"We hereby declare that we have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of degree of Bachelor of Mechanical Engineering (Structure & Material)"

Signature : ....

Supervisor's Name 1 : MR MOHD AZLI BIN SALIM

Date : 27/05/2011

Signature : ....

Supervisor's Name 2 : MR WAN MOHD FARID

Date : ....

A SAFETY DESIGN OF AEROSPACE VEHICLE USING NUMERICAL ANALYSIS

SHAH FATHI BIN SHAWALUDDIN

This report is submitted in partial fulfillment of requirements for the Bachelor of Mechanical Engineering (Structure & Material)

Faculty of Mechanical Engineering
Universiti Teknikal Malaysia Melaka

MAY 2011

"I declared that this project report entitled "A Safety Design of Aerospace Vehicle Using Numerical Analysis" is the result of my own result except as cited in the references."

Signature : ....

Name of Candidate : SHAH FATHI BIN SHAWALUDDIN

Date : 23rd MAY 2011

For my beloved father and mother,
Dearest family members and next of kin,
Lecturers and friends

ACKNOWLEGEMENT

In the name of Allah, the Most Gracious and Most Merciful,

I am really grateful that I have completed this Final Year Project with the help, support, encouragement and inspirations by various parties. All the knowledge and information that they give me are really helpful.

Here I would like to express my gratitude to my supervisor, Mr. Mohd Azli bin Salim, for all the help and advice, through a few consultations, especially his guidance in using the experiment equipment when I was working on this project.

My heartfelt appreciation to the fluid lab technician, Mr. Razmi, who lent me the apparatus needed for the measurement in this study.

Lastly, I would like to thank my beloved family and all my fellow friends especially Muhammad Bukhari al Mukmin, Mohd Khairee, Mohd Khalid and Nor Fariza for all their support, concern, contribution, encouragement and understanding throughout the course of completing this project.

ABSTRACT

This paper presents the study and a design development on force effect for aerospace vehicle during lift and drag behaviour. The main objective of this study is to design and analysis the suitable model of aerospace vehicle using numerical method. In every design of an aircraft, the analysis on the wing joints, tail and propellers of an aerospace vehicle will be very critical since these are the parts which play the major role during takeoff and landing process. All parameter of the aircraft design structure have to be considered and studied to make sure that the aircraft does not fails during airborne. Moreover, analysis on the aerodynamics of the wings and tail considering the drag and lift has to be made to the aircraft's wing design to ensure that it manage to carry the aircraft body and load airborne. In addition, designing and proposing the best designs for the wing and tail part of the aircraft have to be done to increase the safety of the aircraft during airborne generally and during takeoff and landing specifically. The first step in this study is to select an aircraft model to be analyzed theoretically on the lift and drag force acting on the aircraft during takeoff and landing followed by designing the actual and propose models of the wing and tail part using the software SolidWorks. SolidWorks is a 3D mechanical CAD (computer-aided design) program that runs on Microsoft Windows. Then the wing and tail part model that have been designed are transferred to the ABAQUS software to determine its structure tenacity when a stress is applied to get the most suitable design of wing and tail for the aircraft.

ABSTRAK

Makalah ini menyajikan kajian dan pembangunan rekabentuk pada kenderaan udara semasa mengalami daya angkat dan perilaku drag. Tujuan utama dari penelitian ini adalah untuk merekabentuk dan menganalisis model kenderaan luar angkasa berpadanan menggunakan kaedah berangka. Dalam setiap rekaan pesawat, analisis terhadap ekor, sendi sayap dan baling-baling sebuah kenderaan ruang angkasa akan sangat penting kerana ini adalah bahagian yang memainkan peranan utama semasa berlepas dan proses mendarat. Semua parameter struktur rekaan pesawat harus dipertimbangkan dan dipelajari untuk memastikan bahawa pesawat tidak rosak selama di udara. Selain itu, analisis terhadap aerodinamis dari sayap dan ekor mempertimbangkan tarik dan angkat harus dibuat untuk merancang sayap pesawat untuk memastikan bahawa ia berjaya membawa tubuh dan beban pesawat. Selain itu, merekabentuk dan mencadangkan rekaan terbaik untuk bahagian sayap dan ekor pesawat harus dilakukan untuk meningkatkan keselamatan pesawat udara semasa berlepas dan mendarat secara khusus. Langkah pertama dalam kajian ini adalah untuk memilih model pesawat yang akan dianalisis secara teoritis pada daya angkat dan drag yang bekerja pada pesawat semasa berlepas dan mendarat diikuti dengan merekabentuk secara aktual dan mencadangkan model sayap dan bahagian ekor menggunakan software SolidWorks. SolidWorks adalah sebuah program rekabentuk berbantu komputer 3D CAD (CAD) program yang berjalan pada Microsoft Windows. Kemudian sayap dan ekor bahagian model yang telah direkabentuk akan dipindahkan ke peranti perisian ABAQUS untuk menentukan ketahanan struktur bila stres diterapkan untuk mendapatkan rekabentuk yang paling sesuai untuk sayap dan ekor pesawat.

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LIST OF SYMBOLS

Symbol	Description	Value	Unit
ρ air	Density	1.20	kg/m^3
E	Modulus Young	1360	Mpa
C_D	Drag coefficient	0.01	
C_L	Lift Coefficient	0.51	
A	Area of wing span	0.08	m^2
V	Velocity		m/s
F_L	Lift Force	4.6107	N
F_D	Drag Force	0.0903	N
W	Weight of aircraft	4.6107	N
σ	Stress		MPa
F	Force	2.30535	N
m	Mass of aircraft	0.47	kg
L	Length	0.94	m
r	Leading edge radius	0.026	m
$C_{L, max}$	Lift coefficient with no flap	1.52	
$C_{L, max}$	Lift coefficient with slotted flap	2.67	
$V_{min\ 1}$	Velocities corresponding to stall condition without flap	7.95	m/s
$V_{min\ 2}$	Velocities corresponding to stall condition with flap	6	m/s

CHAPTER I

INTRODUCTION

1.1 Background

A fixed-wing aircraft, typically called an aeroplane, airplane or simply plane, is an aircraft capable of flight using forward motion that generates lift as the wing moves through the air. Planes include jet engine and propeller driven vehicles propelled forward by thrust, as well as unpowered aircraft (such as gliders), which use thermals, or warm-air pockets to inherit lift. Fixed-wing aircraft are distinct from ornithopters in which lift is generated by flapping wings and rotary-wing aircraft in which wings rotate about a fixed mast, Blatner, David.2003.

Most fixed-wing aircraft are flown by a pilot on board the aircraft, but some are designed to be remotely or computer controlled.

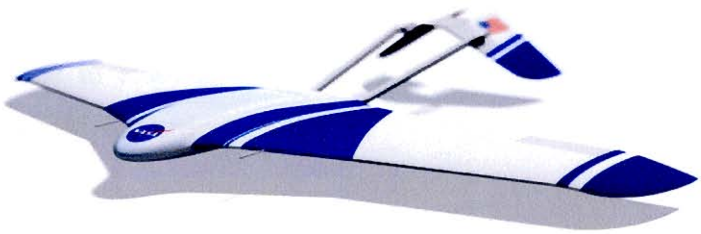

Figure 1.1: Unmanned Aerial Vehicle (UAV)
(Source: http://roboticsblog.org/2009/space-nasa-robots/nasa-ares-uav-to-fly-around-mars-and-stream-video)

The structure of a fixed-winged aircraft usually consists of the following major parts, however some varieties of aircraft, such as flying wing aircraft, may lack a discernible fuselage structure and horizontal or vertical stabilisers:

i. A long narrow, cylindrical, spherical, odd shaped, form, called a fuselage, usually with tapered or rounded ends to make its shape aerodynamically smooth. The fuselage carries the human flight crew if the aircraft is piloted, the passengers if the aircraft is a passenger aircraft, other cargo or payload, and engines and/or fuel if the aircraft is so equipped. The pilots operate the aircraft from a cockpit located at the front or top of the fuselage and equipped with windows, controls, and instruments. Passengers and cargo occupy the remaining available space in the fuselage. Some aircraft may have two fuselages, or additional pods or booms.

ii. A wing (or wings in a multiplane) with an airfoil cross-section shape, used to generate aerodynamic lifting force to support the aircraft in flight by deflecting air downward as the aircraft moves forward. The wing halves are typically symmetrical about the plane of symmetry (for symmetrical aircraft). The wing also stabilises the aircraft about its roll axis and the ailerons control rotation about that axis.

iii. At least one control surface (or surfaces) mounted vertically usually above the rear of the fuselage, called a vertical stabiliser. The vertical stabiliser is used to stabilise the aircraft about its yaw axis (the axis in which the aircraft turns from side to side) and to control its rotation along that axis. Some aircraft have multiple vertical stabilisers.

iv. At least one horizontal surface at the front or back of the fuselage used to stabilise the aircraft about its pitch axis (the axis around which the aircraft tilts upward or downward). The horizontal stabiliser (also known as tailplane) is usually mounted near the rear of the fuselage, or at the top of the vertical stabiliser, or sometimes a canard is mounted near the front of the fuselage for the same purpose.

v. On powered aircraft, one or more aircraft engines are propulsion units that provide thrust to push the aircraft forward through the air. The engine is optional in the case of gliders that are not motor gliders. The most common propulsion units are propellers, powered by reciprocating or turbine engines, jet engines or even rocket motors, which provide thrust directly from the engine and usually also from a large fan mounted within the engine. When the number of engines is even, they are distributed symmetrically about the roll axis of the aircraft, which lies along the plane of symmetry (for symmetrical aircraft); when the number is odd, the odd engine is usually mounted along the centreline of the fuselage.

vi. Landing gear, a set of wheels, skids, or floats that support the aircraft while it is on the surface.

1.2 Problem statements

In every design of an aircraft, the analysis on the wing joints, tail and propellers of an aerospace vehicle will be very critical since these are the parts which play the major role during takeoff and landing process. All parameter of the aircraft design structure have to be considered and studied to make sure that the aircraft does not fails during airborne.

Moreover, analysis on the aerodynamics of the wings and tail considering the drag and lift has to be made to the aircraft's wing design to ensure that it manage to carry the aircraft body and load airborne.

In addition, designing and proposing the best designs for the wing and tail part of the aircraft have to be done to increase the safety of the aircraft during airborne generally and during takeoff and landing specifically.

1.3 The objective of this project is listed below:

i. To design and analysis the suitable model of aerospace vehicle using numerical method.

1.4 Scopes

The scope of study for this project is:

i. Develop an aerospace vehicle model using ABAQUS.
ii. Analysis in model is only limited to force effects of the wing and tail part.
iii. Selection on suitable material to develop aerospace vehicle.

1.5 Project Outline

Chapter I consist the introduction part of the project such as the background, problem statement, objectives of the project and also the scopes of the project.

In chapter II, it consist the literature review on aerospace, aerospace engineering, aircraft design, material and structural optimization. It consists of the definitions, overviews, histories, manufacturing, elements, functions and applications of all the terms stated above.

Chapter III is basically explaining the methodology on how the study and experiment has been conducted. During this thesis, it will review about the methods used, the material selections, the designs, the theory and formula for aerodynamic analysis and also the procedure of the software used for numerical approach via ABAQUS of this study. In this study, an RC aircraft have been used. Anything about the RC aircraft has been review and discussed from the reason the devices are chose to the device's specifications

In chapter IV, all the initial results from aerodynamic analysis and the designs modeling of the actual and propose designs of the wing and tail parts are presented using the calculations and figures. This is including the discussions that have been obtained during the analysis.

In chapter V, the analysis results from ABAQUS are presented and discussed. The best design of each Wing and Tail part will be chosen.

In the last chapter, chapter VI the conclusion has been made and for the future works, there is also recommendation added. The recommendation is added to give an opinion and also an improvement on how the future works should be done.

CHAPTER II

LITERATURE REVIEW

2.1 Introduction

In this chapter, it consists of a literature review of numerous aspects about the aerospace, aerospace engineering, structural analysis and aircraft structural design. It consists of the overview, history, manufacturing and elements of aerospace engineering. The study on the aircraft design, material and structural optimization are also included. This will show a general explanation about the terms stated above.

2.2 Aerospace

Aerospace comprises the atmosphere of Earth and surrounding space. Typically the term is used to refer to the industry that researches, designs, manufactures, operates, and maintains vehicles moving through air and space. Aerospace is a very diverse field, with a multitude of commercial, industrial and military applications. Aerospace is not the same as airspace, which is a term, used to describe the physical air space directly above a location on the ground, Wallace B. Black (1967).

2.2.1 Overview

In most industrial countries, the aerospace industry is a cooperation of public and private industries. For example, several countries have a space program under the command of the government, such as NASA in the United States, ESA in Europe, the Canadian Space Agency in Canada, Indian Space Research Organization and Hindustan Aeronautics Limited in India, RKA in Russia, China National Space Administration in China, SUPARCO in Pakistan, Iranian Space Agency in Iran, and Korea Aerospace Research Institute (KARI) in South Korea.

Along with these public space programs, many companies produce technical tools and components such as spaceships and satellites. Some known companies involved in space programs include Boeing, EADS, Lockheed Martin, MacDonald Dettwiler and Northrop Grumman. These companies are also involved in other areas of aerospace such as the construction of aircraft.

2.2.2 History

The field of aerospace has been investigated for millennia, but modern aerospace began with the first powered flight at Kitty Hawk, North Carolina on December 17, 1903, by the Wright brothers. From there, aerospace has grown to be one of the most exciting, diverse, and fast paced fields of today. From the hot-air balloons of 18th century to the first wood-and-cloth plane of Wilbur and Orville Wright, to the first manned mission to the moon on Apollo 11 to the new and exciting aircraft being developed by companies like Boeing, Airbus, and Bombardier, Crouch and Tom (2004).

2.2.3 Manufacturing

Aerospace manufacturing is a high technology industry that produces aircraft, guided missiles, space vehicles, aircraft engines, propulsion units, and related parts, United States Bureau of Labor Statistics (2010). Most of the industry is geared toward governmental work. For each Original Equipment Manufacturer (OEM), the US government has assigned a CAGE code. These codes help to identify each manufacturer, repair facilities, and other critical aftermarket vendors in the aerospace industry.

In the European Union, aerospace companies such as EADS, BAE Systems, Thales, Dassault, Saab and Finmeccanica account for a large share of the global aerospace industry and research effort, with the European Space Agency as one of the largest consumers of aerospace technology and products.

In the People's Republic of China, Beijing, Xian, Chengdu, Shanghai, Shenyang and Nanchang are major research and manufacture centers of the aerospace industry. China has developed an extensive capability to design, test and produce military aircraft, missiles and space vehicles. Despite the cancellation in 1983 of the experimental Shanghai Y-10, China is still developing its civil aerospace industry.

In India, Bangalore is a major center of the aerospace industry, where Hindustan Aeronautics Limited, the National Aerospace Laboratories and the Indian Space Research Organization are headquartered. The Indian Space Research Organization (ISRO) launched India's first Moon orbiter, Chandrayaan-1, in October 2008.

In Russia, large aerospace companies like Oboronprom and the United Aircraft Building Corporation (encompassing Mikoyan, Sukhoi, Ilyushin, Tupolev, Yakovlev, and Irkut which includes Beriev) are among the major global players in