraft (Aniversario, et al. 1982)

Generally composite are produced to near net shape, however it still have to undergo finishing operation to meet the dimensional requirements for assembly with other components (Neebu, 2001).

The common finishing operation in industry is edge trimming in which to remove the excess material. Edge trimming can be done with conventional router machine or with non-conventional machining process such as ultrasonic machining, laser machining and abrasive water jet machining. Since non-conventional machining processes have disadvantages like heat-affected zone and low material removal rate, the preferred choices for trimming CFRP are with conventional router and abrasive water jet machining (R.Teti, 2009). But due to the inhomogeneous nature of CFRP, machining of composite materials becomes a major cause of concern in the industry (Neebu, 2001).

During CFRP machining the strong anisotropic effect of carbon fibre will produce unstable surface finish. Consequently, the need to machine CFRP both efficiently and effectively are crucial since it will affect its function application (Kalla et al, 2010).

1.2 Problem Statement / Challenge in Machining CFRP Composites

In general, all of the basic composite parts are obtained using different manufacturing processes, such as hand layup or automatic lay-up followed by autoclave cure, RTM, or resin infusion. During the manufacture of the components from carbon fibre reinforced plastic (CFRP), it is usually necessary to carry out a post-machining step after curing in order to meet the required tolerances and to manufacture fitting and joining surfaces. Classical production processes such as milling and drilling are mainly used for this. Auto clave molding usually used to manufactured CFRP part as shown in Figure 1.2 . Regardless of the production process, damage in the form of delamination can occur during the processing of CFRP. This characteristic production defect in CFRPs is particularly prevalent in the top layers of the laminate as these are only supported on one side. Top and bottom plies of a multiaxial CFRP tape are even more critical where crossing fibres are mutually supported. The fibres are cut by the tool in an undefined way, deflect under the action of the cutting edge and consequently delamination occurs in the form of fibre overhang and fibre breakout at the cut edges. Such damage must be absolutely avoided, because this requires time-consuming and costly post-machining to rectify and in some cases leads to rejection of components.

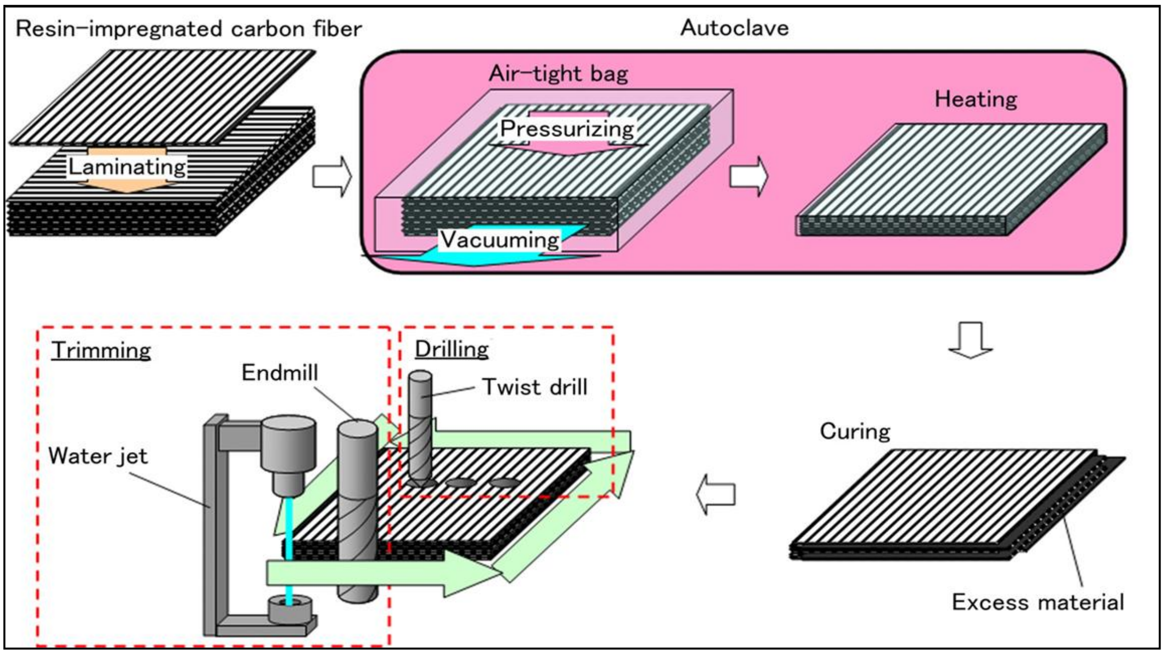

Figure 1.2 : Process to manufacture CFRP (Auto-clave molding)

Despite the advances in near-net fabrication technologies, machining of CFRP remains unavoidable to achieve the required dimensional tolerances and functional surfaces for final assembly. Composite machining has been known to present a myriad of issues such as rapid tool wear, fiber-pull outs, burrs, edge fraying, and delaminations as shown in Figure 1.3. Due to the presence of highly abrasive fibers, CFRPs are difficult to machine often resulting in damaged workpiece and high tool wear rates. Most of the existing research in machining CFRP composite concentrates merely on process planning and often neglects the effects of cutter geometric feature which is significantly important. Tool geometric features such as helix angle have direct influence on the cutting performance and should be seriously considered in machining of CFRP composite.

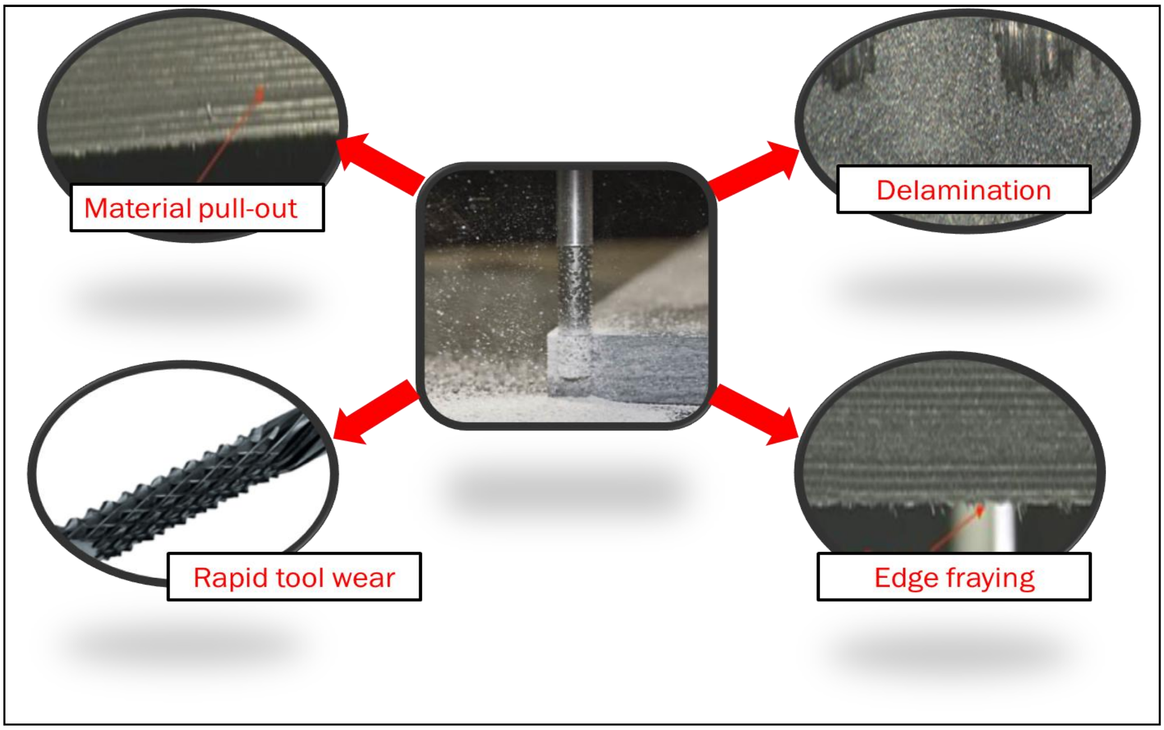

Figure 1.3 : Defects of CFRP

1.3 Objectives

Based on the problem encountered on machining CFRP composites, this project aim to develop a new cutter geometry for effective machining of CFRP composites material. The development of the new cutter consist of three steps:

a) Investigating the effect of cutter geometrical features which is right and left angle for cross nick cutter on the surface roughness and delamination of CFRP composites.
b) Optimizing the angle for right helix and left helix of the cutting tool in order to obtain the minimum surface roughness and delamination when machining CFRP composites.
c) To validate the effectiveness of the new propose cutter design on machining CFRP composites.

1.4 Scope

Scope of the research :

i. Design improvement will focus on right and left helix angle.

ii. Using a statistical Response Surface Methodology to analyses the effect between the factor (Right & Left helix angle) and the performance (surface roughness and delamination).

iii. Edge trimming using a cross-nick cutter.

CHAPTER 2

LITERATURE REVIEW

The study on machining CFRP composite involves many disciplinary areas such as theories of machining, process and composite material. In this chapter, topics that related to the development of the new cutter for trimming CFRP are reviewed. They include the CFRP composite properties, machining, cutting tool, CFRP damage and machining parameter. The purpose of reviewing these topics is to provide a theoretical base for the remainder of the study.

2.1 CFRP Composites

Composite materials are made of two or more constituent materials that are different in chemical structure and form. The main idea behind having two or more constituents is to take the advantage of the favorable material properties of both, without compensating for the weakness of either of the two materials (Ramakrishna et al, 1999). The two phases of composite materials are matrix and reinforcement. The matrix distributes load and forms a protective layer for the reinforcement. However, the main advantage of composite materials over conventional metals and alloys are their high specific strength and specific stiffness (Gordon et al, 2002).

The unique properties and applications of CFRP composites occupy a prominent position of all FRP composite materials. It has useful functional and dimensional properties that extend its applications to various domains. In the present research work, CFRP composite with different ply orientation is used as work piece.