UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Faculty of Manufacturing Engineering

EXPERIMENTAL STUDIES ON EFFECT OF PROCESS PARAMETERS ON TOOL WEAR IN DRILLING CFRP COMPOSITES WITH ULTRASONIC MACHINE

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A thesis submitted

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2019

DECLARATION

I declare that this thesis entitled ‘‘Experimental Studies on Effect of Process Parameters on Tool wear in Drilling 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 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 dedicate my dissertation work to my family and many friends. A special feeling of gratitude to my loving parents whose words of encouragement and push for tenacity ring in my ears. To my supervisor and a father Assoc. Prof. Dr. Mohd Shahir bin Kasim. I also dedicate this dissertation to my many friends who have supported me throughout the process. I will always appreciate all they have done.

ABSTRACT

Hole production was long recognized as the most important process of machining, requiring specialized techniques to achieve optimum cutting conditions. Drilling can be described as a process in which a multi - point tool is used to remove unwanted materials for the desired hole production. However, high production processing and drilling with high cutting speed and feed rate are inherently linked to high heat generation and high cutting temperatures which cause tool wear. CFRP composites used in many applications such as aerospace efficiency, fuel cells, turbo machinery, compressed gas storage and transport, electromagnetic wind turbine shielding materials in automotive energy systems and offshore–deep sea drilling platforms, antistatic due to outstanding properties such as magnetic, low thermal expansion coefficient, high weight-to-strength and weight-to-stiffness ratio and corrosion resistance. High - speed steel (HSS) is the lowest cost drawing material for general purposes and the easiest to find. In this case, submersible reduces the temperature very effectively. A large amount of tool wear appears on the drill bit when the temperature is increased. High temperatures affect both the roundness of the hole or the shape of the chip and the color of the chip. Submersible reduced temperature and improved roundness and also lubricates the tool tip and surface interface. The comparison between parameters and condition has been made to observe the best condition & parameters to increase the tool life.

ABSTRAK

Pengeluaran lubang telah lama diakui sebagai proses pemesinan yang paling penting, memerlukan teknik khusus untuk mencapai keadaan pemotongan optimum. Penggerudian boleh digambarkan sebagai proses di mana alat multi-point digunakan untuk mengeluarkan bahan yang tidak diingini untuk pengeluaran lubang yang diinginkan. Walau bagaimanapun, pemprosesan pengeluaran yang tinggi dan penggerudian dengan laju pemotongan tinggi dan kadar suapan secara inheren dikaitkan dengan penjanaan haba tinggi dan suhu pemotongan tinggi yang menyebabkan alat memakai. Komposit CFRP yang digunakan dalam banyak aplikasi seperti kecekapan aeroangkasa, sel bahan bakar, jentera turbo, simpanan gas dan pengangkutan gas termampat, bahan pelindung turbin angin elektromagnet dalam sistem tenaga automotif dan platform pengeboran laut dalam laut, antistatik kerana sifat-sifat cemerlang seperti magnet, rendah pekali pengembangan haba, nisbah berat ke kekuatan dan nisbah berat ke kekakuan dan rintangan kakisan. Kelajuan berkelajuan tinggi (HSS) adalah bahan lukisan kos terendah untuk tujuan umum dan paling mudah dicari. Dalam kes ini, tenggelam mengurangkan suhu sangat berkesan. Banyak alat memakai muncul pada bit gerudi apabila suhu meningkat. Suhu tinggi mempengaruhi kedua-dua lubang lubang atau bentuk cip dan warna cip. Suhu berkurang tenggelam dan bulat yang lebih baik dan juga melincirkan alat alat dan antara muka permukaan. Perbandingan antara parameter dan keadaan telah dibuat untuk melihat keadaan dan parameter terbaik untuk meningkatkan hayat alat.

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CHAPTER 1

INTRODUCTION

1.1 Background

Since the Stone Age, people have been aware of the importance of using materials. We have many types of material and the knowledge of their strength and weakness in improving the search for new and better materials. Composite materials have been improved until they can be included in various types of industry, especially in engineering. The development and use of composite materials in all engineering industries is 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 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 an 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.

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 drilling processes for fiber - reinforced composite laminates, conventional twist drilling or special drill bits remained the most common and cost - effective 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 are heavily demanding carbon fiber reinforcement polymer composite, many of the problems they face, such as drilling materials, would be dangerous if we do not follow safety procedures, but some material like carbon fiber has more safety procedures than others because it has a hazard dust, the hazardous dust that come out of the carbon fiber is very dangerous inhaling the dust will cut the human lungs due to the carbon fiber strong characteristics. Tool wear happen very fast during drilling due to the high temperature caused by friction and the carbon fiber strong characteristics. So we will try to minimize the tool wear and eliminate the hazardous gas by using submersible.

1.3 Objectives

The objectives of this project are:

1. To measure the hazardous level by using Particulate Matter Detector.
2. To calculate the weight loss of the tool bit and determine which factors have the most effect.

1.4 Scope of the Project

To compare between the parameters such as Ultrasonic and non-ultrasonic in dry & submersible condition and analyze the response graphically and statically using ANOVA method to determine which parameters & condition are the best for tool life.

1.5 Report Outline

The project includes the following five chapters:

Chapter 1: Introduction, this chapter provides a brief overview of the project background and formulates the research problem. The scope, objectives and importance of the research are also discussed in this chapter.

Chapter 2: literature review this chapter focuses on the related theoretical research concept. This chapter discusses available approaches and studies to improve production capacity.

Chapter 3: This chapter presents methodology, approaches to data collection and project sequence flow. This chapter also describes a detailed explanation of the proposed approach and the phases of its implementation.

Chapter 4: Results and discussions, critical assessment of the data collected and identification of possible production loss factors are presented. The efficiency of the proposed methods to determine their capacity to increase production capacity is analyzed.

Chapter 5: Completion and recommendation this chapter summarizes the research findings and also proposes some future project implementation.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Materials, usually shortened to composites, are designed or naturally occurring materials made of two or more components of substantially different physical or chemical properties that are separate and distinct within the finished structure. The most common fiber material is fiber glass fiber. Glass fiber has credible mechanical characteristics (strength and rigidity) and low cost. Composite materials such as boats, tanks, bodies, tubes, etc. Carbon or aramid fibers replace glass fibers for additional advanced applications but are more extensive than glass fibers. These increase stiffness and strength and have an increased effect on strength with aramid. Such composite fibers were used in defense, aerospace (aircraft, satellites) and different types of sports equipment (Mechanical *et al.*, 2019). Carbon fiber Included in two materials are plastic reinforcement (CFRP). Its carbon filaments and a polymer. The carbon strands are covered by the polymer grid in CFRP composites. The carbon strands are used to support the heap, while the polymer grid is used to tie and secure the filaments and replace the heap with the fiber (Ning *et al.*, 2015). Many standard processing methods, such as turning, boring and processing, are typically used in the machining of composites. There are numerous challenges in the machining of composites due to the two- stage frame fiber structure, e.g. Fiber and Delamination Parts (Chandramohan and Rajesh, 2014).

The basic goal of the drilling operations is to achieve the high quality levels desired by creating holes at a minimum price. The achievement of this simple goal will present challenges for those responsible for the establishment and maintenance of efficient production. The wide application of drilling leads to an over-sized variation in customer needs, materials, tolerances, lot sizes and shop installations, which in turn prevent simplified solutions.

Since Taylor discovered the life equation of the tool, many research papers have been published around the world to better understand metal cutting phenomena. Therefore, wear and tool life are necessary from the economic point of view that several efforts have been made to analytically and/or experimentally detect these quantities. The method of metal cutting is incredibly advanced due to the presence of various processes, such as plastic and other deformations, wear and strain hardening and etc.(Karna, Singh and Sahai, 2008).

Rotary ultrasonic drilling is the new process for drilling holes on fiber - reinforced plastics and has attracted more attention in recent years. For the processing of carbon fiber reinforced plastics, dimensional tolerances are important. Moreover, diamond core drills are simultaneously reinforced plastics for drilling and grinding fiber. This paper aims to analyze the thrust strength and dimensional tolerances, as well as the roundness and cylindricity of carbon fiber reinforced plastics rotary ultrasonic drilling using diamond core drills. A proper ultrasonic system for a core drill in ABAQUS is designed and manufactured for this purpose.

2.2 Composites

Composites ' mechanical properties depend on many variables, such as fiber type, orientation and design. Fiber design refers to the fiber configuration form obtained by weaving, tricking or weaving. Composites are aeolotropic materials in a certain direction with completely different powers. The stress curve may be a linear elastic fracture of the composite curve to the point of failure. The composite material's polymer resin, which could be a solid elastic viscoelastic, responds to a given load. However, the material could undergo continuous creep and deformed loading. Composites have a number of excellent structural quality, many examples are high strength, material strength, fatigue resistance and light weight. Another highly desirable feature is high temperature resistance, abrasion, corrosion, and chemical attacks(Eneyew and Ramulu, 2017).

Some of the advantages in the use as a composite structure element are simple manufacturing, handling and installation. Project completion time will be shorter. Composites can be designed for high performance, durability and extend the durability of the treatment. The strength-to-weight ratio of composites (strength-to-weight ratio) was excellent (Farah *et al.*, 2017). High investment prices, creep and shrinkage are a number of the weaknesses in the use of composites in the bridge. Design and construction require a specialist who knows the disciplines of design engineering and material science. Composite can be degraded by the environment as an example of alkaline attack and ultraviolet radiation exposure. There is a lack of binding and connection technology. There are fears of a humpback worldwide and local. Although the nature of the light can be a bonus in response to the earthquake loads, it can also create an unstable aerodynamic structure. There are problems with the consistency of the material properties in the manufacturing of the hand layout process(Che, 2018).

2.2.1 Carbon Fiber Reinforced Polymer (CFRP)

Composite has various materials, but the main element used are fibers. The effects of fibers in type, volume, design and orientation have been developed and written by many scientists. The composite matrix volume was occupied by 30% – 70% of the fibers. Glass fiber, aramid and carbon are the most commonly used reinforced polymer composites in advanced fiber due to structural applications. Glass fiber is cheaper than carbon fiber when compared to fiber cost types, but Aramid cost is nearly the same as low - quality carbon fiber costs(Huang, 2009).

At least 92 wt. % of the fibers are carbon fibers. Carbon fiber must be short or continuous in two; its structure may be crystalline, amorphous or crystalline in part. Figure 2.1 shows a honeycomb structure in the x-y plane for the crystalline form has a graphite crystal structure consisting of two - dimensional sp2 hybridized carbon atoms. Carbon is a good electronic conductor and thermal conductor, and because of its atoms inside a layer, the overlap of sp2 hybridized orbitals made covalent bonds and the delocalization of pz orbitals, Le., the 7r electrons have metal bonds. Van Der Waals bonding is used without difficulty for each other in carbon fiber bonding and carbon layers. It is advantageous for graphite because it is an electric isolator perpendicular to the layers. The difference between the out - of-plan and the in-plane connection is attributable. Graphite is therefore highly anisotropic, but graphite has a large elastic module parallel to the plane and a low perpendicular module to the plane (Chung, no date).

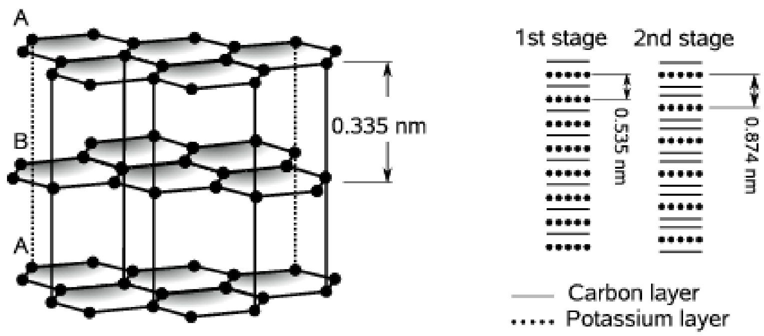

Figure 2.1: The crystal structure of graphite.

Composite is an advanced material and the industry introduces carbon fiber reinforced plastic (CFRP). Due to its superior properties, countless industries used it heavily. In industry such as aerospace and aircraft final phase assembling large numbers of holes is required to be drilled. The combination of the carbon fiber reinforced plastic (CFRP) material consists of two polymer and carbon fiber materials.

2.2.2 Factors Influencing Orientation

CFRP fiber composites are bound by a polymer matrix. The polymer matrix reinforcing fibers are used to bind and protect the fibers, and carbon fibers are used to support the load (Leung *et al.*, 2012).

The plain woven structured carbon fiber and resin matrix in Figure 2.2 shows the orientation of the spinning of carbon fiber woven at 0, 90, + 45, -45 degrees. The example of the CFRP layers has 5 layers, which are bidirectional layers on the bottom and top, and between them there are three layers of unidirectional layers, which are sandwiched with 5 layers. There is also a different way illustrated in Figure 2.3.