UNIVERSITI TEKNIKAL MALAYSIA MELAKA

IMPROVEMENT OF DRILL GEOMETRY FOR DRILLING CFRP COMPOSITE

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

By

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BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

TAJUK: **IMPROVEMENT OF DRILL GEOMETRY FOR DRILLING CFRP COMPOSITE.**

SESI PENGAJIAN: **2013/14 Semester 2**

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I declare that this report entitle "Improvement Of Drill Geometry For Drilling Cfrp Composite" is the result of my own research except as cited in the references.

Signature: ……………………………………

Name: Syahibul Hafiz Bin Basir

Date: 23th june, 2014

APPROVAL

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

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(Supervisor)

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(Co-Supervisor)

ABSTRAK

Secara amnya, CFRP disertai dan berkaitan dengan menyertai elemen ke dalam satu bahagian komposit. Penggerudian CFRP boleh merosakkan lubang dalam bentuk nyahikatan, serat tarik keluar, permukaan kasar, kerepek tepi, serat yg belum ditebang dan penggunaan alat pesat yang bersekutu dengan gerudi ciri-ciri geometri. Dari sastera, ia menunjukkan bahawa latihan menggunakan mata gerudi dengan reka bentuk yang sesuai adalah jenis gerudi yang paling sesuai untuk penggerudian CFRP. Oleh itu, projek ini bertujuan untuk menyelidik dan mencadangkan reka bentuk optimum mata gerudi untuk mengesan penggerudian CFRP komposit. Dua pisau menggerudi rekabentuk geometri akan disiasat iaitu sudut mata dan alat aspek kepada kekasaran permukaan lubang, nyahkaitan dan daya penggerudian menggunakan statistikal RSM. Sejumlah jenis gerudi-reka dengan sudut yang berbeza-beza mata dan alat abih. Dari siasatan yang dijalankan, ia menunjukkan bahawa penggerudian gentian komposit bertetulang CFRP polimer terjejas dengan ketara permukaan ke arah pembentukan serat, duri dan menyebabkan keadaan kekasaran permukaan. Penjelasan mengenai evolusi daya pemotongan dan analisis perkembangan kerosakan telah membantu dalam memahami fenomena penggerudian dengan meningkatkan sudut titik dan abih. Nilai bilangan nyahkaitan terhasil mengikut jenis yang berbeza dari mata alat gerudi direkabentuk yang menunjukkan keadaan yang wujud pada permukaan bahan kerja penggerudian. Di samping itu, reka bentuk geometri yang optimum untuk penggerudian CFRP adalah dengan menggunakan 110 º titik sudut dengan lima alat abih. Satu set ujian eksperimen telah dilakukan untuk mengesahkan reka bentuk alat optimum yang dipilih. Perjanjian yang kukuh sebanyak 90% telah didapati antara meramalkan dan nilai sebenar mengesahkan keberkesanan reka bentuk untuk penggerudian berkesan CFRP komposit.

ABSTRACT

Generally, CFRP are joined and connected by joining elements into one composite section. For this purpose, it is necessary to drill numerous holes which poses several challenges due to its inhomogeneous materials that consist of fibre and matrix. Drilling of CFRP can damage the hole in the form of delamination, fibre pull out, rough surface, edge chipping, uncut fibre and rapid tool wear which associate with the drill geometrical features. From literature, it shows that dagger drill with suitable design is the most suitable drill type for drilling CFRP. Thus, this project attempts to investigate and propose the optimal design of dagger drill for effectively drilling CFRP composite. Two dagger drill geometric design will be investigate namely point angle and tool facet on hole surface roughness, delamination and drilling force using statistical RSM. Total of nine drill design are fabricate with varying point angle and tool facet. From the conducted investigation, it shows that drilling carbon fiber reinforce polymer CFRP was substantially affected the surface towards fibre formation, burr and lead to condition of surface roughness. The explanations about evolution of cutting force and analysis of damage progression have assisted in understanding the drilling phenomenon by increase the point angle and facet. The value of delamination number produces by different type of drill bit tool in the design expert demonstrated the circumstances prevailing at the workpieces drilling surface. In addition, the optimal geometric design for drilling CFRP are by using 110º point angle with five tool facet. A set of experimental test were done to validate the selected optimal tool design. The strong agreement of 90% were found between predicted and actual value confirmed the effectiveness of the design for effective drilling of CFRP composite.

DEDICATION

I would like to dedicate this whole PSM report to my beloved family and beloved siblings.

To my late mother ALLAHyarhammah Hjh. Zaharah Bt. Hj. Othman

Al - Fatihah

ACKNOWLEDGEMENT

"In the name of Allah, the most gracious, the most compassionate"
Alhamdullillah, thanks to Allah S.W.T., finally after facing a lot of challenges during my final year project, lastly it is done. There are numbers of people have contributed in different ways in completing this study with lots of support, indeed, this final year project could not have been completed without any of you.

First of all, billion of thanks dedicated to my supervisor, Dr Raja Izamshah Bin Raja Abdullah for his briefing and passionate guidance throughout the whole process of completing this project as well as for teaching me the proper techniques of writing reports. Thank you so much for all the guidance in helping me doing the project, willing to answer the question that thrown to him and spending his time showing and explaining to me about the equipment and machines that involve in certain process.

Last, I would like to express my appreciation to my family and my friend because a lot of help in completing this study and give me spirit to finish this study. Thank you.

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CHAPTER 1
INTRODUCTION

This chapter provides the background of the research. The research will focus on the improvement of new drill bit geometry for drilling CFRP composite with different fibre orientation. The background of the research covers the development and current achievement of drill geometry for drilling CFRP composite. Moreover, the problem statements followed by the objectives and scope of the project are included.

1.1 Background

Carbon Fibre Reinforced Polymer (CFRP) have widely used in many of industries, especially in aerospace industries due to the great in strength to weight ratio as well as the ability to create large integrated structure.

The matrix for a CFRP composite is a plastic and the reinforcement is glass that has been made into fine threads and often woven into a sort of cloth. The first modern composite material was fibreglass. It is still widely used today for boat hulls, sports equipment, building panels and many car bodies. On its own the glass is very strong but brittle and it will break if bent sharply. The plastic matrix holds the glass fibres together and also protects them from damage by sharing out the forces acting on them.

Generally, CFRP composite are lighter and stronger than fibreglass but more expensive to produce, some advanced composites are now made using carbon fibres instead of glass. They are used in aircraft structures and expensive sports equipment such as golf clubs.

More than 20% of the A380 is made of composite materials, mainly plastic reinforced with carbon fibres. The new Airbus A380, the world's largest passenger airliner, makes use of modern composites in its design. The design is the first large-scale use of glass-fibre-reinforced aluminium, a new composite that is 25 % stronger than conventional airframe aluminium but 20% lighter.

Generally, CFRP are joined and connected by joining elements into one composite section. For this purpose, it is necessary to drill numerous holes which pose several challenges due to its inhomogeneous materials that consist of fibre and matrix.

Drilling of CFRP can damage the hole in the form of delamination, fibre pull out, rough surface, edge chipping, uncut fibre and rapid tool wear which associate with the drill geometrical features. From literature, it shows that dagger drill with suitable design is the most suitable drill type for drilling CFRP.

Thus, this project attempts to investigate and propose the optimal design of dagger drill for effectively drilling CFRP composite. Two dagger drill geometric design will be investigate namely point angle and tool facet on hole surface roughness, delamination and drilling force.

1.2 Problem Statement

Drilling is one of the most important, frequently practiced and unavoidable machining operation for components used in carbon fibre composite structures. High degree of intricacy in structures necessitates creating holes to facilitate the process of assembly. Composite materials pose additional difficulties while solving the problem of controlling the drilling process. These difficulties arise from the anisotropic nature of the material, as determined by the stacking sequence of the laminate. This prevents the use of empirical models for control due to the difficulty in dealing with the large number of parameters that determine the material characteristics, and of quantifying them with any certainty.

There are several common problems associated with drilling carbon fibre composite such as delamination, excessive tool wear, melting and softening of the matrix, fibre pull-outs and scorching of the surface usually reported as the biggest concerns. Delamination usually occurs when the last plies of the material do not withstand the force exerted by the drill bit's chisel edge. In addition, the chip produced during drilling of carbon fibre composites is in the form of abrasive dry dust. The ineffective extraction of the chip is one of the major reasons for high tool wear rates. Tool wear is also related to delamination, as the force necessary to cut the material increases with tool wear. Figure 1 show the defects when drilling CFRP composite. Generally, the holes performances are directly related with the drill geometry.

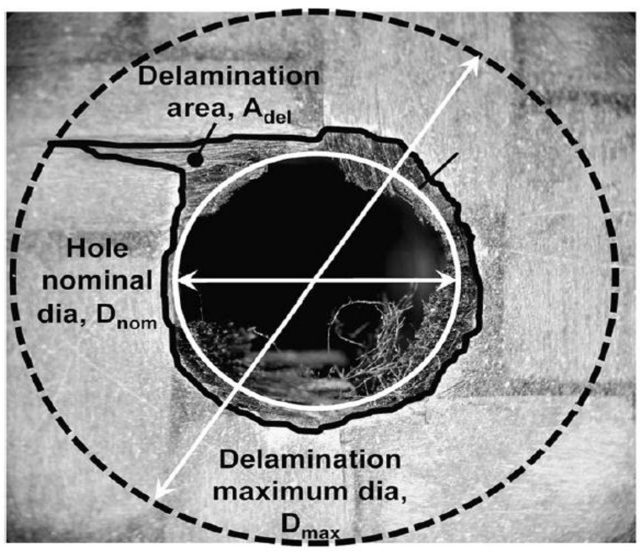

Figure 1.1: Defect after drilling CFRP composite.

Therefore, a better understanding of the drilling of carbon composites with other shaped of drill bits is necessary for further improvement and optimization leading to the quality and productivity of the drilling process.

1.3 Aims and Objectives

1.3.1 Aims and Objectives

Based on the problem and difficulties on drilling CFRP composite, the aim and objectives of this project are:-

a) To investigate the effects of dagger drill geometry design namely point angle and tool facet on CFRP hole performances such as surface roughness, delamination and drilling forces.

b) To propose on optimal dagger drill geometry design that can effectively drilling CFRP composite.

c) To validate the effectiveness of the new propose drill geometry design.

1.4 Scopes

The scopes of this project are:-

a) Fabricate new dagger drill bit. Tool Parameter Point Angle: 90° - 110°. Facet: 3,4,&5.

b) Drilling CFRP and making hole process

c) Delamination and burr analysis.

d) Dynamometer to measure thrust force.

1.5 Report structure

Generally, there are 5 chapters includes in this project. Chapter 1 represents the introduction of the project. The contents included are background, problem statement, objective, and scope and project background. The clear explanation regarding the subtopics influence in this research covered in this chapter. Chapter 2 represents the literature review on the background and basic information about project. Chapter 3 represents the methodology; this chapter included planning of the research and flow chart. This chapter included drawing product sketching and solid work, final design the product to fabricate. Chapter 4 discuss on the detail and the implementation about fabrication drill, by using Design Expert software to get parameter and drilling experiment by using dynamometer method throughout the project. Chapter 5 will be discussing the result and analyses obtain through the process and presentation of the data that have been collected, the progression, experimental data and analysis stated in this chapter and last will be the conclusion of the whole study and recommendation for future research.

CHAPTER 2

LITERATURE REVIEW

This chapter provides the definition of CFRP composite and a brief history of CFRP composite technology for aircraft. In addition, the techniques and types of available drill for CFRP drilling were also. Then, this chapter describes on the related work of drilling CFRP composite. Finally, this chapter cover the damage and difficulties when drilling CFRP composite.

2.1 CFRP composite

Composites CFRP are one of the most widely used materials because of their adaptability to different situations and the relative ease of combination with other materials to serve specific purposes and exhibit desirable properties.
The use of plastic resins has made possible the development of non-metallic materials that are often superior to metals in strength or weight ratio, corrosion resistance, ease of fabrication, and cost. Structural materials known as composites are made of many different materials and in a variety of forms.

According to R.E. Horton and J.E. McCarty, 1987. (Damage Tolerance of Composites, *Engineered MaterialsHandbook,* Vol 1). Continuous fibers have long aspect ratios, while discontinuous fibers have short aspect ratios. Continuous-fiber composites normally have a preferred orientation, while discontinuous fibers generally have a random orientation. A fiber has a length that is much greater than its diameter. The length-to-diameter (*l*/*d*) ratio is known as the *aspect ratio* and can vary greatly.

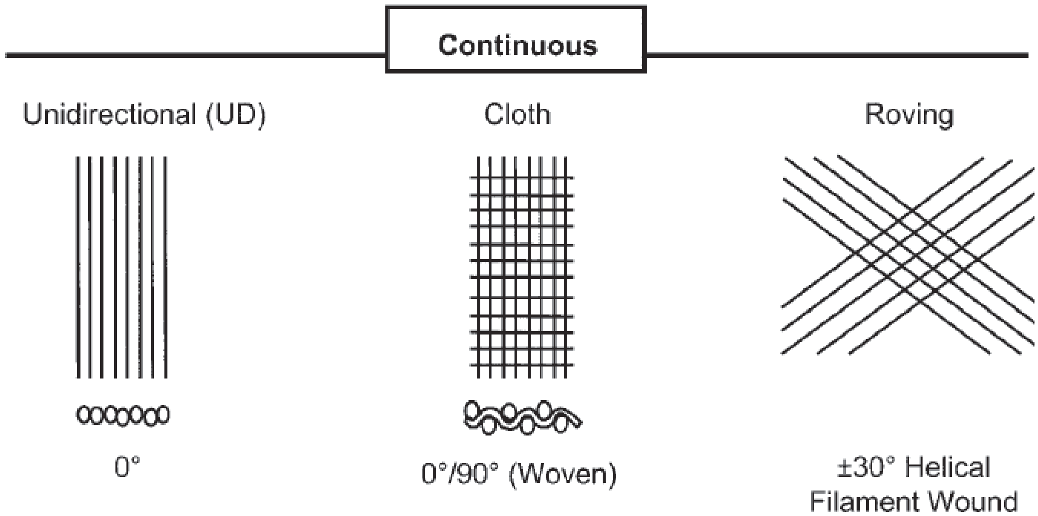

Figure2.1: Continuous reinforcements include unidirectional, woven cloth, and helical winding

Fibers produce high-strength composites because of their small diameter; they contain far fewer defects (normally surface defects) compared to the material produced in bulk. Continuous-fiber composites are often made into laminates by stacking single sheets of continuous fibers in different orientations to obtain the desired strength and stiffness properties with fiber volumes as high as 60 to 70 percent. As a general rule, the smaller the diameter of the fiber, the higher its strength, but often the cost increases as the diameter becomes smaller. Typical fibers include glass, aramid, and carbon, which may be continuous or discontinuous. In addition, smaller-diameter high-strength fibers have greater flexibility and are more amenable to fabrication processes such as weaving or forming over radii. The advantages of composites CFRP are many, including lighter weight, the ability to tailor the layup for optimum strength and stiffness, improved fatigue life, corrosion resistance, and, with good design practice, reduced assembly costs due to fewer detail parts and fasteners.

2.2. CFRP composite for Aircraft

According to Moorthy Chinnasamy, 2012. An important contribution to improve the efficiency and performance can be achieved by decreasing the aircraft weight through considerable usage of composite materials in primary aircraft structures. In the competitive environment of aircraft industries it becomes absolutely necessary to improve the efficiency, performance of the aircrafts to reduce the development and operating costs considerably, in order to capitalize the market. A type of composite material called Carbon Fiber Reinforced Plastic (CFRP) is explored for the usage is aircraft skin panels.

Currently, the use of composite materials has increased in various areas of science and technology due to their special physical and mechanical properties. Composite materials have attractive features, such as high ratios of strength-to-weight and stiffness-to-weight, good corrosive resistance, and low thermal expansion. The high degree of intricacy in composite structures necessitates special process to create holes in them for the purpose of assembly. In surface transportation, reinforced plastics are the kind of composites used because of their huge size. They provide ample scope and receptiveness to design changes, materials and processes. The strength-weight ratio is higher than other materials. Their stiffness and cost effectiveness offered, apart from easy availability of raw materials, make them the obvious choice for applications in surface transportation.

According to James R. Rardon, 1998. Newer aircraft use composite materials for many structural parts, and the use of composite material for wingtips, cowling, fairing, flaps, spoilers, and ailerons is common. Composite materials will be dividing into two categories, laminated and cored, or sandwich, construction. Both types of construction produce lightweight part and components with high tensile strength. The need for adequate stiffness to handle compression and bending loads has resulted in a large variety of material and design configurations. An in-depth coverage of the various materials and design of composite material exceeds the scope of this text. The objective of this section is to give you a basic knowledge of the common design principles and materials used by aircraft industry.

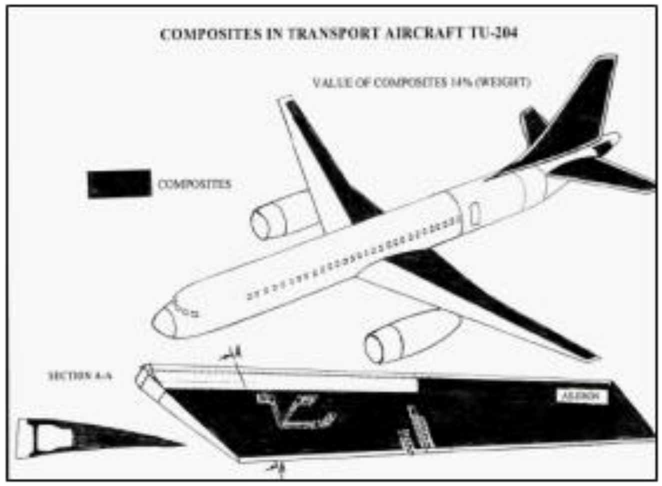

Figure 2.2: composites in transport aircraft TU-204

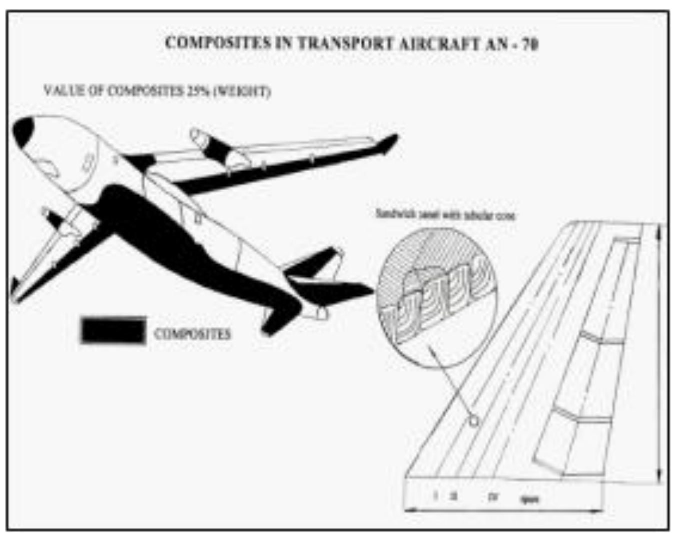

Figure 2.3: value of composites (weight)

According to r.e. Horton and J.e.McCarty, 1987. Both small and large commercial aircraft rely on composites to decrease weight and increase fuel performance, the most striking example being the 50 per cent composite airframe for the new Boeing 787. All