UNIVERSITI TEKNIKAL MALAYSIA MELAKA

STUDY ON DRILLING AERO COMPOSITE MATERIAL

Thesis submitted in accordance with the requirements of the
Universiti Teknikal Malaysia Melaka for the Degree of
Bachelor of Manufacturing Engineering (Manufacturing Process) with Honors

By

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Faculty of Manufacturing Engineering
March 2008

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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DECLARATION

I hereby declare that this report entitled **"STUDY ON DRILLING AERO COMPOSITE MATERIAL"** is the result of my own research except as cited in the references.

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APPROVAL

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ABSTRACT

Drilling is the most frequently employed operation of secondary machining for fiber reinforced material owing to the need for joining structures. However, little is know about the interacting condition between the drilling tool and the material, which may be multi types and multi size. This project proposes the analysis over the factor feed rate and the speed rate spindle speed of the CNC milling machining for drilling onto aero composite material. The experimental investigation consist three type of drill which is saw drill, core drill and step drill. The drilling process performance is determines according to the result analysis that will be analyzed from the tests on the drilled aero composite panel. The tests include measuring the side wall of the drilled hole roughness by using Surface Roughness Tester, measuring the tensile strength by using Universal Tensile Machine (UTM), and observe the condition of the drilled hole area with Scanning Electron Microscope (SEM). The quality of the drilled hole result by low feed rate and high spindle speed by using saw drill. The strongest and the finest aero composite test panel will determine the ideal machining factors value of CNC milling machine and the best drill bit to be use for drilling the aero composite material.

ABSTRAK

Menggerudi merupakan operasi yang kerap digunakan dalam operasi pemesinan tambahan untuk bahan gentian peneguhan (fiber reinforcement material) disebabkan keperluannya untuk struktur-struktur sambungan (joining structures). Walau bagaimana pun, maklumat berkenaan hubungan antara mata gerudi dan bahan yang hendak digerudi adalah sedikit berikutan ia mempunyai pelbagai jenis dan saiz. Projek ini mencadangkan analisis ke atas faktor-faktor seperti kadar pemesinan (feed rate) dan kelajuan 'spindle' (spindle speed) untuk menggerudi bahan 'aero composite'. Eksperimen yang dilakukan menggunakan tiga jenis mata gerudi iaitu mata jenis gergaji (saw drill), mata jenis teras (core drill) dan mata jenis langkah (step drill). Proses pelaksanaan menggerudi dinilai melalui keputusan analisis yang akan di analisa daripada ujian-ujian ke atas panel 'aero composite' yang telah digerudi. Ujian yang dimaksudkan termasuk mengukur kekasaran permukaan pada dinding dalam lubang yang digerudi menggunakan Penguji Kekasaran Permukaan (Surface Roughness Tester). Selain itu, kekuatan ketegangan lubang juga diukur menggunakan 'Universal Tensile Machine' (UTM) serta keadaan kawasan tebukan diperhati menggunakan 'Scanning Electron Microscope' (SEM). Kualiti lubang yang baik dihasilkan dengan gabungan kadar pemesinan yang rendah serta kelajuan 'spindle' yang tinggi menggunakan mata jenis gergaji (saw drill).

DEDICATION

For my beloved parent, my family and to those who's with me all this time

ACKNOWLEDGEMENTS

Alhamdulillah, thank to Allah the Almighty God for giving me strength and patience to work on this Final Year Project Report. I would like to take this opportunity to express my sincere and deepest gratitude to my Project Supervisor Raja Izamshah b. Raja Abdullah, for his guidance and opinion in the cause of completing this report. I would like to extend my gratitude to my beloved family for their prayers, support and encouragement throughout this entire period of this Final Year Project. I would like to thanks Professor Dr. Mohd. Razali Bin Muhamad, Dean of Faculty of Manufacturing Engineering, Universiti Malaysia, Melaka, and to all the lectures in the faculty. I also would like to convey my biggest thanks to all FKP technicians for supporting me throughout my project. The knowledge and experience I gained from you all will not be forgotten. I'm also obliged to everyone who had directly and indirectly involve through contributions of ideas, as well as materials and professional opinions. Last but not least, to all my friends for their moral support and valuable help that they have provided me throughout my project.

TABLE OF CONTENT

Declaration……………………………………………………………………...iii

Approval……………………………………………………………………..iv

Abstract ………………………………………………………………………v

Abstrak……………………………………………………………………….vi

Dedication……………………………………………………………………vii

Adknowledgements…………………………………………………………viii

Table of Contents…………………………………………………………….ix

List of Figure………………………………………………………………..xiii

List of Table………………………………………………………………….xv

List of Abbreviations ……………………………………………………....xvi

CHAPTER 1 INTRODUCTION

1.1 Problem Statement…………………………………….…………………1

1.2 Scope of Project………………………………………….………………2

1.3 Objective…………………………………………………………………2

CHAPTER 2 LITERATURE REVIEW

2.1 Introduction……………………………………………………..….….3

2.2 CNC Milling Machine……………………………………………..…..4

2.3 Drilling………………………………………………………….….….6

2.3.1 Drilling Process…………………………………………….…….….6

2.3.2 Drilling Types……………………………………………….….……6

2.3.3 Aero Composite Drilling……………………………………….…7

2.3.4 Cutting Condition……………………………………………….…...8

2.3.5 Common Problem in Drilling Composite…………………….….10

2.4 Cutting Tool…………………………………………………………..….10

2.4.1 Saw Drill…………………………………………………….…...11

2.4.2 Core Drill………………………………………………….……..11

2.4.3 Step Drill…………………………………………….......…...12

2.5 Drill Bit Material……………………………………………………..……..13
2.5.1 High Speed Steel…………………………………….………...14
2.5.2 Carbides or Coated Carbide……………………….……..16
2.6 Chip Formation Analysis…………………………………….………18
2.6.1 Chip Produce…………………………………….………19
2.7 Material………………………………………………………….….20
2.7.1 Advance Composite…………………………….…...21
2.7.2 Material Type and Properties…………………….……22
2.7.3 Matrix Material…………………………………….…..23
2.7.4 Reinforcing Fibers……………………….…………24
2.7.5 Advance Composite…………………………………25
2.7.6 Term in Composite……………………………………..26
2.8 Backup Plate………………………………………………………...29
2.9 Strengthness of Drilled Hole…………………………………………..30
2.10 Surface Roughness of Drilled Hole……………………………..30
2.11 Design of Experiment……………………………………….…..32

CHAPTER 3 METHODOLOGY

3.1 Introduction……………………………………………………….33
3.2 Selection of Material…………………………………………....35
3.2.1 Basic Air Craft Structure……………………………..36
3.2.2 Axes Rotation……………………………………………37
3.2.3 Specific Structure of composite Material……………….38
3.3 Machining Parameter Setting……………………………………...39
3.4 Drill Bit……………………………………………………………40
3.4.1 Saw Drill………………………………………………40
3.4.2 Core Drill……………………………………………...40
3.4.3 Step Drill………………………………………………41
3.4.4 Drilling Parameter……………………………………..42
3.5 Backup Plate Application……………………………………….44
3.6 Selection of Machine and Equipment……………………………45

3.61 Haas CNC Milling Machine……………………………………...45
3.6.2 Special Features………………………………………….…46
3.7 Experiment Analysis Method………………………………………47
3.7.1 Universal Tensile Strength Machine(UTM)……………………...47
3.7.2 Optical Microscope……………………………………………48
3.7.3 Coordinate Measuring Machine………………………………..49
3.7.4 Scanning Electron Microscope…………………………………50

CHAPTER 4 RESULT

4.1 Surface roughness (Ra)…………………………………….……....51
4.1.1 Saw Drill bit…………………………………….……….……51
4.1.2 Core Drill bit ………………………………………….…...52
4.1.3 Step Drill bit …………………………………………………54
4.1.4 Drilling Without Using Back Up Plate………………….………55
4.1.5 Drilling Using Back Up Plate…………………………………...56
4.2 Effect on Tensile Strength……………………………….………. 58
4.2.1 Saw Drill bit…………………………………….……….58
4.2.2 Step Drill bit…………………………………………………..59
4.2.3 Core Drill bit…………………………………….………….61
4.2.4 Drilling Without Using Back Up Plate……………….……….62
4.2.5 Drilling Using Back Up Plate…………………………….……...63
4.3 Effect on Structure Using SEM……………………………………64

CHAPTER 5 DISCUSSION

5.1 Relationships between the surface roughness and parameter setting……..65
5.2 Relationships between the tensile strength and parameter setting..………….66
5.3 Surface defects on the material after drilling operation………………………67
5.2.1 Crack……………………………………………………………..67
5.2.2 Delamination………………………………………………….… 67

CHAPTER 6 CONCLUSSION AND RECOMMENDATION

6.1 Conclusions…………………………………………………………………..68

6.1 Recommendation…………………………………………………..……….69

REFERENCES……………………………………………………….………70

APPENDIX…………………………………………………………………71

LIST OF FIGURE

Figure 2.0: CNC Milling Machine ………………………………….…….. 4
Figure 2.1: Feed rate application ……………………………………..…. 9
Figure 2.2: Circular plate model for saw drill analysis……………………..11
Figure 2.3: Circular plate model for core drill analysis........................…...11
Figure 2.4: Circular plate model for step drill analysis……………….….…12
Figure 2.5: Flow chart for chip formation analysis……………….…….. 18
Figure 2.6: Drilling with backup plate…………………………….……... 29
Figure 2.7: Drilling without backup plate……………………..………. 30
Figure 3.0: Flow Chart………………………………………….…….. 34
Figure 3.1: Basic Air Craft Structure……………………………….…. 35
Figure 3.2: A320 carbon fiber panel………………………………………… 35
Figure 3.3: Structure of the flaps wing……………………………….……38
Figure 3.4: Saw drill bit…………………………………….…….……......40
Figure 3.5: Core drill bit……………………………………………………...40
Figure 3.6: Step drill bit………………………………...……………..…...41
Figure 3.7: CNC milling machine……………………….….….….………45
Figure 3.8: Experiment setup……………….. …………….……….…….46
Figure 3.9: Universal Testing Machine (UTM)…………….….……………47
Figure 3.10: Optical Microscope…………………………………..………48
Figure 3.11: Scanning Electron Microscope (SEM)……………………….…50
Figure 4.1: Surface Roughness Vs Parameter Setting, *X* (Feed Rate & Spindle Speed) for Saw Drill……………………………………………………………….52
Figure 4.2: Surface Roughness Vs Parameter Setting, *X* (Feed Rate & Spindle Speed) for Core Drill………………………………………………………………53
Figure 4.3: Surface Roughness Vs Parameter Setting, *X* (Feed Rate & Spindle Speed) for Step Drill ……………………………………………………………...55
Figure 4.4: Surface Roughness Vs Parameter Setting, *X* (Feed Rate & Spindle Speed) for panel that drilled without using back up plate…………………………...56

Figure 4.5: Surface Roughness Vs Parameter Setting, *X* (Feed Rate & Spindle Speed) for panel that drilled by using back up plate…………………………………..57
Figure 4.6: Maximum Force Vs Parameter Setting, *X* (Feed Rate & Spindle Speed) for Saw Drill…………………………………………………………………..58
Figure 4.7: Maximum Force Vs Parameter Setting, *X* (Feed Rate & Spindle Speed) for Step Drill…………………………………………………………..…60
Figure 4.8: Maximum Force Vs Parameter Setting, *X* (Feed Rate & Spindle Speed) for Core Drill…………………………………………………………..…61
Figure 4.9: Maximum Force Vs Parameter Setting, *X* (Feed Rate & Spindle Speed) for aero composite panel that drilled without using back up plate…………62
Figure 4.10: Maximum Force Vs Parameter Setting, *X* (Feed Rate & Spindle Speed) for aero composite panel that drilled by using back up plate………………63
Figure 4.11: Photograph of drilling-induced delamination for saw drill, core drill and step drill…………………………………………………………………..…..64

LIST OF TABLE

Table 2.0: Parameter setting of drill test…………………………………………..9
Table 2.1: Types and General Characteristic of Composite Material………………..24
Table 3.0: Control factor with back up plate………………………………………43
Table 3.1: Control factor without backup plate……………………………………43
Table 4.1: Surface Roughness data for Saw Drill………………………………….51
Table 4.3: Surface Roughness data for Core Drill…………………………………52
Table 4.2: Surface Roughness data for Step Drill………………………………….54
Table 4.4: Maximum Force data for Saw Drill……………………………….…58
Table 4.5: Maximum Force data for Step Drill…………………………….………59
Table 4.6: Maximum Force data for Core Drill……………………….…………..…..61

LIST OF ABBREVIATIONS, SYMBOLS, SPECIALIZED NOMENCLATURE

ANOVA	-	Analysis of Variance
CMC	-	Ceramic Material Composite
CNC	-	Computer Numerical Control
CFRP	-	Carbon Fiber Reinforced Plastic
CMM	-	Coordinate Measuring Machine
CTRM	-	Composite Technology Research Malaysia
DOE	-	Design of Experiment
EDM	-	Electrical Discharge Machining
FRP	-	Fiber Reinforced Plastic
FMEA	-	Failure Mode and Effect Analysis
HIP	-	Hot Isostatic Pressing
HSS	-	High Speed Steel
MMC	-	Material Matrix Composite
PMC	-	Polymer Material Composite
SEM	-	Scanning Electron Microscope
TiAlN	-	Titanium Aluminum Nitride
TiN	-	Titanium Nitride
UTM	-	Universal Testing Machine
V	-	Vanadium
W	-	Tungsten

CHAPTER 1

INTRODUCTION

In recent years, polymer composites have gained considerable attention in the aircraft industries due to their light weight and high strength. Even though most of the polymer composite structures are molded into near-net shapes, machining of the components is always necessary to attain the required dimensional tolerance, surface roughness, and complex geometry.

Aircraft manufacturers spend millions of dollars reworking blown fastener holes, especially in portable tool drilling situations. Oval, tapered, rifled, and oversize holes are costly rework issues currently commonplace in the industry. Drilling is one of the major machining operations which are currently carried out on fiber-reinforced composite materials. There are typical problems encountered when drilling fiber-reinforced composites.

The most common causes of imperfectly drilled holes include spindle run out, insufficient clamp and feed force, out-of-balance drill feed forces, spindle windup, and lack of adequate feed control. This study focus on drilling aero composite material with different type of drill bit using the CNC milling machine. It is pertinent to understand the effects of machining processes on carbon fiber reinforced plastic (FRP) because machined surface quality determines the fatigue strength of the component's service life.

1.1 Problem statement

In the aircraft industry, drilling associated delamination accounts for 60% of all part rejections during final assembly of an aircraft. In most cases of drilling aero composite material, the majority of the residual stresses is cause by plastic deformation of the workpiece by the tool. According to Astrom (1997) there are several common problems associated with drilling carbon fiber, with delamination and excessive tool wear usually report as the biggest concern. The thrust forces increases as drill wear increase. The effect of processing variables also contributes to drilling damage. The hole machining defects have significantly reduced the strength and fatigue life of carbon/epoxy laminates. This study is focusing to minimize those problems.

1.2 Objective

The purpose of this study is to aim the objective below:

i. To analyze the performance of different type of drill (saw drill, core drill and step drill) in drilling of aero composite material.
ii. To study the effects of drilling parameter (cutting speed and feed) on the hole performance.
iii. To study the effects of backup plate for minimizing the hole defects.

1.3 Scope of project

i. Drilling the aero composite using three type of the drilling bit.
    a) saw drill
    b) core drill
    c) step drill
ii. Analyze the drill hole into two aspects which is the strength and the surface.
iii. Investigate the contribution of backup plate in drilling process.
iv. Compare which type of drill exhibits the best performance.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Nowadays, structural part made of the composite material have frequently to be drilled in the aircraft industry. Drilling is the most common way in secondary machining of composite materials owing to the need for structure joining. El-Sonbaty *et al*. 2004) report that over 100,000 holes are required in a small engine aircraft, mostly for fasteners. However, little is know about the interacting condition between the drilling tool and the material, which may be multi types and multi size. This section provides the related drilling process on the composite material and the factor that influence hole quality and also include some of the analysis method.

2.2 CNC Milling Machine

Computer Numerical Control (CNC) Milling is the most common form of CNC. CNC Milling is classified according to the number of *axes* that they possess. Axes are labeled as x and y for horizontal movement, and z for vertical movement, as shown in this view of a manual milling table. A standard manual light-duty mill is typically assumed to have four axes:

1. Table x.
2. Table y.
3. Table z.

The number of axes of a milling machine is a common subject of casual shop talk and is often interpreted in varying ways. We present here what we have seen typically presented by manufacturers. CNC milling machines are traditionally programmed using a set of commands known as *G-codes*. G-codes represent specific CNC functions in alphanumeric format. Computer Numerical Control (CNC) Milling is the most common form of CNC. CNC mills can perform the functions of drilling and often turning.

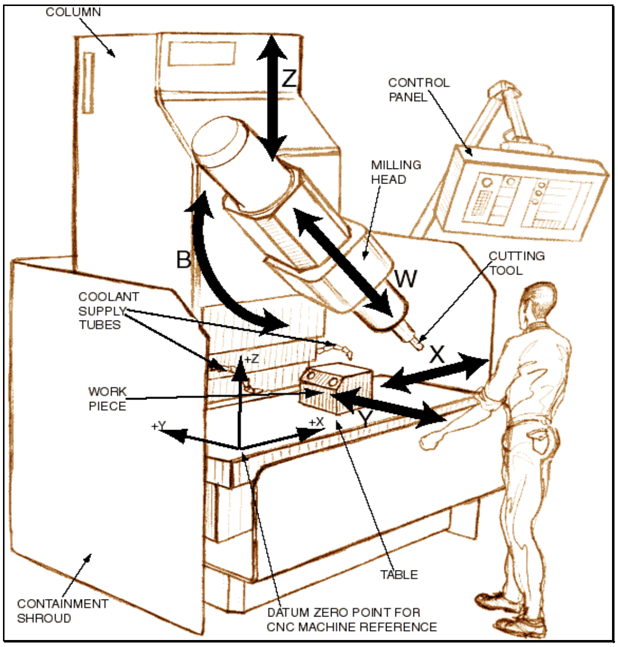

Figure 2.0: CNC Milling Machine

Frame

i. Base
ii. Column
iii. Over arm

Produce the basic structure of the machine. It includes a base to provide stability to the machine, column to provide the height and over arm to support the machine spindle.

Spindle

The device which transmits power from the machine motor to the cutter and provides rotary motion for the cutter. The spindle may be placed horizontally or vertically.

Knee

The knee of the milling machine supports the saddle and the table. The knee is connected to the column and can move up and down on asset of way.

Saddle

The saddle is the machine element between the knee and the table. The saddle moves in and out along ways on the knee.

Table

Table is attached to the saddle. It move right and left along a set of way on the saddle. This movement provides the feed motion.

2.3 Drilling

Many manufactured parts and products require machine operations that put holes in them. These holes may be part of the functional design of the product or are for product assembly with fasteners such as screws, bolts, rivets, shafts, tabs, and tapered pins.

Holes may be produced using a number of manufacturing processes. They may be made by punching, making cores in casting operations, flame cutting, ultrasonic machining, drilling, fly cutting, hole sawing, boring, and electrical discharge machining (EDM). This chapter will discuss those hole- producing operations which are performed on drilling by using the CNC Milling Machine.

2.3.1 Drilling process

Drilling is a machining operation used to create a round hole in a work part. Drilling is usually performed with a rotating cylindrical tool that has two cutting edges on its working end. The tool call is drill or drill bit. The rotating drill feeds into the stationary work part to form a hole whose diameter is equal to the drill diameter. Drilling is customarily performed on a drill press, although other machine tools also perform this operation.

2.3.2 Drill types

i. twist drill
ii. step drill
iii. spade drill
iv. gun drill
v. saw drill
vi. core drill