FACULTY OF MANUFACTURING ENGINEERING

INFLUENCE OF MACHINING PARAMETERS ON SURFACE ROUGHNESS AND DELAMINATION OF HOLE IN DRILLING OF CFRP COMPOSITES WITH ULTRASONIC MACHINE

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INFLUENCE OF MACHINING PARAMETERS ON SURFACE ROUGHNESS AND QUALITY OF HOLE IN DRILLING OF CFRP COMPOSITES WITH ULTRASONIC MACHINE

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DECLARATION

I declare that this thesis entitled ‘‘Influence of Machining Parameters On Surface Roughness and Quality of Hole in Drilling of CFRP Composites with Ultrasonic Machine” is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in the candidature of any degree.

Signature :……

Name :…….

Date :…….

APPROVAL

I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of master of Manufacturing Engineering (Industrial Engineering).

Signature : ……

Supervisor Name : ……...

Date : …….....

DEDICATION

I would like to give a very special appreciation to my beloved family and friends for always been there in the time of need. Thanks for giving me continuous support in order for me to fulfill the needs of my Master Project. To my beloved parents and to my supervisor, Dr. Mohd Shahir bin Kasim, and all my friends who have encouraged, guide and inspired me throughout the study process. UTeM has a big part of my success I have achieved in my life, so thank you.

ABSTRACT

Carbon fiber reinforced composite materials are used in a variety of engineering applications due to their significant properties. Armor steel composites are used in areas of application such as military vehicles, tanks, cars, etc. Currently, composites are used to replace conventional metallic materials in a wide range of industries, including aerospace, aircraft, and defense, which require high strength- to- weight and stiffness- to- weight structural materials. Due to their high mechanical properties, CFRP composites are used in fairings, passenger compartments, and storage room doors. Of all the processing operations, drilling is the most commonly used operation. However, the drilling of these composite materials, regardless of the area of application, can be considered a critical operation due to their tendency to delaminate when mechanically stressed. It is therefore important to understand the drilling behavior by conducting a large number of drilling experiments and by screening drilling parameters such as feed rate, spindle speed, ultrasonic and with or without using submersible. These composites provide corrosion resistance. The influence of machining parameters on surface roughness and quality of hole in the drilling of CFRP composites with an ultrasonic machine is investigated in detail.

ABSTRAK

Bertetulang gentian karbon bahan komposit digunakan dalam pelbagai aplikasi kejuruteraan kerana sifat penting mereka. Komposit keluli perisai digunakan dalam bidang aplikasi seperti kenderaan tentera, kereta kebal, kereta, dan lain-lain. Pada masa ini, komposit yang digunakan untuk menggantikan bahan-bahan logam konvensional dalam pelbagai industri, termasuk aeroangkasa, pesawat, dan pertahanan, yang memerlukan kekuatan - tinggi berat kepada- dan berat kepada bahan struktur kekakuan. Oleh kerana sifat-sifat mekanikal yang tinggi, komposit CFRP digunakan dalam fairings, petak penumpang, dan pintu bilik penyimpanan. Semua operasi pemprosesan, penggerudian adalah operasi yang paling biasa digunakan. Walau bagaimanapun, penggerudian bahan-bahan komposit, tanpa mengira kawasan permohonan, boleh dianggap satu operasi kritikal kerana kecenderungan mereka untuk delaminasi apabila mekanikal tertekan. Oleh itu, adalah penting untuk memahami tingkah laku penggerudian dengan menjalankan sebilangan besar eksperimen penggerudian dan dengan menayangkan parameter penggerudian seperti kadar suapan, kelajuan gelendong, ultrasonik dan dengan atau tanpa menggunakan tenggelam. Ini komposit menyediakan rintangan kakisan. Pengaruh parameter pemesinan pada kekasaran permukaan dan kualiti lubang dalam penggerudian komposit CFRP dengan mesin ultrasonik disiasat secara terperinci.

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CHAPTER 1

INTRODUCTION

1.1 Background

Since ancient time, a human was aware of the importance of the use of materials. With the improving of searching for new and better material, we have a lot of types of material and the knowledge of their strength and weakness. Composite materials came along with the improvement till it reaches to include it in a different kind of industry especially engineering. The development and use of composite materials in all engineering industries are taking place at an increasingly rapid rate. Hard to machine material combinations and special unidirectional layouts with a high fiber content are widely used to meet the high mechanical specifications of a structural component.

Carbon fiber polymers (CFRP) are hard-to-machine materials widely used in the industry. Its excellent properties such as high weight-to-strength and weight-to-stiffness ratio, low thermal expansion coefficient, magnetic and corrosion resistance lead to increasing demand for CFRP in the aerospace and aviation industries. Low weight-to-strength and weight-to-strength ratio reduce the overall weight of the aircraft and thus increase its performance.

Carbon fiber reinforced plastics (CFRP) are the most widely used materials in civil aircraft today in the aerospace industry. Hard to machine material combinations and special unidirectional layouts with a high fiber content are widely used to meet the high mechanical specifications of a

structural component. To date, the aircraft components are connected to rivets that require high - quality bores before they join Limited tool life, bore, and channel damage and diameter variances are currently the limiting factors and key criteria for the selection of a CFRP process and tool geometry for a certain application. Manual workmanship due to insufficient quality should be avoided in competitive manufacturing.

Among the various fiber - reinforced composite laminates drilling processes, conventional twist drilling or special drill bits remained the most frequently and economically used machining operation in the industry. Drilling is a complex process and, due to the anisotropic and non-homogeneous properties of these materials, differs significantly in many respects from the machining of conventional metals and alloys. There are many problems with drilling composite materials that do not occur in other materials. Among the various defects caused by drilling, delamination is the most common mode of life that limits the growth of damage.

1.2 Problem Statement

Since industries heavily demand carbon fiber reinforcement polymer composite, so it has many problems that they face such as drilling materials would be dangerous if do not follow safety procedures but some material like carbon fiber has more safety procedures than other because it has hazard gas would come out during the drilling due the high-temperature cause by friction and also the small particles are dangerous for the skin and lung in case of inhaling. Quality of the hole would be effected to those problems too.

1.3 Objectives

The objectives of this project are:

1. To measure the effect of ultrasonic drilling machining on surface roughness of Carbon Fiber Reinforced Polymer (CFRP) Composite.
2. To measure the delamination of Carbon Fiber Reinforced Polymer (CFRP) Composite hole.

1.4 Scope of The Project

The scope of this project focuses on:

In this research, the relationship between cutting parameters and ultrasonic frequency was developed by historical data method. The influence of cutting parameters on the surface quality in terms of surface roughness and delamination of CFRP was analyzed by Design Export program. The workpiece will be drilled by a CNC machine and High-speed steel (HSS) cutting tool.

1.5 Report Outline

The project comprises fives chapter which is presented as follow:

Chapter 1: Introduction, this chapter gives a brief overview of the project background and formulates the problem of the research. The research scope, objectives, and significance are discussed in this chapter as well.

Chapter 2: literature review, this chapter focus on presenting the related theoretical concept of the research. Available approaches and studies of enhancing the production capacity are discussed in this chapter.

Chapter 3: Methodology, data collection approaches, and project sequence flow are presented in this chapter. A detailed explanation of the proposed approach and its implementation phases are described in this chapter as well.

Chapter 4: Results and Discussion, critical evaluation of the collected data and identifying the possible factors of production losses are presented. The effectiveness of the proposed methods is analyzed to determine their ability in increasing the production capacity.

Chapter 5: conclusion and recommendation, this chapter summarizes the research finding and suggest some future implementation of the project as well.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Materials, usually shortened to composites, are designed or naturally occurring materials made of two or additional constituent materials with significantly different physical or chemical properties that keep separate and distinct within the finished structure glass fiber is the most common fiber material. Glass fiber has credible mechanical properties (strength and stiffness) and low price. Composite materials used in many applications such as boats, tanks, bodies, tubes, etc. For additional advanced applications, carbon or aramid fibers will be replacing glass fiber but is more expansive than glass fiber. These provided raise on stiffness and strength, and with aramid, an increased have an effect on strength. Those kinds of composite fibers been applications in defense, aerospace (aircraft, satellites), and various sorts of sports equipment Petersson *et al.*,(2013) reported. Carbon fiber Reinforce plastic (CFRP) composites included two materials. its carbon filaments and a polymer. Within CFRP composites, carbon strands are encompassed by the polymer grid. The carbon strands are used to bolster the heap, whereas the polymer grid is utilized to tie and secure the filaments and exchange the heap to the strengthening fiber (Ning *et al.*, 2015). Numerous standard machining methods like turning, boring and process are typically used to

machine composite materials. numerous challenges are experienced in machining of composites due to framework fiber two-stage structure, e.g. delamination and fiber part.

The basic objective of drilling operations focuses on good quality levels desired by making holes at the minimum price. The achievement of this simple objective will present challenges to those accountable for establishing and maintaining efficient production operation. The broad applicability of drilling leads to an over-sized variation in client necessities, materials, tolerances, lot sizes and shop facilities that, in turn, prevent simplified solution.

Since the tool life equation was discovered by Taylor, many research papers been published throughout the planet for a better understanding of metal-cutting phenomena. Wear and tool life is thus necessary from the economic purpose of view that several efforts have been created to spot those quantities analytically and/or through an experiment. The metal cutting method is incredibly advanced as a result of the presence of assorted processes like plastic and other deformation, wear, strain hardening, etc.(Karna *et al.*, 2008).

Rotary ultrasonic drilling is the new machining method used to drill holes on fiber-reinforced plastics and has been attracting increased attention in recent years. Dimensional tolerances are important in the machining of carbon fiber reinforced plastics. in addition, diamond core drills are at the same time drilling and grinding fiber reinforced plastics. The experiment aims to analyze thrust force and dimensional tolerances as well as roundness and cylindricity in rotary ultrasonic drilling of carbon fiber reinforced plastics using diamond core drill. To this end, a proper ultrasonic system for a core drill in ABAQUS is meant and fabricated.

2.2 Composites

The mechanical properties of composites rely upon many variables like fiber type, orientation, and design. Fiber design refers to the configuration form of fibers obtained by braiding, knitting or weaving. Composites are aeolotropic materials with completely different powers in a certain direction. The stress-strain curve could be a composite curve linear elastic fracture to the point of failure. polymer resin within the composite material, that could be a solid elastic, viscoelastic will respond to a given load. however, the material could undergo creep and deformed on loading continuously. Composites have several structural quality is superb, a number of examples are high strength, material toughness, fatigue resistance, and light-weight. Another extremely desirable characteristic is resistance to high temperatures, abrasion, corrosion, and chemical attack.

Some of the benefits within the use as an element of the composite structure are simple manufacturing, handling, and installation. Project completion time is going to be shorter. Composites can be designed for high-ability, durability and prolong the lifetime of the treatment. Composites have a strength-weight ratio (strength-to-weight ratio) was excellent (Huda, Ascroft and Barnes, 2016). A number of the weakness within the use of composites in bridge be the high investment prices, creep and shrinkage. Design and construction need a specialist who is aware of regarding design engineering and materials science disciplines. Composite has the potential to be degraded by the environment, as an example of alkali attack and exposure to ultraviolet radiation. There's a shortage at the connection and binding technology. There are fears of worldwide and local buckling. Though the nature of light may be a bonus in responding to the earthquake loads, however, it may also create aerodynamic structure unstable. In manufacturing the hand lay-up process, there are issues regarding the consistency of the material properties.

2.2.1 Global Carbon Fiber Consumption

The estimated world carbon fiber consumption is shown in Table 2.1. Huang reports that the major carbon fiber manufacturers around the globe and their estimated nameplate capacities are shown in Table 2.2. A gradual increase in each production and consumption within the future will be expected. In fact, most of the carbon fiber manufacturers have plans for expansion to fulfill market demand. However, the large-volume application of carbon fiber in the automotive industry has been hindered because of the high fiber price and therefore the lack of high-speed composite fabrication techniques.

Table 2.1: world estimated carbon fiber consumption (Huang, 2009).

	1999(tons)	*2004 (tons)*	*2006 (tons)*	*2008 (tons)*	*2010 (tons)*
Aerospace	4000	5600	6500	7500	9800
Industrial	8100	11400	12800	15600	17500
Sporting goods	4500	4900	5900	6700	6900
Total	16600	21900	25200	29800	34200

As in the year, 1999 was the start of the used composite in many industries but in 2004 the total use of carbon was 21900 tons which are 5300 tons difference. The increment is major between years as in 2010 has 34200 tons with all the technologies have discovered later in 2010.

Table 2.2: world estimated carbon fiber consumption per industry (Huang, 2009).

	1999 (tons)	*2004 (tons)*
Toray Industries (Small Tow)	9100	
Toho Tenax (Teijin) (Small/Large Tow)	8200	
Mitsubishi Rayon/Grafil (Small Tow)	4700	
Zoltek (Large Tow)	3500	
Hexcel (Small Tow)	2300	
Formose Plastics (Small Tow)	1750	
Cytec Engineered Materials (Small Tow)	1500	360
SGL Carbon Group/SGL Technologies (Large Tow)	1500	
Mitsubishi Chemical		750
Nippon Graphite Fiber		120

2.2.2 Carbon Fiber Reinforce Polymer (CFRP)

Composite has different materials but the main elements that have been used are Fibers. Chung finds the effects of fibers fiber in the type, volume fraction, the design and orientation has been developing and wrote by a lot of researchers. the volume in the composite matrix has been occupied by 30% - 70% of Fibers. reinforced polymer composites are the most commonly used in advanced fiber due to structural applications is Glass fiber, Aramid and carbon. with comparing the types of fiber cost, glass fiber is more inexpensive than carbon fiber but Aramid cost is almost similar to the low-quality carbon fiber cost.

At least 92 wt.% of composition fibers are carbon fiber. Carbon fiber has two short or continuous; their structure can be partly crystalline, amorphous, or crystalline. In figure 2.1 shows