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Modelling and Finite Element Analysis of Aircraft Vertical Stabilizer

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ABSTRACT: *An aircraft arrest the gravitational force with the help of either static or dynamic lift of an airfoil and also with the downward thrust of jet engines. The vertical stabilizers are typically found on the rear end of the aircraft body which is intended to reduce aerodynamic side slip and provide directional stability. It is a type of fin which provides stability while moving through any medium. In this paper, we develop the aero fin structure using the CAD implement (CREO) and for aero foil shape software being used is design foil, where we can directly imports coordinates into CREO, with this we can develop our model and then analyze the structure which is made of different materials with the CAE tool (ANSYS workbench fluent and static structural analysis). Our objective of the paper is to find the stresses on the fin structure i.e. on the vertical stabilizer and to find which material has fewer stresses and possess the better strength to weight ratio. Here we have considered a vertical stabilizer made of existing material Al 7075 and other materials like SiC, Ti 6 alloy). From the obtained results we can suggest which fin material composition would be better for aircraft model.*

KEYWORDS: Vertical Stabilizer, Aluminum Alloy, CREO, ANSYS

I. INTRODUCTION

The aircraft vertical tail is the aerodynamic surface that must provide sufficient directional equilibrium, stability, and control. These have streamlined cross-sections that are subject to aerodynamic forces and act as an aerofoil. The aerodynamic efficiency of an aero fin is expressed as its lift-to-drag ratio. Lesser the aspect ratio more the drag force is experienced on the aerofoil.

The tail of an airplane is called by various names, such as “empennage” and “stabilizer”. The chosen term is “stabilizer,” because it is at smallest partially descriptive of the component’s function An airplane’s tail design is significant because it stabilizes and controls the airplane in both up-and-down movements of pitch and side-to-side movements of yaw.

A common misconception is that, to generate lift, a wing must have a longer air path across its topside compared with its underside. Wings with this shape are the norm in subsonic flight, but symmetrically shaped wings (above and below) can generate lift by using a positive angle of attack to deflect air downward. Symmetrical airfoils have higher stalling speeds than cambered airfoils of the same wing area but are used in aerobatic aircraft[citation needed] as they provide practical performance whether the aircraft is upright or inverted. Another example comes from sailboats, where the sail is a thin membrane with no path-length difference between one side and the other.

The rudder is the aerodynamic control surface of the vertical tailplane. The most important parameters that characterize the aerodynamics of directional control (neglecting propeller and flap effects) in cruise conditions are the vertical tail aspect ratio, the ratio between the vertical tail span and the fuselage diameter at vertical tail aerodynamic center, and the horizontal tailplane position. The wing has a slight effect, because of its distance from the asymmetric flow field induced by the rudder.

Generally, the basic function of vertical preservative is that it provides directional static and dynamic stability also provides control and symmetry of the aircraft. It also provides steadiness in all instructions of aircraft. Without a vertical tail, it is not possible to design aircraft but it also costs moreover more on the other part of the design. This vertical tail end part contains of the rudder which inhabits most of the tail part, particularly in vertical zone. Basically, design standards for the vertical tail are mentioned in below points:

1. Provides mandatory directional and static stability to the complete aircraft section.
2. Provides essential dynamic stability to the total aircraft section when it is in equilibrium.
3. Also, planes with high tailplane angles of attack which grades from the oscillation produced by the rudder result in the deflection which leads to rapid failure of an engine.

II. LITERATURE REVIEW

A.P. Hettema deals with the various methodologies of vertical stabilizers which develops the complete rapid aerodynamic analysis which results in the required design of rear end of aircraft. Both conventional and unconventional aircraft configurations are explored for a design of aircraft vertical stabilizer. Already working designs are investigated and based on that the stability, control of conventional aircraft are developed and based on the effectivity, these required conditions and systems are implemented in the current aircraft designs.

Farrukh Mazhar deals with structural design methodology for the vertical tail of an Unmanned Aerial Vehicle. In this study, the application of computational methods in design is successfully explored. The strength and stiffness analysis of the UAV vertical stabilizer was performed using an FEA software ANSYS. The available CAD model and aerodynamic CFD analysis of the vehicle were used as design input. The aerodynamic loads were applied to the structure as pressure functions using a novel approach employing Artificial Neural Networks. Effects of variability in geometry, material, and lay-up were also analyzed to find the best possible combination with optimal strength and stiffness amid minimum weight and cost. The finally designed vertical stabilizer has main component ruder and other secondary components which are a composite structure.

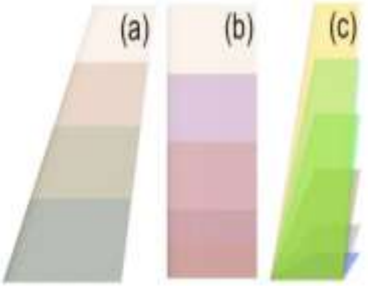
Yuvaraj SR, Subramaniam P deals with the structural design and analysis of vertical tail of an ultralight aircraft. The structural tail design involves the design calculations for the selection of airfoil, an area of the vertical tail, tail loading characteristics and weight of the vertical stabilizer. The design is done corresponding to the calculated values with the help of designing software CATIA and the analysis is done to show the structural deformations and stress for the applied loading conditions with the help of ANSYS 14.0. The objective of this project is to compare the results obtained for different materials like Al 7075-T651, SiC, Ti 6 alloy using analysis software. From the results, we will conclude which material is having better properties

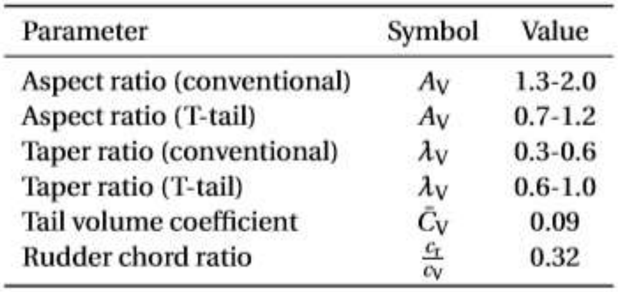
i. Tail Design Parameters:

The upward force of lift (acting from the center of pressure on the wings) is balanced by the downward forces of weight (acting from the center of gravity) and down force produced by the horizontal stabilizer. Without the down force applied by the horizontal stabilizer, the fact that the lift is behind the weight would cause the airplane to "want" to pitch down. The down force on the tail provided by the horizontal stabilizer is added to offset that downward pitching tendency.

III. METHODOLOGY

For the design of vertical tail, parameters which can be considered are aspect ratio; taper ratio and sweep are taken into account at the time of basic estimation of tail design. When considered over a larger variety of aircrafts these parameters vary slightly. For having a lower vertical tail aspect ratio, the heaviness applied on the horizontal tail over the top of vertical tail results in the reduction of pressure on the aircraft. Airfoils for the vertical tail can be of NACA type which can be applied as standard airfoil for stabilizers. Tail volume coefficient parameter is one the most important parameter which is to be considered during the design of tail. Increase in length of vertical tail affects the stability of the aircraft. CAD has been a major driving force for research in computational geometry, computer graphics (both hardware and software), and discrete differential geometry. The below are the various vertical tail families considered for design in CREO 4.0 & also various parameters for the vertical tail is mentioned below:





Parameter	Symbol	Value
Aspect ratio (conventional)	A_V	1.3-2.0
Aspect ratio (T-tail)	A_V	0.7-1.2
Taper ratio (conventional)	λ_V	0.3-0.6
Taper ratio (T-tail)	λ_V	0.6-1.0
Tail volume coefficient	$\bar{C}_V$	0.09
Rudder chord ratio	$\frac{c_r}{c_V}$	0.32

ii. Vertical Tail Design in CREO 4.0:

Below are the images grabbed from CREO: these are the two-dimensional layouts of Tail section,

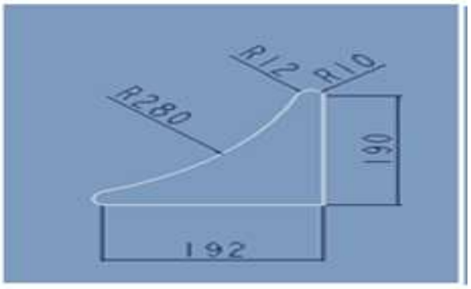


Fig. (a) Model 1

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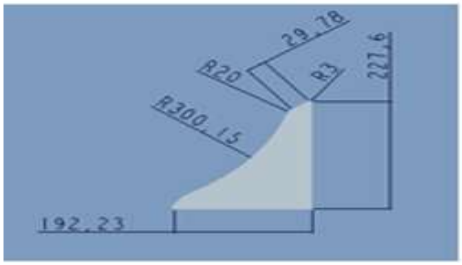

Fig. (a) Model 2

iii. Vertical Tail Analysis in FEA:

Finite Element Analysis, usually abbreviated as FEA, is a numerical method for problem solving of engineering. Typical areas of problematic contain structural analysis, heat transfer, fluid flow, mass transfer. To solve the problem, it subdivides a large problem into simplified parts known as finite fundamentals. The simple calculations that express these finite elements are then assembled into a better system of equations that models the whole problem. The snapshots below are regarding the various area of cross section considered for designing of an aero fin. (Figure: I, ii, iii). From this we can conclude that these three cross sections of aero fins are appropriate for the comparison:

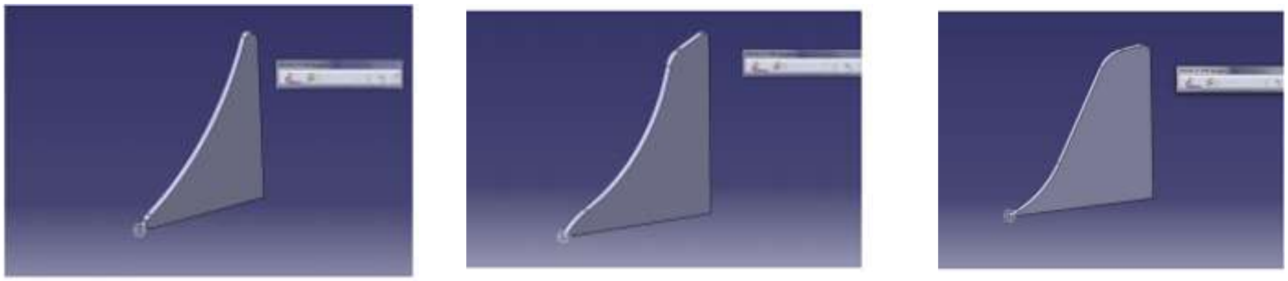

Fig: (i) Fig: (ii) Fig: (iii)

Fig. (a) Three Dimensional model of Aero fin

iv. Models of Aero Fin captured from Creo software:

Analysis of vertical stabilizer is performed in ANSYS with two different models and three different materials used (i.e. cross sections). And materials considered are Al 7075, SiC, Ti 6 alloy. Below are the snapshots of model one (1a, 1b, 1c) & model two (2a, 2b, 2c) :

For Aluminum Alloy 7075: (a) Total deformation (b) Von-mises Stress (C) Von-mises Strain

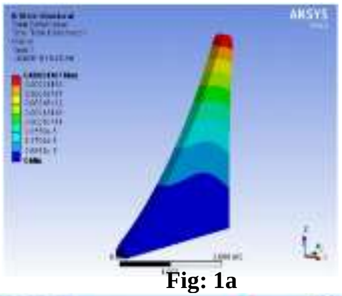

Fig: 1a

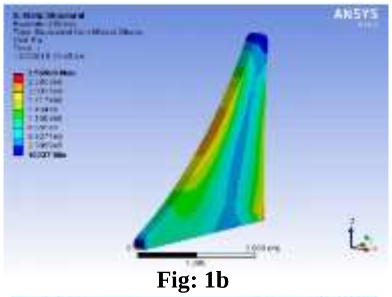

Fig: 1b

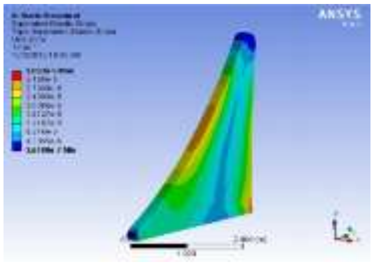

Fig: 1c

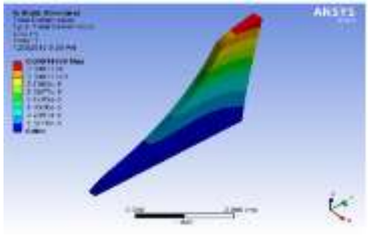

Fig: 2a

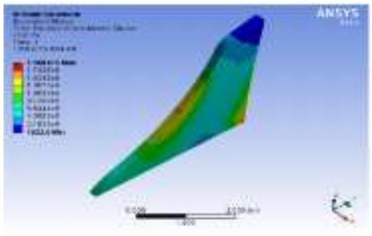

Fig: 2b

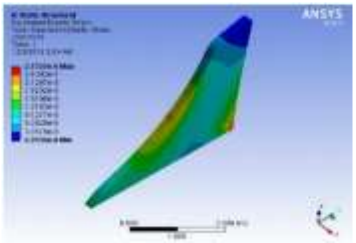

Fig: 2c

For Silicon Carbide Material: (a) Total deformation (b) Von-mises Stress (C) Von-mises Strain

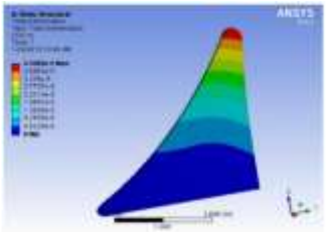
Fig: 1a

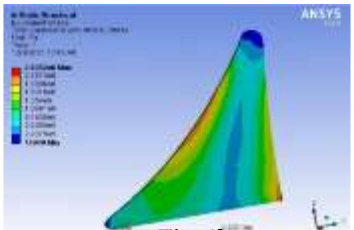
Fig: 1b

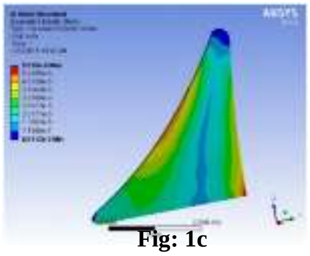
Fig: 1c

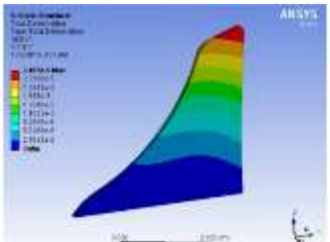
Fig: 2a

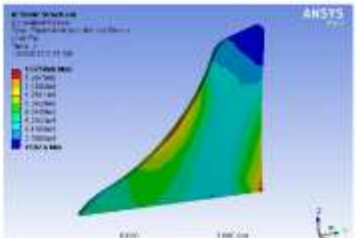
Fig: 2b

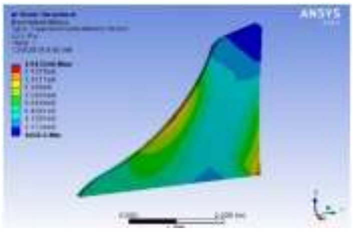
Fig: 2c

For Titanium 6 Alloy: (a) Total deformation (b) Von-mises Stress (C) Von-mises Strain

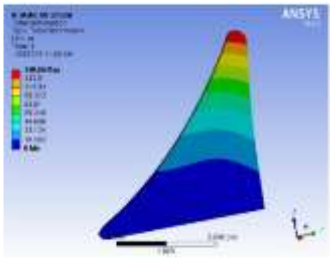
Fig: 1a

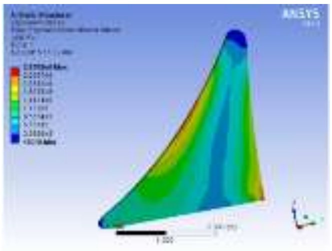
Fig: 1b

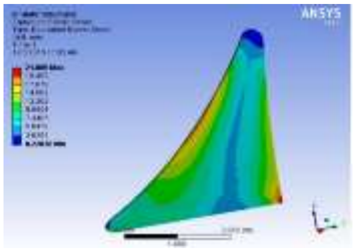
Fig: 1c

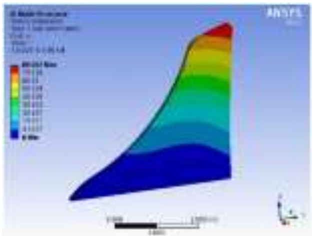
Fig: 2a

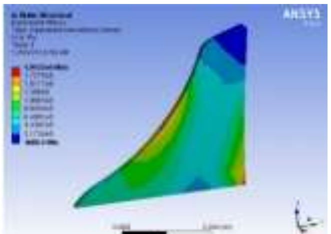
Fig: 2b

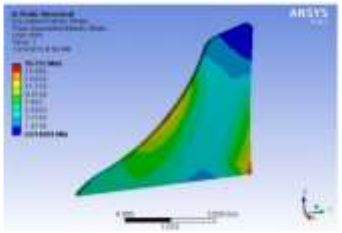
Fig: 2c

Results values of model one

Material	Stress		Strain		Total Deformation	
	Min	max	Min	Max	Min	max
AL 7075	15237	2.75E+06	3.65E-07	3.58E+05	0.00E+00	2.42E-04
SiC	14949	2.43E+06	6.91E-08	5.92E-08	0.00E+00	4.16E-05

T6	15226	2.54E+06	2.28E-01	21.889	0.00E+00	1.49E+02

Result Values for model two

Material	Stress		Strain		Total Deformation	
	Min	max	Min	Max	Min	max
AL 7075	1623	1.96E+06	2.29E+08	2.73E+05	0.00E+00	1.46E-04
SiC	1583	1.88E+06	3.87E-09	4.58E-06	0.00E+00	2.49E-05
T6	1606	1.94E+06	1.40E-02	16.752	0.00E+00	8.97E+01

IV. CONCLUSION

In this paper, the aircraft vertical tail structure is considered for the detailed analysis. In this approach, we are considering 2 different models with 3 different materials for analysis & the stresses & deformations obtained in each case is studied. In this thesis, we have considered the original model as model – 1 and other modification model is done to the basic original model. From the results obtained in the analysis we can conclude that the stress (2.43E+06) and strain (5.92E-06) and total deformation (4.16E-05) obtained for material silicon carbide is less, with this we can conclude that the material with SiC is the best material for the aero fin in the model - 1 By observing static analysis of ultra-light trainer vertical tail structure, we can say that the less stress value is obtained for silicon carbide material slag compared with aluminum alloy 7075 and Titanium 6 alloy. Hence silicon carbide strength and increased strength to weight ratio. So it can be concluded that silicon carbide BLF slag is better material for the ultra-light trainer aircraft vertical tail section.

V.REFRENCES

[1]. Design optimization of fin blades of cargo aeroplanes J.S Manikanta, Bikkavolu Joga Rao December 2015, India.
[2]. Design and Structural Analysis of the fuselage & rudder component Mohamed Hamdan A Nithiyakaly ni S.
[3]. Structural design of an aero fuselage using finite element method Farrukh Mazhar.
[4]. Achyutha Krishna Rao K, Akash Mohanty and Shiva Rama Krishna, A Finite Element Modeling And Analysis Of Fuselage Stiffened Panel Subjected To Cabin Pressurization, ICAMB 2012, and Jan 9-11, 2012.
[5]. Srirangam.k, Kumar .r stress analysis and fatigue life prediction of the wing-fuselage lug joint attachment bracket of a transport aircraft, eissn: 2319-1163 | pissn: 2321-7308.
[6]. A.Rukesh Reddy, 2, P. Ramesh, B. Siddeswararao, Stress Analysis of Splice Joint of the Aircraft Bottom Wing Skin by Finite Element Method International Journal of Computational Engineering Research, Volume 03, Issue, 11.
[7]. Marco Aurelio Rossi, SérgioFrascino Müller de Almeida DESIGN AND ANALYSIS OF A COMPOSITE FUSELAGE.2009 Brazilian Symposium on Aerospace Eng. & Applications September 14-16, 2009, S. J. Campos, SP, Brazil.
[8]. MarampalliShilpa*, M. Venkateshwara Reddy, Dr. A. Siva Kumar Design & Analysis of Fuselage Structure Page 1593 using Solid works& ANSYS ISSN: 2277-9655 September 2014.