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Design and Analysis of a Fixed Wing V- Tailed UAV

Dr. Prathik S Jain, Professor, Department of Aeronautical Engineering, Dayananda Sagar College of Engineering, Bengaluru, India
Jayanth V, Student, Department of Aeronautical Engineering, Dayananda Sagar College of Engineering, Bengaluru, India
Kiran Reddy, Student, Department of Aeronautical Engineering, Dayananda Sagar College of Engineering, Bengaluru, India
Saurav Kumar Singh, Student, Department of Aeronautical Engineering, Dayananda Sagar College of Engineering, Bengaluru, India

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Abstract:
In recent years, there has been tremendous development in the field of unmanned aerial vehicle (UAV). The UAV can be piloted from the ground remotely which can be safe as the pilot flying the aircraft is on a safe place and economical in operating the aircraft as the overall weight of the UAV can be reduced. The UAVs are mainly used in military applications where it can remain airborne for many hours without putting the crew in danger. Besides military applications, the UAV can also be use for civil purposes. It can be used for aerial imaging or aerial surveying which provides the bird's eye view of the area to be surveyed. This technique can be used for disaster management, urban planning & management and for agricultural purposes.

Keywords: *UAV; CATIA; ANSYS.*

I. INTRODUCTION

A UAV or an Unmanned Aerial Vehicle is a flying machine with no people on board. It can be autonomous or semi-autonomous while pilots can control it from ground station remotely. There are two types of UAVs such as fixed wing and rotary wing aircrafts. The fixed wing UAVs are widely used due to their increased stability. For small aircraft, the conventional control surfaces can be altered to increase the stability and performance and also decrease drag. A V-tailed fixed wing is designed using CATIA V5 software and will be analyzed for air flow around it. Structural analysis will also be carried out on this model using ANSYS 18.1 software.

The wide range of UAV applications has led to use for aerial surveying Literature survey on unmanned aerial Vehicle (UAV)

I. [1] Paper gave information on UAV and aerial vehicles equipped with sensors and software that enable the aircraft to fly without a human pilot on board. This is an emerging technology with a tremendous potential to revolutionize warfare and to enable new civilian applications like real estate, farming, Low-altitude, high-resolution aerial imaging systems for row and field crop phenotyping. [2] Paper gave information on UAVs with sensors can be used to evaluate in-field agronomic traits. These techniques are high-throughput and provide quantitative data for decision making. High-resolution imaging can complement and potentially replace the standard agronomic traits evaluation in future. To investigate effect of mesh number turbulent models on propeller. [3] Paper gave information on number of blades, has a small effect on the efficiency. Usually a propeller with more blades will perform slightly better, as it distributes

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its power and thrust more evenly in its wake. But for a given power or thrust, more blades also mean more narrow blades with reduced chord length. The chord length can be increased while decreasing the diameter to keep the power consumption constant, but diameter reduction is usually not a good idea in terms of efficiency. To investigate effect of V-tail on UAV. [4] Paper gave information on the advantages of V tail over other tail configuration was studied. A properly designed V tail configuration will give a better recovery from spin than a conventional or T tail. They keep the major mass of the tail assembly close to the tail boom for minimal torsional loading during ground loops. They usually have fewer joints, less interference drag, less stress concentrations, less parts count, and less weight

II. DESIGN AND DEVELOPMENT OF UAV

1. CATIA Designing:

Computer Aided Three-Dimensional Interactive Application (CATIA), allows the making of 3D parts, 3D sketches, sheet-metal, composites etc. Innovative technologies are provided by the software for mechanical surfacing. It provides an extensive variety of application for tooling project, for both generic tooling and mold and dye.

2. Model Design:

The total length of the UAV model is 902 mm with a wing span of 1300 mm. It has a V tail with an angle of 87 degrees. The chord length of the model is 154 mm and the tip chord length is 101 mm.

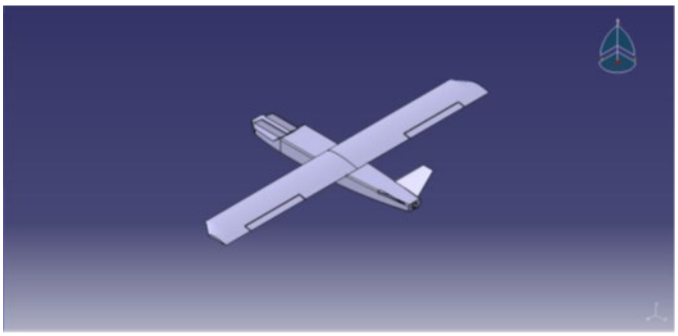

Fig. 1: 3D CATIA Isometric View

3. Meshing:

Two different types of mesh is used to carry out analysis i.e., structured mesh and unstructured mesh. Before carrying out the analysis for any object the meshing should be done for rendering to get precise analysis results. Here, unstructured mesh is used as the model has a complex. The magnified view of the model is shown in fig. 2. The advantage of using unstructured mesh is that is does not flow in any defined direction. Therefore it occupies every corner of the model. Structured mesh can be used for simple shapes which will give precise values much faster only for simple designs.

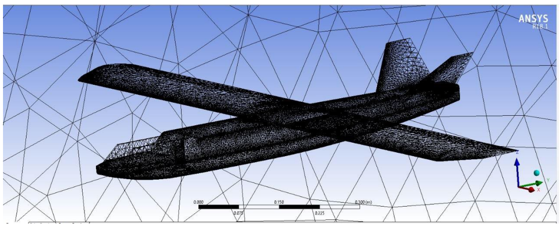

Fig. 2: Magnified view of model

The total number of nodes in the mesh are 313,328 and number of elements are 1,732,827.

4. Analysis:

The software used to carry out the analysis on the model is ANSYS 18.1. The analysis is carried out in the software to create various flows or stresses on the aircraft to improve the design before it is finally built.

i. Flow analysis:

The flow analysis is carried out using ANSYS 18.1 Fluent. It is used to observe the flow around the model. Drag and lift generated by the wing can also be calculated using the software.

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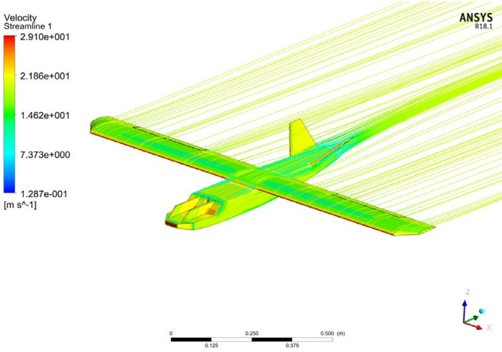

Fig. 3: Flow across the model

Fig. 3 shows the flow across the model. The inlet velocity is given as 20m/s and the flow is observed. High velocity of air occurs over the wing while the lower velocity is below the wing and aft of the tail section.

ii. Pressure analysis:

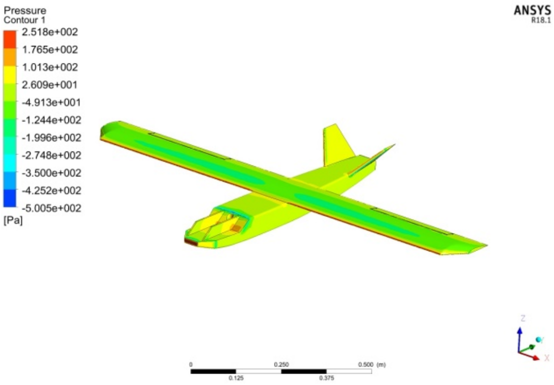

Fig. 4: Pressure on the model

Fig. 4 shows the pressure analysis carried out on the aircraft. A high pressure is observed on the leading edge of the wing and on the nose of the aircraft. This is due ti the static pressure. A low pressure is seen over the top of the wing which creates lift

iii. Stress on the wing:

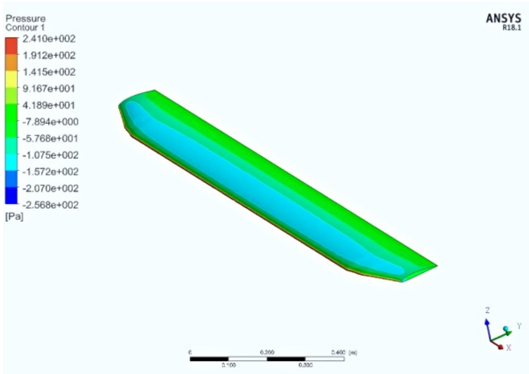

Fig. 5: Pressure over the wing

Fig. 5 shows the pressure over the wing is observed. There is low pressure over the top surface of the wing. This provides lift.

iv. Stress on the wing:

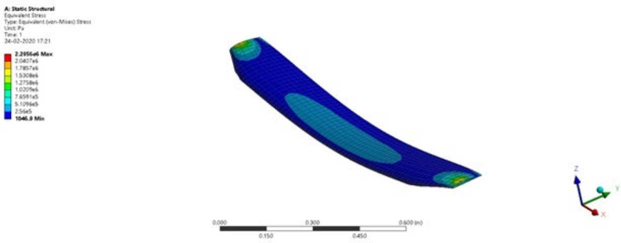

Fig. 6: Stress on wing

Fig. 6 shows the stress on the wing due to the weight exerted by the fuselage. The force of the fuselage is given as 25 Newton on the 'negative Z' direction i.e., downward force. The maximum stress is at the wing tips as the force acting on that small area is more.

v. Total deformation:

II.

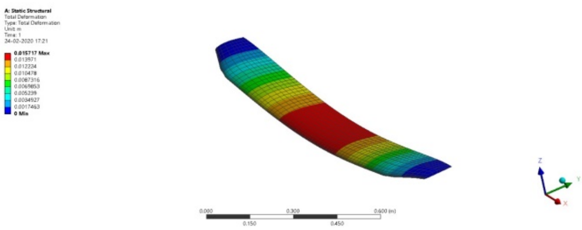

Fig. 7: Total deformation

Fig. 7 shows total deformation of the wing caused by the force acting by the fuselage. 25 Newton force is applied n the 'negative Z' direction i.e., in the downward direction. It is observed that there is maximum deformation at the center of the wing

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where the fuselage is attached to the wing. Minimum deformation occurs at the wing tips.

vi. Flow across the wing:

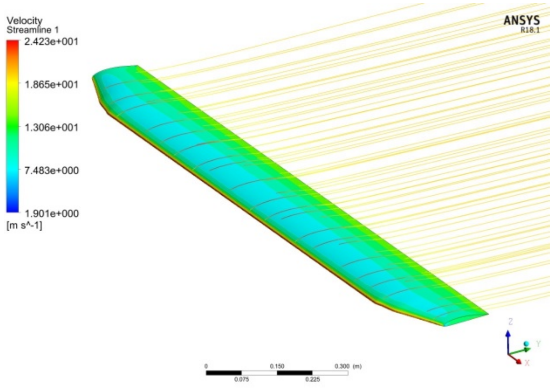

Fig. 8: Air flow across the wing

Fig. 8 shows the air flow over the wing. A high velocity flow is observed at the top surface of the wing.

Using this, the software can calculate the lift force (+Z axis) and drag (-Y axis) produced by the wing.

The lift force produced by the wing is :16.2N

The drag force produced by the wing is :1.4N

5. Graphical Representation:

Graphical representation is done to show the lift at various angles of attack and to find out other data which will be difficult to obtain from analysis and it is time consuming. While the graphical method gives precise data quickly.

i. C_L v/s Angle of Attack (Alpha):

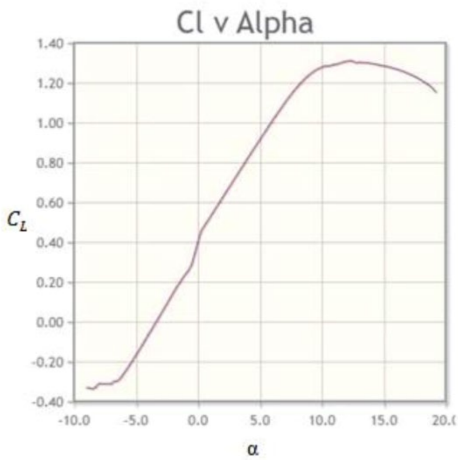

Fig. 9: C_L v/s Alpha

Fig. 9 shows the C_L (coefficient of lift) on the Y-axis and the angle of attack (Alpha) on the X-axis in degrees. This graph is important as it shows the stall angle on the aircraft. As the angle of attack increases, there is increase in lift. But in one point even when angle of attack increases there will be decrease in lift. This is the stall angle. Here, the stall angle is observed as 12.5 degrees.

ii. C_L v/s C_D:

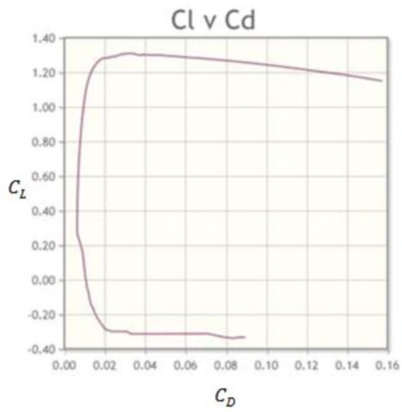

Fig. 10: C_L vs C_D

The above fig. 10 Shows a graphical representation of the C_L (coefficient of lift) vs C_D(coefficient of drag). As seen, while the C_L increases, the C_D decreases and at C_L=0.02, there is a sudden increase in C_L. Further, there is a decrease in C_D. This phenomenon is called a drag bucket.

Drag bucket in which the laminar flow airfoil shows a dip in drag over a range of C_L values in comparison with normal airfoils.

iii. C_L/C_D v/s Alpha:

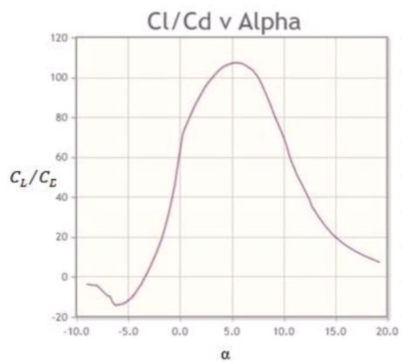

Fig. 11: C_L/C_D v/s Alpha

The above figure 11, C_L/C_D (coefficient of lift v/s coefficient of drag) gives the lift force which is on the Y-axis versus the angle of attack which is on the X-axis.

As the Angle of attack increases, there is increase in lift force. As the Angle of attack is more than 5 degrees, the lift force exerted on the wing decreases.

It can be justified from the reference paper "A study of gurney flaps and their influence on an airfoil in ground effect" Conducted by Eric Davis at 15% ground effect of chord the cl and cd at 5 degree AOA was 1.10 and 0.008

III. Conclusion:

- The fixed wing UAV having a V-tail is designed using CATIA V5.
- 3D model of the same is obtained using CATIA V5.
- Meshing is done on the model.
- Streamline flow distribution is analyzed and the results are obtained for the wing using ANSYS 18.1.
- Pressure distribution is analyzed and results are obtained for the wing using ANSYS 18.1.
- Deformation due to stress is analyzed and results are obtained for the wing using ANSYS 18.1.
- Lift and drag values for normal flight conditions are obtained.
- Graphs are plotted.

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