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Design and Structural Analysis of Delta Wing (Composite) Payload of Light Combat Aircraft

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ABSTRACT

Need of light combat aircraft in Indian aviation lead is the development of tailless compound delta wing, single engine, aircraft Tejas. Tejas employs CFC (carbon fiber composites) up to 45% of its airframe including fuselage (doors and skins), wings (skin, spars, and ribs) elevons, tailfins, rudder, airbrakers, and landing gear doors. Here present study involves a design and analysis (linear static structural) of compound delta wing of LCA which serves multiple functions such as integral fuel tanks, analysis also extended up to the consideration of bounding due to presence of various armaments such as missiles.

Aero elastic problem arises in an aircraft structural due to continuous interaction between aerodynamic forces, inertial forces and elastic forces. Wing flutter is one of the major dynamic aero elastic problem which leads to catastrophic failure of structure. The aerodynamic forces acting on the wing vary accordance with altitude i.e. density and flight speed which contributes to wing flutter. The objective of this project is to predict the structural stability of delta wing with pay loads. Delta wing model is drafted using modeling software CATIA V5 and structural analysis is carried out using HYPERMESH and NASTRAN PATRAN. The resulting structural deformation and stress is studied completely and validated with the help of numerical analysis.

INTRODUCTION

The light combat aircraft is used as a fighter aircraft mainly, because now a day the light combat aircraft plays an important role in the field of defence. As the name indicated the light combat aircraft have only less weight if compared with the others, and possessing good maneuverability during flight. The light combat aircraft have high maneuverability due to light weight, and the composite structure gives the better performance against all types of loads over all other materials i.e. the composite material and combat aircraft combination have so many advantages over other models, also they have some disadvantages also. Because of the advantages of delta wings now a day everyone uses the delta wing in fighter aircraft. For an example HAL Tejas, Mirage series and Mig series.

A fighter aircraft is a military aircraft designed primarily for air-to-air combat against other aircraft, as opposed to bombers and attack aircraft, whose main mission is to attack ground targets. The hallmarks of a fighter are its speed, manoeuvrability, and small size relative to other combat aircraft.

Many fighters have secondary ground-attack capabilities, and some are designed as dual-purpose fighter-bombers; often aircraft that do not fulfil the standard definition are called fighters. This may be for political or national security reasons, for advertising purposes, or other reasons. A fighter's main purpose is to establish air superiority over a battlefield.

Figure 01 - Delta Wing Aircraft

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LITERATURE SURVEY

Design And Structural Analysis Of Delta Wing Payloads Of Light Combat Aircraft (Tejas)

Shaik Shama Sultana, Y.N.V.Santosh Kumar, Shaik Azmatullah Rahaman

Now a days, in such advanced world where the technology has tremendously increased. Need of aircrafts in the field of defense aviation has increased a lot which lead to the development of the light combat fighter aircrafts. This concept let us to design and analyze the delta wing payloads of tailless compound delta-wing indigenous 4th generation aircraft (TEJAS). It includes design of supersonic delta wing with customized airfoil according to the aircraft performance requirements, and integrates technologies such as relaxed static stability, fly-by-wire flight control system, multi-mode radar, integrated digital avionics system, composite material structures, and a flat rated engine. It is supersonic and highly maneuverable, and is the smallest and lightest in its class of contemporary combat aircraft. The delta wing structure is designed using catia software, which includes payloads such as drop tanks and missiles. Meshing is done in hyper mesh and static analyses of the delta wing payloads by including weights in different cases are analyzed.

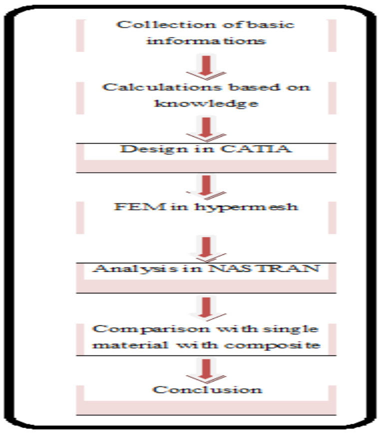
Structural Design Of Delta Wings Of An Executive Supersonic Airplane

Joao Marcelo de Castro Monteiro, Flavio Luiz de Silva Bussamra

The technology of composites has been more and more acknowledged these days, with an ever-increasing study of its behaviour, properties and applications. Following this tendency, this work presents the preliminary structural design of supersonic executive delta wings.

This is a jet aircraft with wingspan of about 18 m. Two types of primary structure are analysed: one made of carbon fiber and another of aluminium. Several models of finite elements have been created to help the conceptions and analyses of the primary structures in order to obtain initial proposals with low weight. Tension and stability criteria were checked in both solutions. The results are presented, compared and discussed.

Methodology



PREPROCESSING

Generation Of Airfoil

Selection of airfoil is an important thing in the design of aircraft wing. The shape of wing is based on the shape of aerofoil. So we should aware about all the extreme limits of aircraft in the base of loads and stresses. Designing a new aerofoil coordinate for our design is difficult, so we are selecting an existing shape of aerofoil. Here we are using NACA 64-A-204 type aerofoil. The general coordinate of the aerofoil is available so we can import these coordinate in to an excel sheet. Then following the basic procedures we get our aerofoil in CATIA.

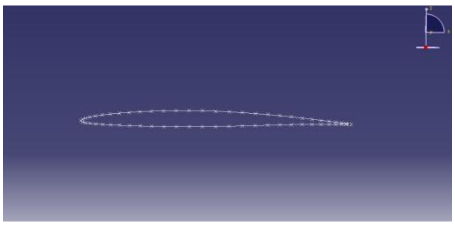


Figure 2 - Naca 64-A-204

Analysis

The structural analysis of delta wing is carried out by using MSC Nastran software. MSC Nastran to ensure structural systems have the necessary strength, stiffness, and life to preclude failure (excess stresses, resonance, buckling, or detrimental deformations) that may compromise structural function and safety. MSC Nastran is also used to improve the economy and passenger comfort of structural designs. It is a finite element analysis program. It is also used for static, dynamic and thermal analysis across linear and non-linear domains. The analysis of delta wing is based on two ways, i.e. first we assign only one single material to whole wing and analyses it. Then we assign composite material to the same wing and analyses it. The comparison of each analysis will give the final result of our study.

Delta Wing With Aluminium Alloy

In the case of single material we are using aluminum alloy (aa2024 t6). And we give 2.5mm thickness to wing and 20mm thickness to spar and ribs. The mechanical properties of material are given below.

TABLE 15 - MATERIAL PROPERTIES OF AA2024-T6

MATERIAL	AA 2024-T6
ULTIMATE TENSILE STENGTH	427 MPa
SHEAR STRENGTH	283 MPa
DENSITY	2.79 E-6 Kg/mm³
YOUNGS MODULUS	72400 MPa
POISSON'S RATIO	0.33

The analysis of delta wing gives maximum and minimum displacements, von-mises stress, maximum principal stress, and maximum shear stress.

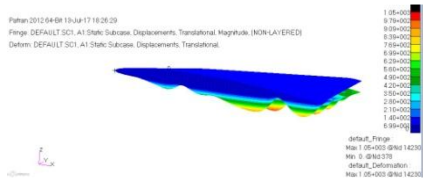


Figure 3 - Displacement Of Wing With Al

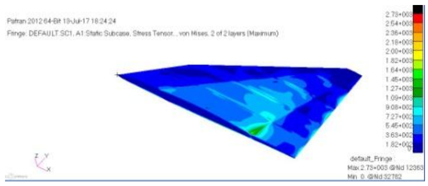


Figure 20 - Von Mises Stress Of Al Wing

Table 16 - Result Table Of Delta Wing With Aluminium Alloy

Displacement	1.03e3 mm
Von-mises stress	2.73e3 MPa
Maximum principal stress	2.63e3 MPa
Maximum shear stress	1.53e3 MPa

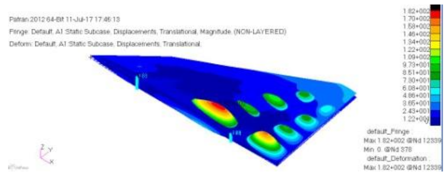


Figure 4 - Overall Displacement Of Composite Delta Wing

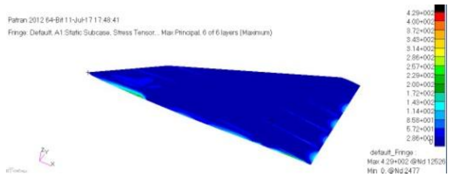


Figure 5 - Maximum Principal Stress Of Composite Delta Wing

Table 17 - Result Table For Composite Delta Wing

Displacement	182 mm
Von-mises stress	3.76e2 MPa
Maximum principal stress	4.29e2 MPa
Maximum shear stress	2.14e2 MPa

Lower Skin - Layer 1

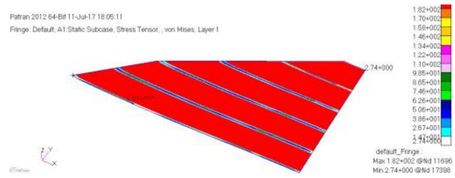


Figure 6 – Von-Mises Stress Lower Surface Layer-1

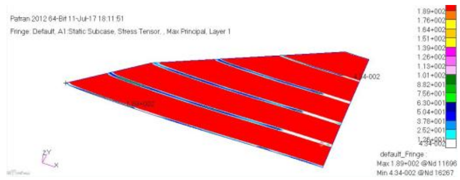


Figure 7 - Maximum Principal Stress Lower Surface Layer-1

5.2.3 Lower Skin - Layer 2

Figure 8 - Von Mises Stress Lower Surface Layer-2

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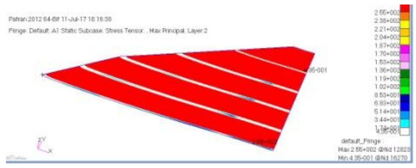

Figure 9 -Maximum Principal Stress Lower Surface Layer-2

Lower Skin – Layer 3

Lower Skin – Layer 4

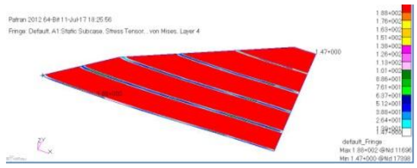

Figure 10 - Von Mises Stress Lower Surface Layer-4

upper skin – layer 2

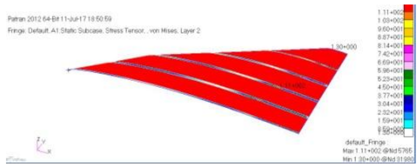

Figure 11 - Von Mises Stress Upper Surface Layer-2

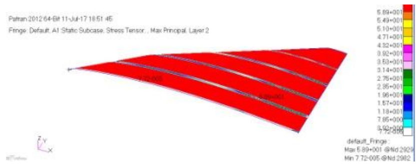

Figure 12 - Maximum Principal Stress Upper Surface Layer-2

upper skin – layer 3

Figure 13 - Von Mises Stress Upper Surface Layer-3

upper skin – layer 4

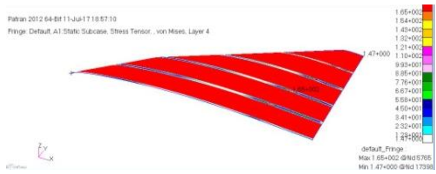

Figure 14 - Von Mises Stress Upper Surface Layer-4

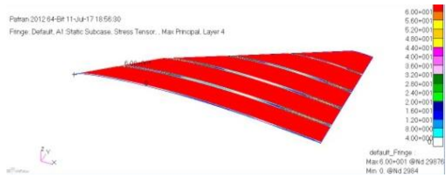

Figure 15 - Maximum Principal Stress Upper Surface Layer-4

Ribs – Layer 1

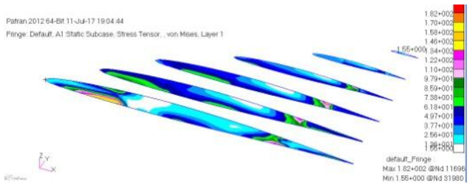

Figure 16 - Von Mises Stress, Rib Layer-1

Ribs – Layer 2

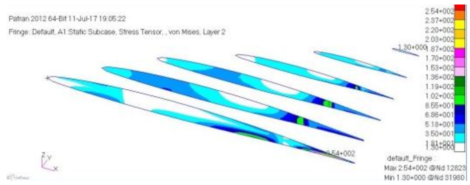

Figure 17 - Von Mises Stress, Rib Layer-2

Ribs – Layer 4

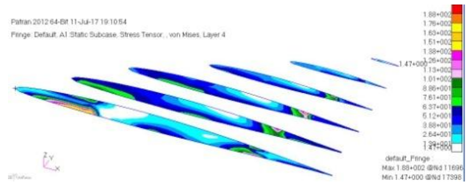

Figure 18 - Von Mises Stress, Rib Layer-4

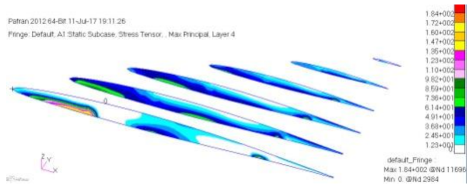

Figure 19 - Maximum Shear Stress, Rib Layer-4

Rib Overall

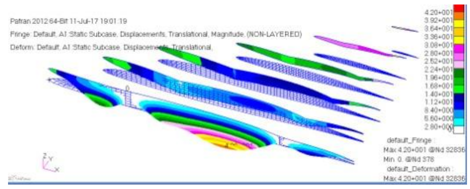

Figure 20 – Displacement, Rib Over All

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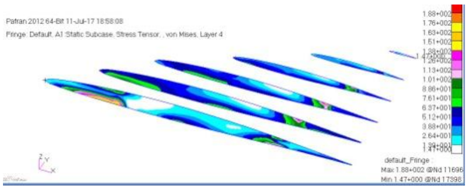

Figure 21 - Von Mises Stress, Rib Over All

Table 1 - Result Table Of Rib With Composite Material

Rib	Over all	Layer 1	Layer 2	Layer 3	Layer 4
Displacement mm	42				
Von mises stress. MPa	188	182	254	257	188
Maximum principal stress. MPa	184	189	89.3	255	95.9
Maximum shear stress. MPa	95.9	94.4	128	131	184

Spar

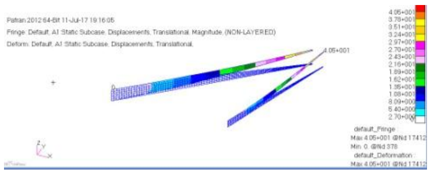

Figure 22 – Displacement Of Spar

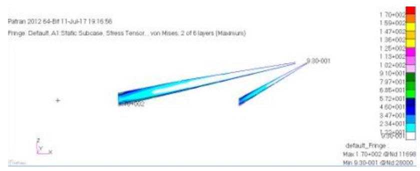

Figure 23 - Von Mises Stress Of Spar

Table 2 - Result Table Of Spar

Displacement	40.5 mm
Von mises stress	170 MPa
Maximum principal stress	182 MPa
Maximum shear stress	95.8 MPa

CONCLUSION

From the analysis result table and the general information regarding the material properties are explain that the wing with aluminium alloy is not a possible option for a light combat wing. Because the wing is not sufficient for carry the load acting in the wing. If we try to make a wing with single material it not comes under the category of light combat aircraft. And assigning more materials increases the wing weight, and also to carry the whole weight of aircraft we have to give extra number of spars and ribs. And also more number of stringers.

For composite materials, have an ability to with stand more weight with in small material limits. Because of good strength to weight ratio and high load withstandibility now a day every one promotes composite materials for aircraft design. And the composite material satisfies the light weight of aircraft.

My conclusion and study result are this, composite material is more efficient that single alloy for an aircraft wing design. This can satisfy all loading conditions on aircraft wing. And it is very useful in LCA. It overcomes all the drawbacks of single materials. But it is true that the design is very difficult than a single material.

FUTURE PLAN

Now a days the fighter aircraft aircrafts are designed in the basis of high maneuverability because more efficient in fight will survive a long. Now we designed a 6g aircraft but presently 8g are available in the world.

My future scope is to design a wing which is more efficient and that can maneuver at 8g conditions with full composite materials. Add more stiffeners to carry more weights.

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