ISSN No.: 2455-6130
Volume 4, Issue 4, 2020, pp. 06-11

website: www.ijoetr.com

International Journal of Emerging Trends in Research

Modeling and Structural Analysis of Aircraft Wing

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Abstract

Aircraft wing is the main component which produces LIFT required for the Aircraft to take-off. So, the maximum amount of load will be acted upon WING section of an aircraft. So, the WING must be designed in such a way that it can withstand the load acting upon it. For this withstanding capability the internal parts i.e. STRINGERS, RIBS etc., must withstand the load acting upon the WING. The material that is required to withstand this capability must withstand the maximum amount of load acting on the WING. So, in order to know the withstanding capacity of the material used, STRESS analysis were made upon two different materials CFRP[Carbon Fiber Reinforced Polymer] and Titanium alloy , as these are most preferred materials used to construct the major portion of WING. Therefore the STRESS analysis, Maximum deformation analysis was made on the parts made up of these materials and the results are determined.

Keywords: Structural Analysis; Airfoil; Wing

1. Introduction

A number of parts which work together to make an air craft worthy to fly. These parts have their own unique function and design the various structures work together to create lift. The different parts of the aircraft which are movable cause it to turn, ascend or descend by varying the direction and lift on the wing.

1.1 Wing

Wings play a key role in wing design. Wings generate the lift required to keep Airplanes in the air. Lift occurs as the plane is pushed through the air. The top part of the wing is curved while the bottom is straight. This causes the air on top to move faster. The When the air move faster on the top of wing crates low pressure that lift while higher pressure acts on the bottom of the wing.

During wing design, wings play an important role. They generate the lift that requires to keep aircraft inn flying. As the aircraft is pushed through the air lift occurs. The wing has top parts covered whereas the bottom is straight.

Figure 1: Aircraft Wings

1.2. Material Properties

Titanium alloy:-

a. Young's modulus (E) → 96,000 Mpa [Mega Pascal]

b. Poison's ratio (μ) → 0.36

c. Density (ρ) → 4.5 mg/m^3

Carbon Fiber Reinforced Polymer [CFRP]:-

Young's modulus (E) → 1,500 Mpa [Mega Pascal]

Poison's ratio (μ) → 0.28

Density (ρ) → 1.5 mg/m^3

Aircraft Specifications

Dimensions

Overall length 72.72 m

Cabin length 49.90 m

Fuselage width 7.14 m

Max cabin width Main deck: 6.5 m

Upper deck: 5.8 m

Wing span (geometric) 79.75 m

Height 24.09 m

Track 14.34 m

Wheelbase 31.88 m

1.3 Wing Design Procedure Using CATIA:

Steps:

1. Entering coordinates
2. Joining points with spline
3. Multi-section solids

Generic Steps to Solving Any Problem in ANSYS:

1. It is essential to solve any problem analytically it requires to define (1) Our solution domain (2) The physical model (3) Boundary conditions and (4) The physical properties. Then problem is solved and thereby present the results.

2. While solving the problem numerically the main difference in extra step is called mesh generation. In this step a complex model is divided into small elements that in an otherwise too complex situation following in the described terminology which more attune to software.

Build Geometry:-

A model is constructed which is representation of the 2 or 3D object which is later tested using the work plane coordinate system in ANSYS.

Define Material Properties:-

As the parts exists, a library of necessary material is defined and composed an object which being modelled. The thermal and mechanical properties are included in the process.

Generate Mesh:-

The makeup of the part is understood by the ANSYS. Now, at this point how the model system should be broken down in to finite piece should be defined.

Apply Pressure:-

Now, as the system is fully designed the last task is to burden the system with constraints like physical loadings or boundary conditions.

Obtain Solution:-

This step is required as ANSYS need to understand at what state (steady state or transient state etc.). The problem must be solved.

Present the Results:-

After obtaining the solution there are number of ways to present ANSYS results selected from many options such as tables, graphs and contour lots.

1.4 Specific Capabilities of Ansys

1. **Structural:-**

Finite element method is commonly applied for structural analysis most commonly used for bridges and buildings, naval, aeronautical and mechanical structure e.g. Ship hulls, aeroplane and machines housing. It is also applied for mechanical components such as piston, machine parts, tools, static analysis is used to determine displacement, stresses etc. under static conditions.

Both linear and nonlinear static analysis can be computed by ANSYS. Non linearity may include, stress stiffness, large deflection, large strain, plasticity, hyper elasticity, contact surface and creep.

2. Static Analysis:-

A static analysis includes the calculation of the effects of steady loading conditions on a structure by ignoring inertia and damping effects like those caused by time varying loads. It can also include steady inertia loads (such as gravity and rotational velocity) and varying loads that can be approximate as static equivalent loads (such as the static equivalent winds and seismic load, commonly defined in many building codes).

2. Structural and Static Analysis of Wing:-

Procedure for Analysis:-

Open ANSYS workbench 16.0

Step 1: Preferences Structural and Thermal

After the Solid Model in ANSYS, Choose the preference as structural and thermal then close the menu.

Step 2: Analysis type Select static structural

1. Static structural
2. Engineering data [Properties of selected material]
3. Geometry [Import the geometry]
4. Model [To generate MESH]
5. Setup [apply loads and pressure]
6. Solution
7. Results

Step 3: Save Results

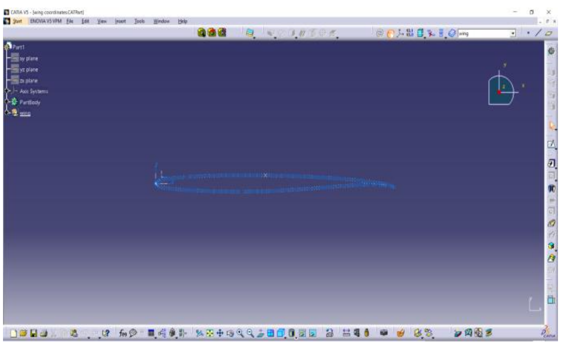

Figure 1. Graphic area on CATIA

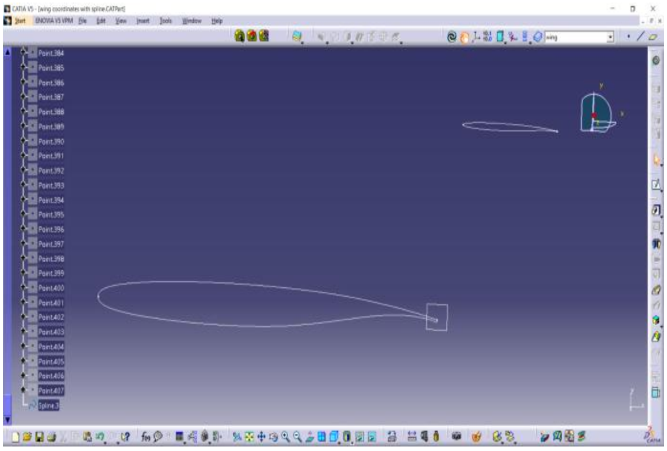

Figure 2. D Sketch of Wing

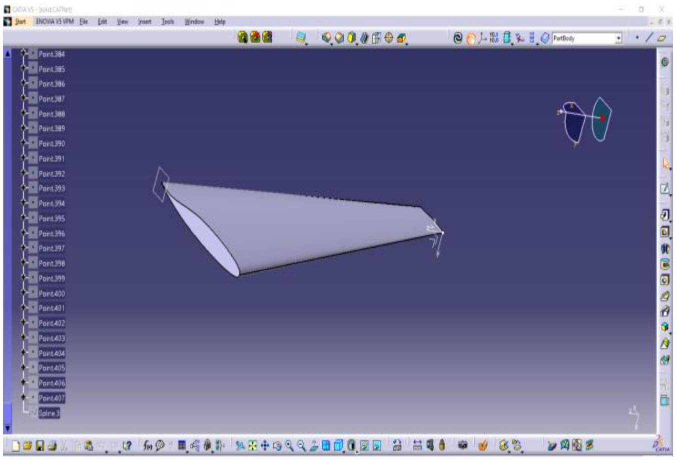

Figure 3. D Model of Wing

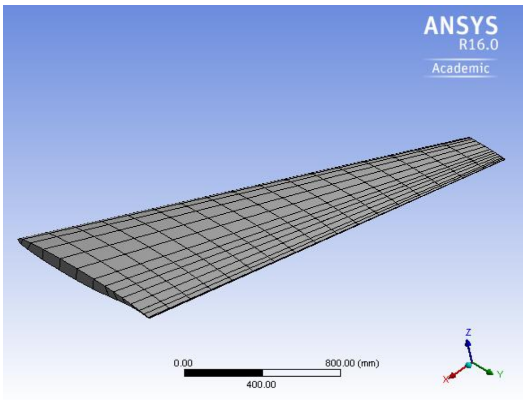

Figure 4. Meshed model of Wing

3. Conclusions

Based on the data obtained from the above analysis we can say that Titanium alloy is more preferable for internal structures as the density of Titanium alloy has more density than the CFRP.

CFRP is more preferable is for external structures as the maximum stress that CFRP allows is more than that of the Titanium alloy.

Material used	**Von mises stress**	**Density (ρ)**
Titanium alloy	990.84 MPa [Mega Pascal]	4.5 mg/m^3
Carbon Fiber Reinforced Polymer [CFRP]	993.35 MPa [Mega Pascal]	1.5 mg/m^3

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