DESIGN OF MODEL GLIDER

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ABSTRACT

Design of a model glider is a conceptual understanding of aerodynamics and aeronautical engineering which is not provided in daily lectures room due to the fact that it is advance knowledge in this field. It is becoming a necessary knowledge in Malaysia due to the demands in the flight industry. As such, it is vital to attain this basic knowledge through this project. The purpose of this project is to design, fabricate and test a model glider to achieve flight. Extensive designs were performed on two softwares that proved to be vital. Material that is light in weight was used to fabricate the model glider using simple and easy methods. Evaluation of the performance was based on the range achieved. The target range is 50 meters. The center of gravity, balancing mass and height were the aspects studied during testing. The model glider proved flyable and nearly reached the target range. The findings suggest that with greater height, appropriate mass balancing and location of the center of gravity, greater range can be achieved. The design from the softwares, fabricating using simple methods and testing outdoor, the model glider proved its capability of flight. The framework used to design this project is general enough and can be improved by using better materials to achieved good performance.

ABSTRAK

Rekabentuk sebuah model peluncur memerlukan pemahaman tentang konsep bidang aerodinamik dan kejuruteraan aeronautik di mana pengajaran tentang ilmu ini tidak diberikan dalam kuliah harian kerana bidang ini masih baru. Ilmu ini perlu dikenali dan difaham kerana industri penerbangan di Malaysia semakin meluas dan maju. Oleh itu, pengenalan ilmu ini dikenalkan melalui projek tahun akhir. Tujuan projek ini dilaksanakan adalah untuk merekabentuk, membina dan menguji model peluncur untuk terbang. Hasil rekaan model ini menggunakan 2 jenis perisian komputer yang dibuktikan penting. Jenis bahan yang ringan digunalan untuk membina model ini dengan cara yang mudah dan senang. Penilaian rekabentuk ini berdasarkan pencapaian kejauhan penerbangan model. Matlamat model ini adalah untuk mencapai penerbangan sebanyak 50 meter jauh. Pusat graviti, pemberat dan ketinggian adalah faktor yang penting yang dikaji. Model ini membuktikan kebolehan untuk terbang dan hampir mencapai matlamat jarak yang ditetapkan. Kajian menunjukkan bahawa dengan lebih ketinggian, penggunaan pemberat yang sesuai dan pusat graviti yang tepat boleh meningkatkan prestasi penerbangan model ini. Penggunaan perisian komputer untuk merekabentuk, binaan model ini dengan cara yang mudah dan senang dan juga pengujian di kawasan lapangan membuktikan kebolehan model ini untuk meluncur di udara. Struktur yang digunakan dalam mereka model ini adalah cukup am dan boleh dibaiki dengan menggunakan bahan yang lebih baik untuk mencapai prestasi yag lebih bagus.

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LIST OF SYMBOLS

AR	-	aspect ratio
D	-	drag
L	-	lift
W	-	weight
b	-	wing span
c	-	wing or airfoil chord
$\bar{c}$	-	wing mean aerodynamic chord
c_d	-	airfoil (two-dimensional) drag coefficient
c_l	-	airfoil (two-dimensional) lift coefficient
c_m	-	airfoil pitching moment coefficient
c_r	-	wing root chor
c_t	-	wing tip chord
d	-	airfoil drag
l	-	airfoil lift
m	-	airfoil pitching moment
S	-	reference planform area
V	-	velocity
Λ	-	wing taper ratio
λ	-	wing taper ratio
ρ	-	air density

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CHAPTER 1

INTRODUCTION

The sole purpose of this project is to understand the fundamental knowledge of flight. This basic perspective is aerodynamics. The definition of this word is described as the dynamics of gases, especially atmospheric interactions with moving objects (The American Heritage Dictionary of the English Language, 1969). It is also explained that:

> The term "aerodynamics" is generally used for problems arising from flight and other topics involving the flow of air.
>
> (Ludwig Prandtl,1949)

Therefore, as a student of mechanical engineering of University Malaysia Pahang, this project interest and exposes me the field of aeronautical engineering as part of mechanical engineering. The design and fabrication of model glider is the baby steps of heavier-than-air flight or airplane principles to be caught whole.

1.1 Project Synopsis

The design and fabrication of a model glider requires the finished glider to glide about 50 meters long on any runway. The use of light weight material is applied in order to enhance the glider's flying capability and performance as well as to reduce to cost of the project. This simple flying object is done so that the knowledge of aeronautical and aerodynamics can be acquired and applied.

1.1.1 Project Synopsis Analysis

The title Design and Fabrication of Model Glider involves the mechanics of flight. The mechanisms are studied and the information that is the retrospective of glider is extracted. This information is applied in the design perspective of the model glider which is to be fabricated later on. The prerequisites are fluid mechanics, good engineering problem solving skills and hands-on fabricating process. The 50 meters of glide range could then be achieved with this acquired knowledge.

1.2 Objective of the Final Year Project

1.2.1 General Objective

This final year project is part of the required subjects to be taken during the Diploma of Mechanical Engineering course. This is done during the final semester before advancing into the industrial training program. Therefore, it is vital to complete this project in order to receive a final grade depending on the effort put in.

The final year project is also to give students the individual ability and confidence to complete a task with under less supervision of lecturers. With this, students can learn problem solving skills in areas of designing, analysis, fabrication, and testing as well learn to do a complete formatted report which is important for future thesis writing.

1.2.2 Specific Objective

- To design, fabricate and test model glider

1.3 Scope of Work

Finishing the model glider requires precise scope of work to be followed. This project title is new as well as the knowledge for this project is not entirely covered in the subjects taken during this diploma course. Therefore, aerodynamic knowledge is the extension of fluid mechanics and thermodynamics detailing in the aspects and scopes of fluid motion over a moving object. Likewise, unique scopes of work should be determined to achieve the purpose and goal of the project.

These scopes are:

i. Literature review on the knowledge of aerodynamics and design analysis.
ii. Design the model glider using theoretical and practical approach.
iii. Fabricate the model glider using light materials.
iv. Test designed and fabricated glider to achieve 50 meters of glide range.

Only with these scopes, total effectiveness can take place to satisfyingly complete this title of final year project.

1.4 Project Planning

To start of this project, a thoroughly research of literature review is done with the means of the internet, books, available published articles and materials that is related to the title and supervisor's guidance. This is a continuing progress until sufficient knowledge is attained to complete the project.

In the first week, an appointment with the supervisor is done to manage the schedule of weekly meetings. The purpose is to inform the supervisor on the progress of the project and guided by the supervisor to resolve difficulty.

Briefing based on the introduction and next task of the project is given by supervisor in the first week.

Designing phase starts of by sketching few models using manual sketch on A4 papers. Software applications are downloaded from the internet to design the model based on the sketches. These softwares helps to estimate which is the better design as this would be a flying object that needs optimum design features. However, the selected design is still the preliminary design of the model.

The preparation of mid-presentation of the project is next. Before presenting, the supervisor will see through the slide presentations and comment on corrections to be made. Then, presentation on the knowledge attained and instilled in the design phase is presented to a panel of three judges.

Following up, is the fabrication of using light materials to study whether the design is capable of flight. Modification is done on the design so as the model would glide and which changes would make the model glide better. It would take seven weeks to get this design and fabrication alteration done.

Finally, the main material is chosen and bought. This would be the main material for the fabrication. The fuselage, wing, and stabilizers are fabricated. This would take about three weeks to complete.

The assembly of parts will be next and then testing. Modification or add-ons, and more trials will be done until it reaches above the 50 meters glide range for about the period of three weeks. Results are jotted done during this timed trials.

After that, the final report writing and final presentation will be the last task to be accomplished during the final week. The supervisor will review the final presentation and revise the mistakes to be amended. The final presentation then again will be presented to three panels. A draft report would then be submitted to the supervisor to be point out the flaws. Corrections are done and the real final report is handed over as a completion of the final year project.

CHAPTER 2

LITERATURE REVIEW

The title design and fabrication of a model glider requires an amount of good understanding on the knowledge of this science. Therefore, executing a research is necessary to obtain all the information available and related to this topic. The information or literature reviews obtained are essentially valuable to assist in the construction and specification of this final year project. With this grounds established, the project can proceed with guidance and assertiveness in achieving the target mark.

2.1 Terminology

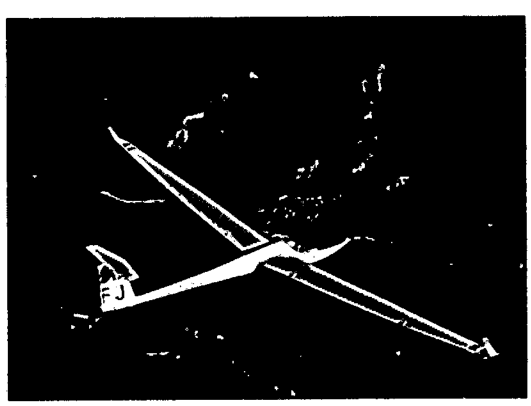


Figure 2.1: A soaring glider

Glider is a heavier-than-air aircraft that is not powered up or uses thrust force of an engine to achieve flight. This unpowered flyer is also known as sailplane. The glider consist the basic features of a body of an airplane that are fuselage, wings, and stabilizers. The fuselage is the main body that holds the wings and stabilizers together which looks like a long tube. The wings are the justification of an airplane because the wings are the source of producing lift for flight. The stabilizers or known as the tail are divided into horizontal stabilizer and vertical stabilizer. The function of the tail is basically to stabilize the aircraft during flight.

2.2 History

Gliders were built before the first human flight was recorded. Chinese was the first to design true gliders according to the *Extensive Records of the Taiping Era* (978) during the 5th century BC by a man named Lu Ban, a Confusionist. Another incident was recorded from the *History of Northern Dynasties* (659) and *Zizhi Tongjian* (1084) that Yuan Huangtou in Ye made a successful glide, taking off from a tower in 559.

The first hang glider was invented by Abbas Ibn Firnas to be known as weight shift aircraft. There are claims that he is the inventor of the first manned glider in 875 by fixing feathers to a wooden frame fitted to his arms or back. He achieved a ten minute flight according to a written account.

Aviation pioneering resumed in the 18th century with Sir George Cayley's series of gliders achieving first heavier-than-air aircraft to be flown in Europe around 1804. From here, aviation was then led by designing and building glider reaching America. Great names was known for pioneering this science such as Otto Lilienthal (1891), Samuel P Langley (1891), Octave Chanute (1894), John Jay Montgomery and finally Orville and Wilbur Wright. The Wright brothers created history with the first heavier-than-air flight using an engine at Kitty Hawk, Ohio. The aircraft was called the "Flyer".

With the coming of World War 1, aviation boomed. Gliders were used for military purposes during World War 2. Finally space shuttles acts as gliders after the re-entry from space flight.

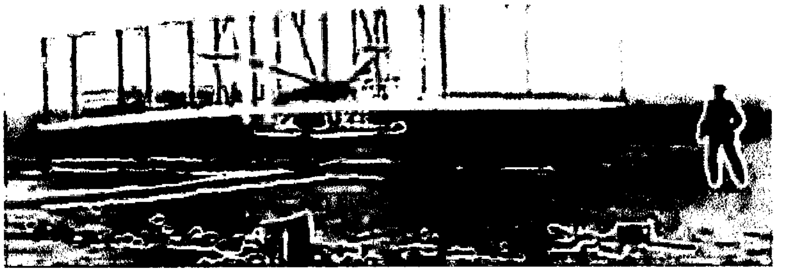


Figure 2.2: Actual flight of the Flyer by Orville Wright at Kitty Hawk

2.3 Types of Gliders

The most common types of gliders these days are basically used for sporting purposes. The design of these types enable them to climb using rising air and then glide for long distances before finding the next source of lift. These glider types are hang glider, paraglider, self-launching glider, and sailplane.

2.3.1 Hang Glider

Hang glider is a simple aircraft consist of an aluminum- or composite- fabric wing. The pilot is mounted on a harness connecting to the wing frame and exercising control by shifting the body weight. Hang gliders are foot-launched aircraft where the pilot launches itself from the tip of a hill or mountain. The glide ratio for a hang glider is in the range of 15:1.

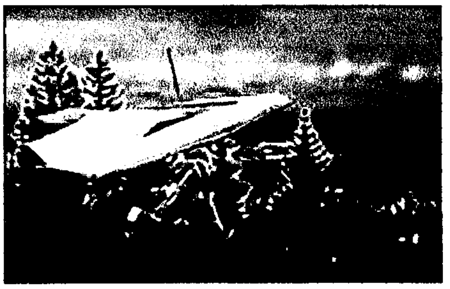


Figure 2.3: A hang glider launched from hill top

2.3.2 Paraglider

Paraglider is just a wing or canopy known in aeronautical engineering as ram-air airfoil or parafoil. The paraglider comprised of two layers of fabric which are connected to internal supporting material in such a way as to form a row of cells. By leaving most of the cells open at the leading edge only, incoming air (ram-air pressure) keeps the wing 'inflated', thus maintaining its shape. When inflated, the wing's cross-section describes the typical 'teardrop' aerofoil shape. The pilot is supported underneath the wing via a network of cascading lines. The pilot can buckle into a harness with standing or sitting position. The glide ratio range is 8:1

Figure 2.4: A paraglider catching wind

2.3.3 Self-launching Glider

These gliders have retractable propellers powered by an engine to have sufficient thrust and climb rate for take off. The engines also have a starter motor and a large battery to allow the engine to be started on the ground, and an alternator to recharge the battery. A two blade propeller is typically coupled to the engine via a belt reduction drive, and the propeller alignment must be checked by the pilot using a mirror, before it is retracted into the fuselage. Self launching engines are typically in the range of 50-60 hp (38-45 kW).

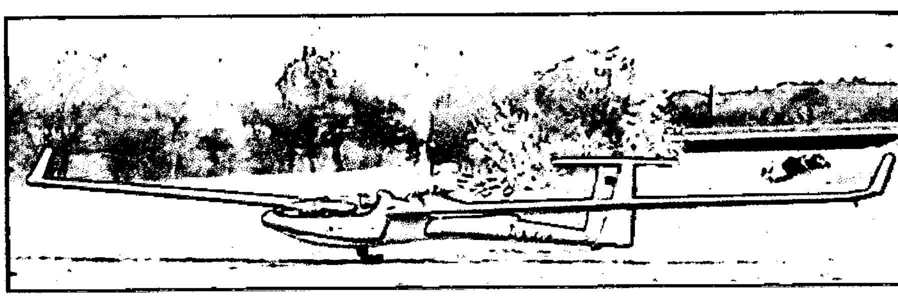


Figure 2.5: Self-launching glider

2.3.4 Sailplane

Sailplane or known as pure glider is distinguishes an unpowered glider to a motorized glider. These are pure gliders that use upwardly moving air to soar to greater altitudes. These were the first gliders developed during the 19^{th} century in small scale size and hand launched in competitions. Now these gliders are towed by an airplane to a certain altitude and released to achieve total gliding condition. These gliders have the highest gliding ratios. This type will be selected for the model glider project.

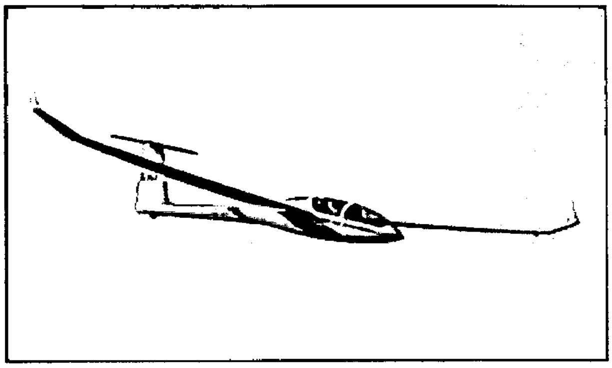


Figure 2.6: Sailplane

2.4 Mechanisms of a Glider

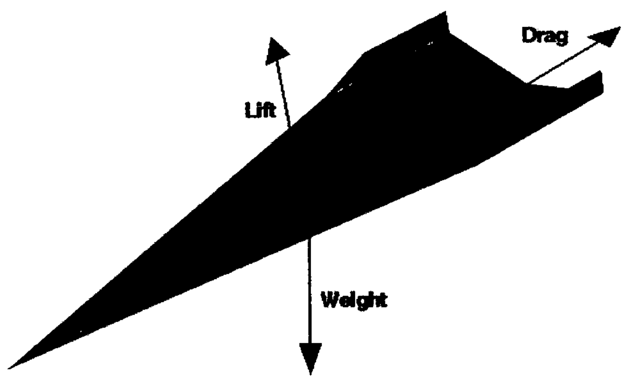
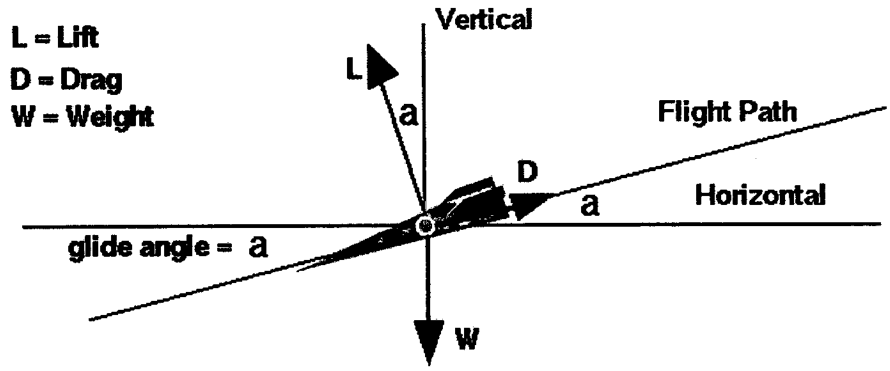


Figure 2.7: Forces acting on a glider

Basically, there are only three forces working on a glider which are lift, drag and weight. These forces are vector quantities which has a magnitude and a direction. The weight acts through the center of gravity of the glider and is directed towards the center of the earth. The magnitude of the weight is calculated using the weight equation and this depends on the mass of the aircraft and its payloads. The lift and drag are aerodynamic forces which act through the center of pressure of the glider. Drag force is in the opposite direction of the flight path whereas the lift force is directly perpendicular to the flight direction. These aerodynamics forces are due to two basic sources which are pressure distribution and shear stress distribution over the body surface.

2.4.1 Vector Balance Forces



Equations: **Vertical:** $L\cos(a) + D\sin(a) - W = 0$

Horizontal: $L\sin(a) - D\cos(a) = 0$

From the Horizontal equation: $\frac{L}{D} = \frac{\cos(a)}{\sin(a)} = \frac{1}{\tan(a)}$

For small angles, tan(a) = a (in radians!): $\frac{L}{D} = \frac{1}{a}$

Figure 2.8: Balance forces on a descending glider

On a descending glider, there are three forces working on it which are lift, drag and weight. According to figure 2.8, the lift force works perpendicular to the flight path. The drag force acts parallel but opposite the direction of the flight. The weight force acts downward of the center of gravity of the glider through the vertical axis. The lift and drag forces magnitude are given by the lift and drag equations and also depends on several factors. These factors are shape, size, velocity, inclination to flow, mass, viscosity and compressibility. The flight path crosses the horizontal axis an angle **a** which is known as glide angle. This angle also defines the angle between the lift and the vertical, and between the drag and the horizontal.

Assuming that the forces are balanced (no acceleration of the glider), we can write the two vector component equations for the forces. In the vertical direction, the