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Designing of an radio control aircraft

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ABSTRACT

The goal of this project was to design a remote controlled aircraft. The plane had to be light as possible, carry a payload fraction and fit in the box with a 24"x 18"x 8" interior dimension. The design has a 50.2 inch wingspan and is capable of carrying a payload of 3KG after being hand launched. Innovations such as modular assembly jigs in the fabrications process allow the aircraft to be constructed in less than eight hours. This report details about the design process and final configuration of the aircraft. By completing aerodynamics, structures, stability, propulsion and selection analysis, then we able to create a lightweight aircraft with a high payload fraction.

INTRODUCTION

The main aim of this project was to design, analyze and build an RC plane. This involves understanding the various aerodynamic forces and moments acting on the plane, choosing the right motors, controllers for its operations and hence making it fly. Hence this project involved optimization of various parameters for an enhanced flight. In order to achieve the stated objective, extensive literature review was done in determining the various parameters for building of the plane. Authors in suggest development of a Canard type aircraft, with the mission of aerial reconnaissance and surveillance. Ryan et al provide insight into flapping flight configuration that provided an insight into improved aerodynamic performance, improved maneuverability, and hover capabilities. Luca et al [3] provide a review of state of art with respect micro and nano aerial vehicles, which helped better understanding of different design and engineering principles for such vehicles. Reference [4] provided detailed information on RC controlled aircrafts design and build. Based on all the literature review and available knowledge, it was decided to systematically design, analyze and build an RC plane. In addition it was decided to develop such a plane, to maximize the aspect ratio, minimize the wing loading and optimize the weight. Basic terms like lift coefficient, tip, root chord, taper ratio etc help understand the aerodynamics of flight while movement of air over the airfoil help understand the behavior of flight in air. Keeping these considerations in mind the design and optimization were done. The aim of this paper is therefore to explain the systematic methodology followed for designing, analyzing and building the RC plane including details of optimization. The following are the major steps in this.

LITERATURE REVIEW

This chapter provides a brief overview of the key historical changes in the aviation industry,

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with a focus on the evolution of the aircraft business in the United States since the Deregulation Act of 1978. The goal is to present high level information regarding the aircrafts' customary planning objectives and strategic consideration involved in the management of aircraft fleets and the development of new routes at a network level. Using a complex variety of factors, aircraft plan their development on a system wide basis and usually on a shorter horizon than airports plan for their own development. This timing inconsistency is generally a source of uncertainty in the assessment of future airport activity and can potentially result in risks to airport investments. For this reason, it is important to determine the causes of airline up gauging or down gauging to better understand the impacts on airports and identify the best solution and practices to develop flexible plans and strategies at the airport level.

DESIGN SPECEFICATION

A trainer aircraft basically will have a high wing design, simple sturdy construction, excellent plans and instructions having high stability in the air in order to make flying easy. Parameter selection changes for each type of aircraft. Usually the only assembly to be done is joining the wing halves, adding the tail surfaces, mounting the radio system, engine and landing gear, and connecting the control surfaces. Another consideration when choosing to fabricate first plane is how many control functions or channels to use. Trainer aircraft are available in both three channel and four channel configurations. Most aircraft fly with four functions, these being the Rudder, Elevator, Throttle, and Ailerons. Trainers, however, can also fly without the use of ailerons.

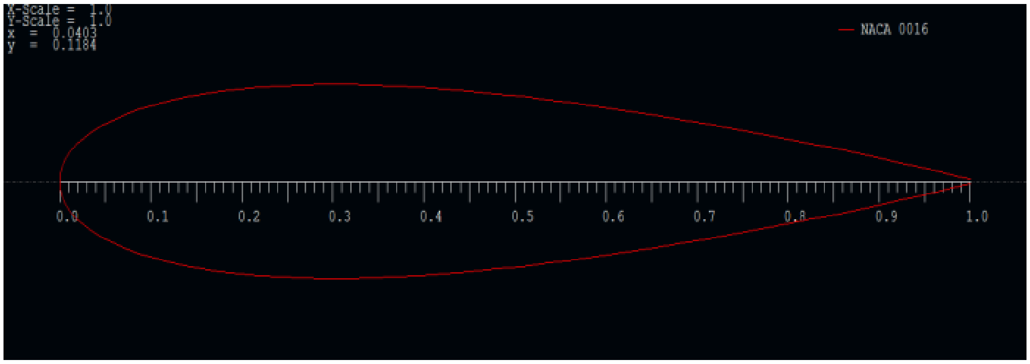
CONCEPT OF STABILITY AND TAIL SIZING

Longitudinal static stability is the stability of an aircraft in the longitudinal, or pitching, plane under steady- fligh conditions. If an aircraft is longitudinally stable, a small increase in angle of attack will cause the pitching moment on the aircraft to change so that the angle of attack decreases and vice versa. The nature of stability may be examined by considering the increment in pitching moment with change in angle of attack at the trim condition. The moment equilibrium condition is called trim, which is of general interest for considering the longitudinal stability of the aircraft. In principle trim limits could determine the permissible forward and rearward shift of the centre of gravity. Usually it is only the forward Cg limit which is determined by the available control, the aft limit is usually dictated by stability. A mathematical analysis of the longitudinal static stability of a complete aircraft yields the position of center of gravity at which stability is neutral. This position is called the neutral point. The larger the area of the horizontal stabilizer, and the greater the moment arm of the horizontal stabilizer about the aerodynamic center, the further aft is the neutral point. The static center of gravity margin (e.g. margin) or static margin is the distance between the center of gravity and the neutral point. It is usually quoted as a percentage of the Mean Aerodynamic Chord. The center of gravity must lie ahead of the neutral point for positive stability/ If the center of gravity is behind the neutral point, the aircraft is longitudinally unstable .This concept is used to find the neutral point and also the tail sizing.

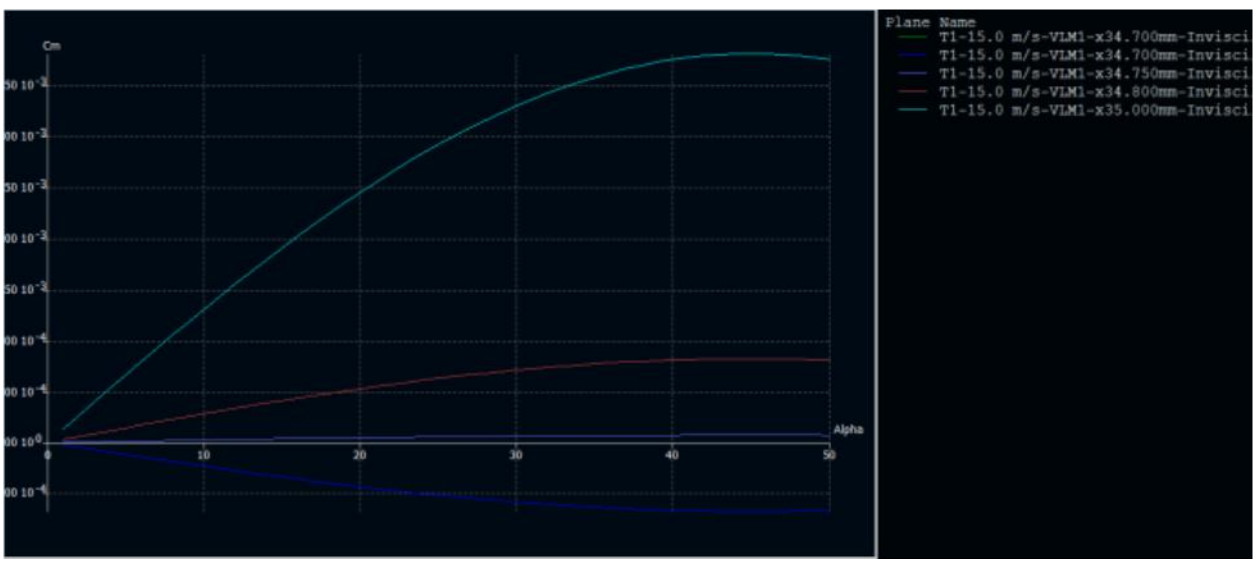
DETAILS OF DESIGN

Wing

Initially the parameters were chosen using the basic formulae of aspect ratio, taper ratio and then analyzed and validated using ANSYS15. The aspect ratio was chosen to be in the range of 6-6.5, the wing loading .46 - .55g/cm2, surface area of the wing 1250 - 1350cm2 and weight of the wing to be 500g.The all up weight, lift and drag forces, lift and drag coefficients etc were optimized on the basis of these design parameters. The aim was to maximize lift. The free stream velocity of operation was chosen to be 1500cm/s. Based on this the stall speed was also determined. Since it was chosen to make it an aerobatic plane a symmetric airfoil had to be chosen. Also in the region of the ailerons and wingtip a symmetric airfoil would help increase the range of angles of attack to avoid spin and stall. Thus relatively a large range of angles can be used without boundary layer separation. Hence NACA0016 wing configuration was considered. Here, the number16 indicates that the airfoil has a 16% thickness to chord length ratio. With this, the wing length was fixed at 90cm having a fixed chord length of 15cm. The particular airfoil considered for the purpose of this study.



Further, an analysis of the airfoil was done and the neutral point (i.e. where the coefficient of moment is 0) was found to be at 3.47 cm from the tip of the airfoil. Neutral point is basically the point where coefficient of moment is 0 and it coincides with the centre of lift for a symmetric airfoil. Also, the centre of gravity must lie ahead of the neutral point for positive stability. This was since stability was required as explained earlier under stability.



The neutral point was found using XFLR-5 and validated using ANSYS15, the variation of the coefficient of moment v/s alpha. The neutral point was found to be 3.47cm. The validated data from an ANSYS run confirming the location of the neutral point at 3.47cm.Since ansys is a more accurate software and values are obtained by the use of k-w turbulence module and good meshing procedures this value is used for all further calculations.

Also the neutral point is found to lie between 3.47 and 3.48 since the moment changes its value from the current to +.00328.Hence 3.47 is taken as the approximate value. The pressure forces acting on the airfoil were also analyzed in order to place the wing in such a way that maximum lift were to be obtained.

Fuselage

Next the fuselage design and related parameters were to be determined. Extensive literature review and analyzing of various designs were done. The elevator and rudder dimensions were determined subsequently and the plane was modeled with the exact values in CATIA to determine the centre of gravity i.e. at which the entire mass is assumed to be concentrated.

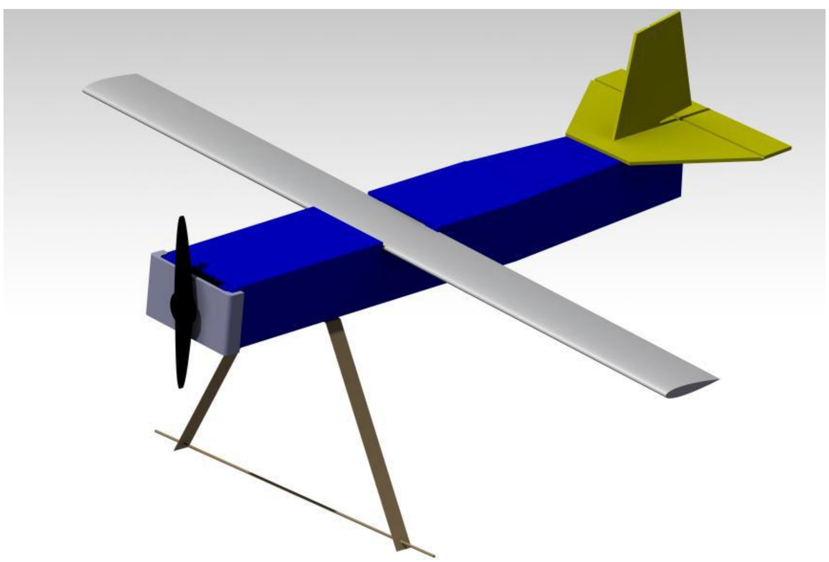
The concept used in determining the fuselage, elevator and rudder dimensions are as shown in figure 1 i.e. conventions to be followed for a balanced plane. Also the stall angle was obtained from the graph of CL versus alpha and was found to be at 150 and hence the safe angle of operation was taken to be 100 - 120. The following were the additional parameters considered.

- Horizontal Stab: 20% - 25% of the wing area
- Elevator: 20% - 25% of the horizontal stab chord
- Vertical Stab: 7% -12% of the wing area
- Rudder: 30% - 50% of the vertical stab chord
- Fuse Length: 70% of wing span (measured from nose/thrust washer to rudder hinge line).

From this analysis the following dimensions were obtained. The length of the fuselage was optimized to be 65cm. The breadth of the fuselage was 7cm. From front till 40 cm along the length of the fuselage, the cross section is rectangular and then it converges to a trapezoidal cross section. The wing was mounted at 21cm from the tip of the motor mount. The battery was placed at the centre of gravity which was required for stability and balancing of forces of the plane. At the aft part of the fuselage the elevator and rudder were attached, dimensions of which were as follows.

Elevator

The total length of the elevator was 25cm and width 4.5. The V shaped portions were found to be 14cm on both side and the last side of the trapezium to be 9.3cm.It was mounted in such a way that its centre coincided with fuselage centre line.



Tail sizing

For tail sizing the concept of longitudinal stability was used. From this the dimensions were obtained. The moving part of the rudder was found to be 12cm in length and 4cm in width. 0.5cm was cut in order to allow its movement by the servo mechanism. The hinged part was of length 15cm and width varying from 7 cm at the bottom to 2 cm at the top. The attaching part was joined at a distance of 3cm from the base.

Ailerons

The ailerons were 6cm in width and 23cm in length. They were attached to the wing as per conventions. i.e. at a distance of 8cm from the tip of the wing.

CONCLUSION

An attempt has been made to systematically design, analyze a prototype RC plane. This project provided the team an insight into basics of aircraft design, engineering, albeit on a small scale. The team also could learn aircraft technology fundamentals and use design and analysis tools. The project also provided an opportunity for multi-disciplinary team to work together and understand the interactions. The teams also have been able to document the lessons learnt to be further used in the upcoming aerospace projects.

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