

Design and Analysis of V-Tail Unmanned Air Vehicle (UAV) for Surveillance Application

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Abstract

Unmanned Aerial Vehicles (UAVs) are gaining popularity in military operations as surveillance and weapons platforms. The size of military UAVs varies from very large to hand-held and they are so popular that more UAVs are now being produced than conventional aircraft. These military platforms are expensive to buy and to support. This cost factor has so far limited their use in commercial and industrial applications, such as, security, inspection, ensuring obedience to the laws or search and rescue. The conclusion is made that the design what is made is air worthy and easy to handle and CATIA V5 software is used for designing the V tail and analysed by Ansys and XFLR5 softwares.

Keywords— UAV, CATIA, VTAIL, ANSYS, XFLR5.

I. INTRODUCTION

An Unmanned Air Vehicle (UAV), in simple terms is an aircraft without a human pilot on board. Its flight is controlled moreover autonomously or by computers in the automobile or beneath the remote control of a pilot on the ground or in another vehicle. Of the many types UAV's that are available, one of the types of UAV is UAV (Unmanned Aerial Vehicle / Unmanned Aerial Vehicle). The thought behind V tail UAV is that the system could be hind packed, assembled and deployed by no more than two persons. Formerly these UAV's were designed to be hand launched and handled through a laptop, through the presentation showing video images and navigation and housekeeping data. They were powered by small petrol or diesel engines and this requisite the fuel supply to be encompassed in the backpacks. Now days with the growth of improved battery control and less weight electric motors, makes the back pack more convincingly possible. However battery recital at low temperatures might be a cause for apprehension.

The V-tail, invented and patented in 1930 by Polish engineer Jerzy Rudlicki, has not been a prevalent choice for aircraft manufacturers. The X-shaped tail

surfaces of the experimental Lockheed XFV were basically a V tail that protracted both above and below the fuselage. [1] Conservatively the most popular orthodoxly V-tailed aircraft in mass construction was the Beech craft Bonanza Model 35, frequently acknowledged as the V-tail Bonanza or just V-Tail. Other examples include the F-117 Nighthawk stealth fighter and the Fouga Magister trainer.

Preferably, with fewer surfaces than a predictable three-aerofoil tail or a T-tail, the V-tail is lighter, has less dampened outward area, so thus harvests less persuaded and scrounging drag. However, NACA studies specified that the V-tail surfaces must be grander than simple prognosis into the vertical & horizontal planes would suggest, such that total wetted area is unevenly constant; lessening of joint surfaces from three to two does, however, produce a net reduction in drag through removal of some interference drag.

In current day, light jet universal aviation aircraft as Cirrus Jet, Eclipse 400 or unmanned aerial drone Global Hawk frequently have the power plant positioned external the aircraft to defend the passengers and make authorisation easier. In such cases V-tails are used to avoid contacting the vertical stabilizer in exhaust of the engine, which would interrupt the flow of the exhaust, reducing thrust and increasing wear on the stabilizer, perhaps leading to destruction over time.

II. MODELLING

Computer Aided Design (CAD), also known as Computer Aided Design and Drafting (CADD), is the use of computer technology for the process of design and design- documentation. Computer Aided Drafting refer to the process of drafting with a computer. CADD software delivers the user with basic input for the persistence of streamlining design processes, drafting, documentation, and

manufacturing processes. CADD output is often in the form of electronic files for print or machining operations. CADD software uses either vector built graphics to represent the objects of out-dated drafting, or may also produce raster graphics viewing the overall look the of designed objects.

III. DESIGN PARAMETER

Out of the case studies carried out the following configuration for the airframe is selected.

1. Design configuration

An aerofoil-shaped body enthused through a fluid yields an aerodynamic force. The module is perpendicular to the direction of motion is called lift. The module parallel to the direction of motion is called drag. Subsonic flight aerofoils need a characteristic shape with rounded leading edge, trailed by sharp straggling edge, often with uneven camber. Foils of alike function designed through water as the working fluid, called hydrofoils. The lift on an aerofoil is mostly result of its angle of attack and shape. After oriented at appropriate angle, the aerofoil glances the oncoming air, ensuing in a force on aerofoil in direction conflicting to the deflection. This force is known as the aerodynamic force and can be determined in two components: Lift and drag. Most foil shapes necessitate a positive angle of attack to produce lift, nevertheless cambered aerofoils can produce lift at zero angle of attack. This "turning" of air in vicinity of aerofoil generates curved streamlines which grades in lower pressure one side and higher pressure on other. This pressure difference is convoyed by velocity difference, via Bernoulli's principle, consequently resulting flow field around the aerofoil has an advanced average velocity on the upper surface than on lower surface. The lift force can associated directly to average top/bottom velocity difference deprived of calculating the pressure via the concept of circulation and Kutta-Joukowski theorem.

2. Design approach

For Aerofoil selection for the rectangular wing section Eppler 61 aerofoil has selected for wing and NACA0012 for V tail has designed, and its aerodynamic parameters are analysed through XFLR5 software for performance characteristics of

the V tail MAV. The specifications are specified below.

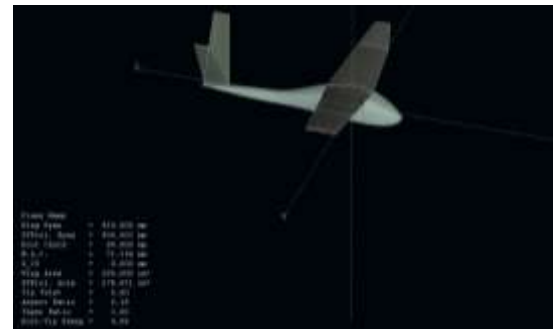


Fig 1: Pressure Distribution on V tail UAV using XFLR5

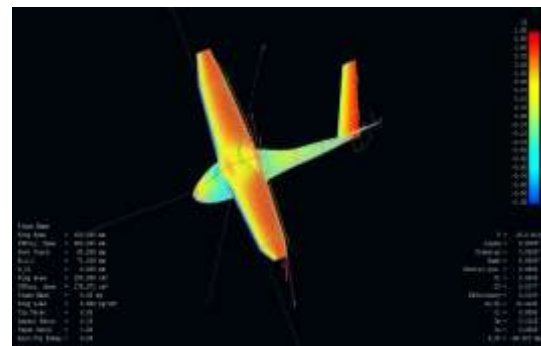


Fig 2: V tail UAV parameters

3. Performance Comparison

The following analysis of baseline was directed at $Re=350000$. Figure shows gen for the Eppler 61 airfoil at -5 to 15 degrees deflection. These deflections were selected as they signify the maximum deflection for present aircraft.

Portrays the information about variation of induced drag against angle of attack. From this graphical info we concluded that Aerofoil produces less amount of induced drag .This generates maximum lift in less angle of attack with low Reynolds number.

4. Wing Design

Wing design is made by combination of many airfoil segments. So to design a wind turbine blade airfoil coordinates are required. The airfoil coordinates were taken from airfoil investigation database. Defining airfoil coordinates in CATIA is mind-numbing, as it requires manually feeding each

coordinate of the aerofoil in the text pad. So the airfoil coordinates were moved to a Microsoft Excel file. Microsoft excels enables coordinates to be transferred to other software’s using macros. This feature of Microsoft excel is used to transfer the airfoil coordinates from excel to CATIA.

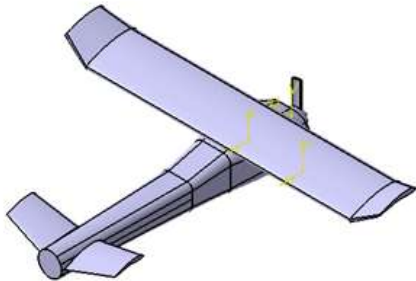


Fig 3: V Tail Cad Model in Catia

IV. STRUCTURAL ANALYSIS

1. FEA section for static structural analysis.

To complete this project, we followed the following flow chart to do this project in a proper sequence respectively.

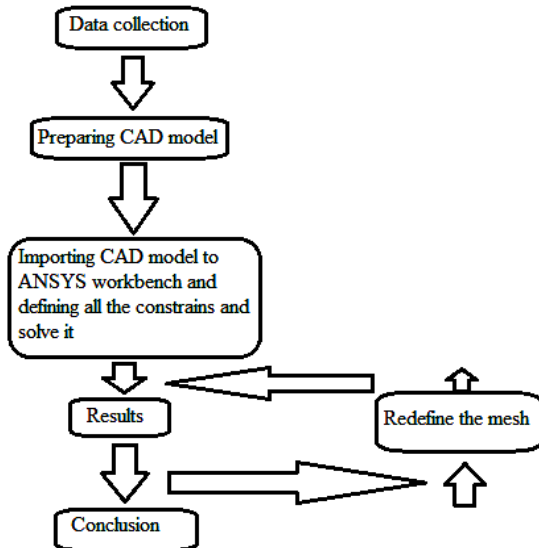


Fig 4: Ansys Flowchart

The important stages are importing CATIA model, defining constrains, results, redefining the mesh size and comparing results to the original results to validate the results and conclusion

2. Problem specification:

In static structural analysis we are interested in the total deformation, Von Misses stress which is also known as equivalent stress, shear stress and stress intensity induced in the skin structure of the V tail MAV.

3. Open ANSYS Workbench

We are ready to do a simulation in ANSYS Workbench. Open ANSYS Workbench by going to **Start > ANSYS > Workbench**. This will open the start-up screen seen as seen below.

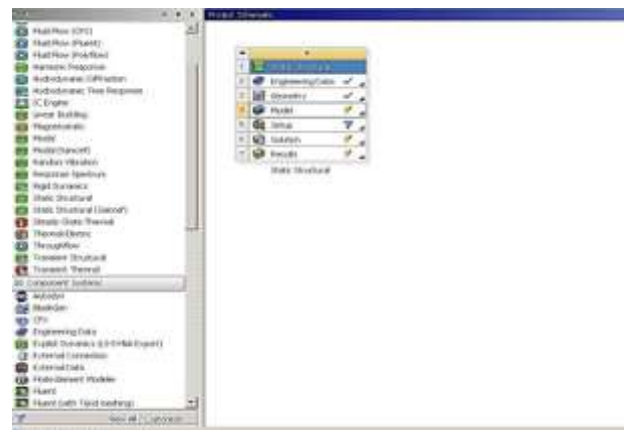


Fig 5: Ansys Workbench

4. Material Properties of ABS:

We have selected ABS standard grades have been developed specifically to meet the requirements of major customers. ABS is readily modified both by the addition of additives and by variation of the ratio of the three monomers Acrylonitrile Butadiene and Styrene, hence grades available include excellent impact resistance, good strength and stiffness, high heat resistance, good machinability. Fibre reinforcement can be incorporated to increase stiffness and dimensional stability. ABS is readily blended or alloyed with other polymers further increasing the range of properties available. Fire retardancy may be obtained either by the inclusion of fire retardant additives or by blending with PVC.

Density (g/cm3)	1.06
Surface Hardness	RR107
Tensile Strength (MPa)	42
Flexural Modulus (GPa)	2.4
Notched Izod (kJ/m)	0.4

Linear Expansion ($^{\circ}\text{C} \times 10^{-5}$)	8
Elongation at Break (%)	8
Strain at Yield (%)	2.5
Max. Operating Temp. ($^{\circ}\text{C}$)	70
Water Absorption (%)	0.3
Oxygen Index (%)	19
Volume Resistivity (log ohm.cm)	16
Dielectric Strength (MV/m)	20
Dissipation Factor 1kHz	0.008
Dielectric Constant 1kHz	2.7
HDT @ 0.45 MPa ($^{\circ}\text{C}$)	98
HDT @ 1.80 MPa ($^{\circ}\text{C}$)	89
Material. Drying hrs @ ($^{\circ}\text{C}$)	4 @ 90
Melting Temp. Range ($^{\circ}\text{C}$)	210– 240
Mould Shrinkage (%)	0.6
Mould Temp. Range ($^{\circ}\text{C}$)	40 – 80

5. Mesh:

The imported V tail model is subjected for meshing for the mesh size of 5mm. the generated nodes and elements are 445791 and 281002 respectively.

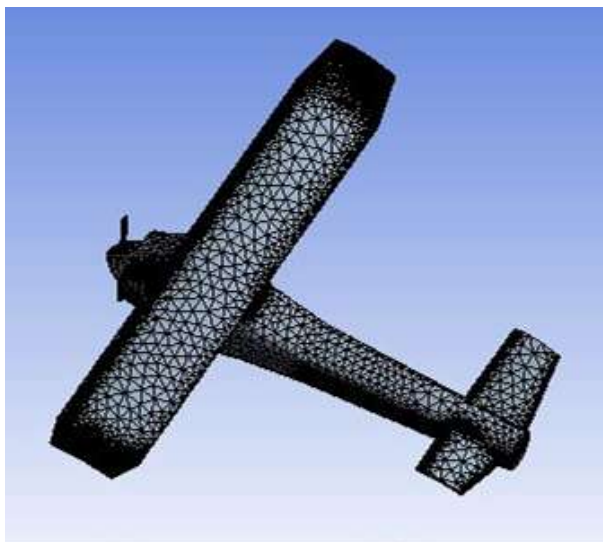


Fig 6: Meshing

6. Boundary Condition:

For the structural analysis over the wing we have applied 20 N force is applying on the wing , the desired von misses and strain have produced , the stress produced over the wing membrane is less compared with yield strength of the ABS material so the design is safe.

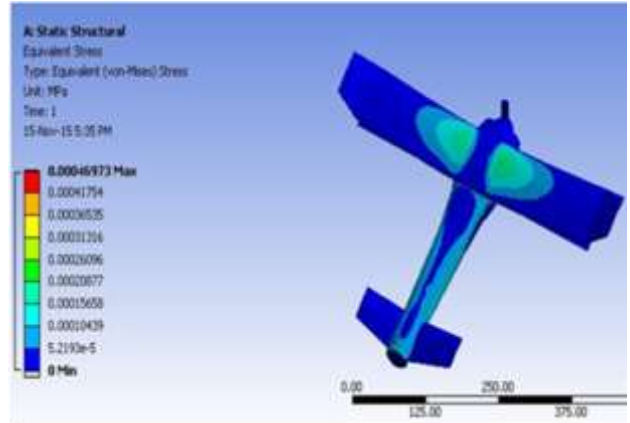


Fig 7: Von misses Stress

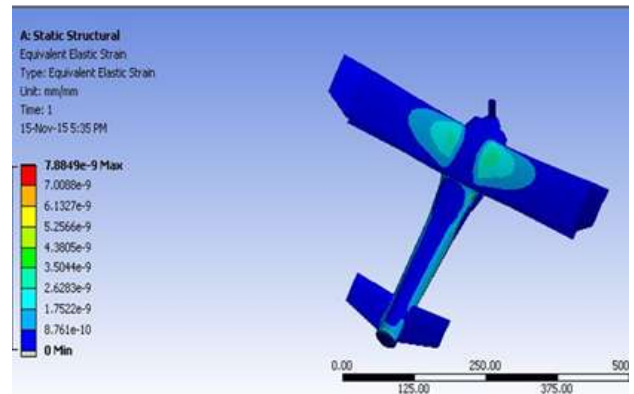


Fig 8: Von- misses Strain

7. Rapid prototyping:

The model has been fabricated through FDM Technique using ABS material.

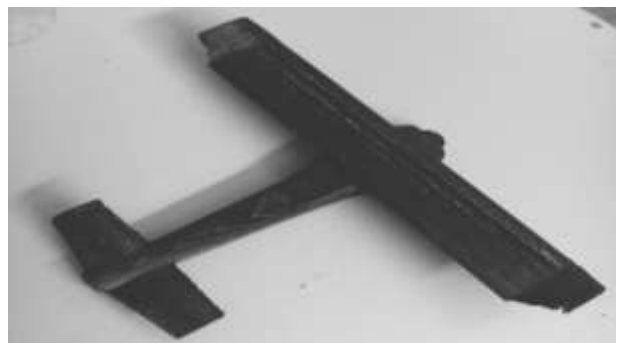


Fig 9: Fabricated V-Tail UAV through 3DP

V. FUTURE WORK

In future the model will be developing in the composite material to add more strength as per the battlefield usage. In V-Tail section satellite radio/video transmitter will be fixed to make the visible and audible from the ground, they could be used for military applications, such as aerial reconnaissance without alerting the enemies that they are under surveillance.

Special type of cameras will be boarded in the aircraft such as sonar cameras thermal cameras which helps by detecting mines and underground building and there are many future improvements are going to be included in it.

VI. CONCLUSION

The developed V tail model has developed with proper design parameters within the design limits and also fabricated in lightweight ABS material and high strength material to withstand maximum payload capacity of 2 kg the design what is made is airworthy and easy to handle for surveillance application.

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