UNIVERSITI TEKNIKAL MALAYSIA MELAKA

OPTIMIZATION OF COMPOSITE OF AEROSPACE TOWARDS TENSILE STRENGTH USING DESIGN OF EXPERIMENT

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

by

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APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfilment of the requirements for the degree of Bachelor of Mechanical Engineering Technology (Automotive) with Honours. The member of the supervisory is as follow:

……………………………

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ABSTRAK

Gentian karbon adalah salah satu bahan komposit yang digunakan dalam industri aeroangkasa. Penggunaan gentian karbon dalam pengeluaran pesawat tersebut boleh mengurangkan berat pesawat di samping mengekalkan ketahanan bahan yang tinggi. Ketahanan yang tinggi adalah ciri-ciri penting yang perlu konsisten dalam bahan untuk menahan tekanan yang tinggi apabila pesawat tersebut terbang tinggi di langit. Objektif utama projek ini adalah untuk mencari reka bentuk optimum komposit yang mempunyai kekuatan maksimum dengan menggunakan reka bentuk eksperimen. Sebelum mencapai matlamat ini, spesimen gentian karbon dihasilkan dengan menggunakan kaedah resin infusi. Kedua-dua pembolehubah yang dimanipulasikan dalam eksperimen ini adalah bilangan lapis dan orientasi gentian karbon. Kemudian, spesimen menjalani ujian tegangan dengan menggunakan mesin ujian universal untuk mendapatkan kekuatan tegangan bagi setiap spesimen. Tambahan pula, analisis dibuat berdasarkan data output yang diperolehi untuk mencari kombinasi yang dioptimumkan faktor dengan menggunakan reka bentuk kaedah eksperimen yang diperolehi daripada perisian Design Expert. Hasil kajian menunjukkan bahawa model dioptimumkan untuk memaksimumkan kekuatan tegangan gentian karbon adalah rekabentuk dengan bilangan lapis yang tinggi dan darjah orientasi yang rendah.

ABSTRACT

Carbon fibre is one of the composite materials used in the aerospace industry. The usage of carbon fibre in production of the aeroplane can reduce the weight while maintaining the high durability of the material. The high durability is a crucial characteristic that needs to be consistent in the material in order to withstand the high pressure while the aeroplane is flying high in the sky. The main objective of this project is to find the optimum design of composite that has the maximum strength by using the design of experiment. Before achieving this objective, the carbon fibre specimens are produced by using the resin infusion method. The two variables that are manipulated in this experiment are the number of ply and the orientation of the carbon fibre. Then, the specimens undergo tensile testing by using the universal testing machine in order to obtain the tensile strength of each specimen. Furthermore, analysis was done based on the output data obtained to find the optimized combination of factors by using the design of experiment method obtained from the Design Expert software. The result shows that the optimized model for maximising the tensile strength of the carbon fibre is the design with high number of ply and low degree of orientation.

DEDICATION

To my beloved mother, Rohaya Yap binti Abdullah and beloved father, Razuin bin Che Pa.

ACKNOWLEDGEMENT

I would like to thank my supervisor, Pn Nor Hamizah binti Miswan for guiding me to finish my final year project from the beginning until the very end. Apart from that, I also would like to thank Mr Saiful Naim bin Sulaiman as my co-supervisor for helping me getting through the experiments.

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

UTeM	-	Universiti Teknikal Malaysia Melaka
FTK	-	Fakulti Teknologi Kejuruteraan
No.	-	Number
N	-	Newton
DOE	-	Design of experiment
RCBD	-	Randomized Complete Block Design
UTM	-	Universal testing machine
CCC	-	Central composite circumscribed
CCF	-	Central composite faced
CCI	-	Central composite inscribed
CCS	-	Central composite scaled
σ	-	Stress
P	-	Pressure
A	-	Area

CHAPTER 1

INTRODUCTION

1 Introduction

This chapter discusses about the background, problem statement, objectives and scope of the study. The background states about the factor for the change of aircraft production material over time and the requirements needed for selecting the materials for the composite. Later on, this chapter clarifies the objectives and the scope of the study.

1.1 Background

These days, travelling by airline is the most effective and time saving if we are going to a place that is far away. Aeroplane helps us to travel to other country in no time. Aerospace engineering gives the highest impact among the transportation mediums. Despite of it, the production of an airplane is very high due to expensive materials used in the aircraft production in order to sustain a lightweight and durable enough to withstand high pressure during operation hours. In the modern aircraft production, composite replaces the traditional material used in aircraft production which includes aluminium, steel and titanium. This change occurs mainly due to the reducing of the weight and cost of production. The lower weight is proven to lower the consumption of fuel of the aircraft.

In order to create a strong composite, there are few requirements needed to be considered in choosing the materials. Some of the requirements are lightweight, high reliability, high aerodynamic performance and can operate at all weather conditions. These requirements are very crucial to produce the best design for the composite in terms of the thickness of layers and orientation. These factors are the key criteria in designing the composite. Besides, every factor gives its own importance when producing the composite.

1.2 Problem statement

In the field of manufacturing, cutting down the budget of the production is the major priority for researchers. Referring to this study, the current production of composite of aerospace is high due to the expensive materials used in the composite. There are limitations in terms of the high weight and the high manufacturing cost of the composite material used in aerospace that constraint some of the component designs. In order to eliminate the limitation, a more optimum design for the composite in the term of type of material, number of ply and orientation of layer must be proposed to produce the maximum strength, minimum cost and minimum weight for the composite so we can get the best design before assembling the real component.

1.3 Objectives

The general objective of this study is to propose an optimum design for the composite of aerospace that has the maximum strength. There are several other objectives which are:

1. To study the basic composition of the composite of aerospace in term of ply thickness and orientation.
2. To set up the experiment for the tensile strength of the composite of aerospace.
3. To find the optimum design of composite that has the maximum strength by using design of experiment method.

1.4 Work scope

The scope of the project starts with the study of basic composition for composite of aerospace in term of the ply thickness and orientation of the plies. This involves the study from various journal interconnected to the research topic. Next, the project proceeds with the preparation of the composite. After that, the project proceeds with the setup of tensile strength experiment for composite of aerospace. Lastly, by using the design of experiment method, the optimum design of aerospace composite with maximum strength will be obtained.

CHAPTER 2

LITERATURE REVIEW

2 Introduction

This chapter discusses about the fundamental of the topics in this project including the basics of aerospace, fundamental of composites and the basic of experimental design.

2.1 Aerospace

Aerospace is the branch of technology and industry that concerns with both aviation and space flight. It is the human effort to fly in the atmosphere of Earth (aeronautics) and surrounding space (astronautics) in terms of science, engineering and business. Aerospace organisations do research, manufacture, design and maintain aircraft or spacecraft. Furthermore, aerospace activity is mainly connected to the multitude of commercial, industrial and military purposes.

2.1.1 History of aerospace

The modern aerospace starts with the idea of fixed wings by a distinguished British scientist named Sir George Cayley (1773-1857) which was inspired by the physical structure of bird"s wings. He believes that the fixed wing is the solution to flight and it should have mechanical power to drive through the air. This idea is the pioneer to the design of an aircraft during that time. In 1678, the research furthers with the experiment done by Besnier. He hand-made built a pair of wooden wings covered with fabric and glided successfully in his few experiments. Because of that, he was honoured as the first successful glider. His success later becomes a benchmark to the flying mechanics.

The technology continues with the experiment by Montgolfier Brothers. They discover the warmed air rises because of the very light gas, the hydrogen. That resulting in development of balloon flight that searches for the method to control the direction of a balloon flight. Later, Henri Giffard pioneered the first flight by an airship which fitted a light-weighted steam engine and an envelope with pointed ends. Years after that, an engineer named Zeppelin built an airship with capacity of 350,000 cubic feet of hydrogen and propelled by two benzine engines each driving two four-bladed propellers. This airship successfully made three flights but further development was abandoned because of lack of money. (Mohan, 2004)

Figure 2.1: The first aircraft by Wright brothers

After a while, a few men including Frenchman Octave Chanute, the German Otto Lilienthal and Professor Samuel P. Langley conducts researches regarding Cayley‟s theory and developed more effective wing shapes, balancing methods and made a thousands of flight. Among of these men, Professor Langley managed to build a few successful models but could not fly at long time. Following these researches, the Wright brothers collected as much data available and began their experiments. After a while, the brothers finally managed to build an aircraft which is capable of carrying a person in 1903. The aircraft was flying for 12 seconds before it is slowly darted to the ground. It is the first flight of the century which can carry a person.

2.1.2 Theory of flight

2.1.2.1 Shape of the wing

The cross-section of the wings has the shape of the aerofoil. The aerofoil is rounded at the leading edge and sharp at the trailing edge which is the design for commercial flights that not exceeds the supersonic speed. The lower surface of the wing is flat while the upper surface is curved. The range of the thickest part of the aerofoil is one-third to one-half of the length between leading edge and trailing edge (Figure 2.2).

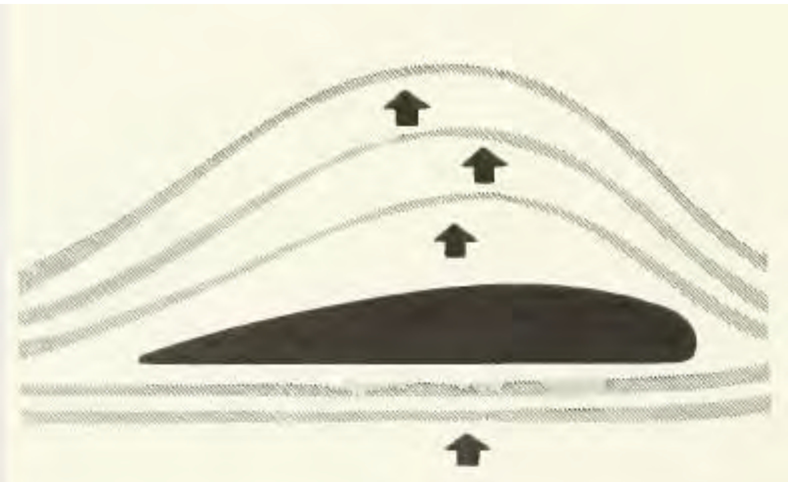

Figure 2.2: The aerofoil shape

2.1.2.2 Speed of the wing

When the wing moves at very high speed, the leading edge will push the air over and under the wing. The air travelled over the wing become faster and thinner compared to the air travelled bottom of the wing. This will create a pressure difference between over and bottom of the wing. The pressure over the wing become lower and the pressure are higher at the bottom (Figure 2.1). This will create a lift force. The higher the speed of the wing, the higher the pressure difference. Thus this will result in higher lifting force.

2.1.2.3 Lift and angle of attack

Another factor that affects the lifting force is the angle at which the wing strikes the air. The wing will generate higher lifting power if the leading edge is elevated slightly higher than the trailing edge or the wing travels at higher angle of attack through the air. This is because the wing displaces more air as the angle of attack increase and creates a higher lifting force until it reaches a certain point in which the lift force drops drastically because of the stalling angle. The stall occurs because the angle is too high that exceeds the necessary maximum lift force. Furthermore, swirling of air above the wing surface also can cause the loss of lifting force

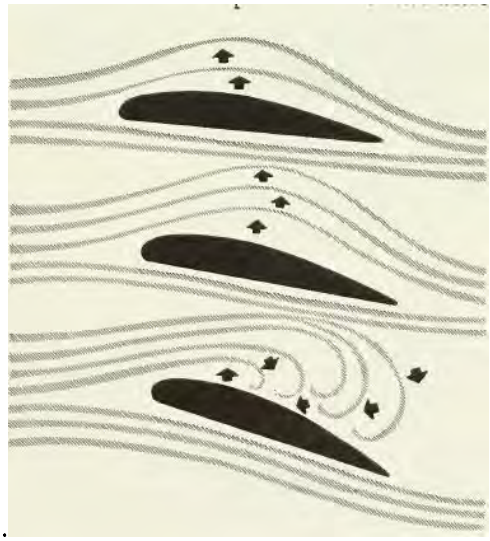

Figure 2.3: Lift and angle of attack

2.1.2.4 Lift and weight

The amount of lift needed is depending on the weight of the aeroplane. Moreover, it is also depends on the situation whether it is cruising, taking off or landing. The lift force must be higher than the weight of the aeroplane if the aeroplane wants to climb and vice versa for descent. The lift force is determined by the shape of the wing, the speed of the aeroplane and the angle of attack.

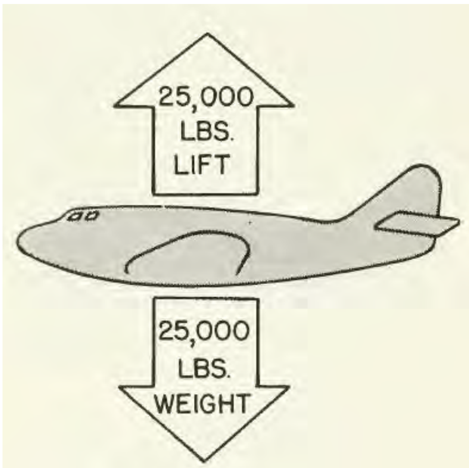

Figure 2.4: Lift force and weight

2.1.2.5 Thrust and drag

Thrust is the force produced by the propeller and engine jet which propagated in the direction of the motion of the aeroplane. The force produced enable the aeroplane moves in a high speed and produce a lift force that enables the aeroplane to fly. The amount of thrust needed depends on the value of aeroplane‟s drag in different situation which is the taking off, cruising and landing. The amount of thrust is equal to drag when the aeroplane is cruising. The thrust needs to be greater than drag when accelerating and the engine burns more fuel to produce the additional thrust.

The lift force increases as the thrust increase. In order to maintain a level flight, thrust needs to be increased. The angle of attack needs to be increase to produce additional lift force. It will cause the aeroplane‟s drag to be increase. Extra thrust is needed to counter the increasing drag. In the nutshell, drag affects the amount of thrust needed in many flight situations. Thus, engineers studied the shape that enables the aeroplane to fly smoothly and the result is the streamlined shape because the shape requires the least thrust to move through the air.

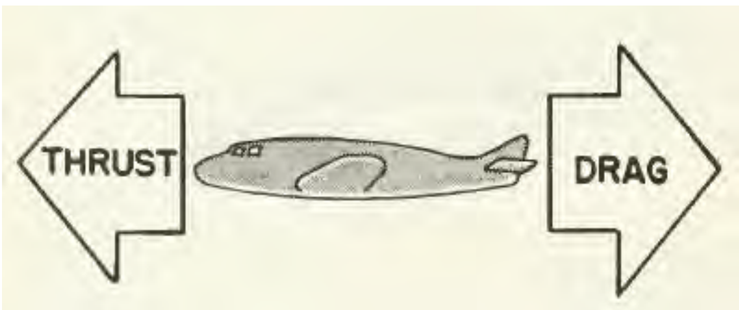

Figure 2.5: Thrust and drag