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MODELING AND STRUCTURAL ANALYSIS OF AIRCRAFT WING USING COMPOSITE MATERIAL

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***Abstract* – Aircraft Wing structure consists of skin, ribs and spar sections. The spar carries flight loads and the weight of the wings while on the ground. Other structural and forming members such as ribs are attached to the spars, with stressed skin. The wings are the most important lift producing part of the aircraft. The design of wings may vary according to the type of aircraft and its purpose. Experimental testing of wing structure is more expensive and time consuming process. In this project detailed design of aircraft wing structure made by using CATIA V5 R20. Then structural analysis of the wing structure is carried out to compute the stresses at wing structure. The stresses are estimated by using the finite element approach with the help of ANSYS-14.5 In static analysis find out the Stresses, strains, shear stress, total deformations of the structure and dynamic analysis find out the frequencies and different total deformations using different materials AL 7075 T6 , AL-ZN-MG-ALLOY 7178, CARBON FIBER, TITANIUM ALLOY 10V-2Fe-3Al,Kevlar finally concluded the suitable material for the air craft wing .**

***Keywords* – Aircraft, wing, static, modal, catia, stress, total deformation, Ansys**

1. INTRODUCTION

In an aircraft wing structure ribs and spars are provided to support and give rigidity to the wing section. Although the major focus of structural design in the early development of aircraft was on strength, now structural designers also deal with fail-safety, fatigue, corrosion, maintenance and inspect ability, and productability. The wings are airfoil attached to each side of the fuselage and are the main lifting surfaces that support the airplane in flight. There are numerous wing design, size and shape were used by the various manufacturers. Each fulfils a certain need with respect to the expected performance for the particular airplane. Wings may be attached at the top, middle, or lower portion of the fuselage. These designs are referred to as high wing, mid wing and low wing configurations respectively. The number of wings can also vary, an Airplane with a single set of wing is referred as a monoplane, while those with two sets called biplane. Many high-wing airplanes have external braces or wing struts which transmit the flight and landing loads through the struts to the main fuselage structure. Since the wing struts are usually attached approximately halfway out on the wing, this type of wing structure is called semi-cantilever. A few high-wing and most low-wing airplanes have a full cantilever wing designed to carry the loads without external struts. Modern aircraft structures are designed using a semi-monocoque concept. A basic load-carrying shell reinforced by frames and longerons in the bodies, and a skin-stringer construction supported by spars and ribs in the surfaces. Proper stress levels, a very complex problem in highly redundant structures, are calculated using versatile computer matrix methods to solve for detailed internal loads.

2. LITERATURE REVIEW

The purpose of the literature survey is to study the works of different researchers concerned with the detailed study of the air craft wing design. Also to find out the scope for any new methods of design by which the design process is made simple, robust, less time consuming and cost effective. The literature survey is entirely based on the previous research methods. It is desired to explore the application of the fundamental properties such as vibration which plays an important role in the failure of the structure. Hence the literature survey is carried out emphasizing the structural design of the aircraft wing subjected to vibration.

K. Sruthi, T. Lakshmana Kishore, M. Komaleswara Rao[1], This paper deals with the reduction of weight ratio in the wing structure improves the efficiency and performance of an aircraft wing. Amongst all the aircraft parts reduction in the weight of the wing has got higher importance A suitable wing profile NACA 4412 is selected and modelled in CATIAV5 R20. The generated wing profile is imported to ANSYS WORKBENCH. Static structural analysis is carried out in ANSYS by inputting the properties of the optimum specimen which are obtained experimentally. Similarly by in putting pure AL25 properties. The results obtained from ANSYS for pure AL25 and metal matrix composite (SiC) are compared. By comparing the results it is found that composite material has better material properties and stresses than pure aluminium.

3. PROJECT OVER VIEW AND METHODOLOGY

3.1 PROJECT OVER VIEW

1. Have sufficient mechanical strength and stiffness of integral aircraft wing.

2. Can effectively shape design of the aircraft wing

3. Apply the lift and drag forces on structure

OBJECTIVE OF THE PROJECT:

1. Modeling of the aircraft wing using Catia software

2. Determination of linear stresses, strains, deformations, shear stresses and deformation using structural analysis ,on these materials **AL 7075 T6 ,AL-ZN-MG-ALLOY 7178, ALIMINIUM LITHIUM A8090, CARBON FIBER ,TITANIUM ALLOY 10V-2Fe-3Al , ALPHA BETA TITANIUM ALLOY, Al 5052-H32 0.097**

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3.2 LOADS ACTING OVER THE WING STRUCTURE:

- Lift load is considered as important criteria while designing an aircraft. Fuselage and wings are the two main regions where lift load acting in an aircraft. Here 80% of the lift load is acted on the wings (i.e., maximum lift load is acted on the wings) and remaining 20% in acted on the fuselage. Therefore in wings the maximum load is acted nearer to the wing roots.

- **DIMENSIONS OF THE AIRCRAFT WING:**

Wing Span		4500mm
Chord Length		1000mm
Airfoil		BOEING BACXXX
Taper Ratio		1
Sweep Angle		0°
Ribs Design	Root and Tip Thickness	40mm
	Other Ribs	20mm
Spars	Length	4500mm
	Thickness	60mm

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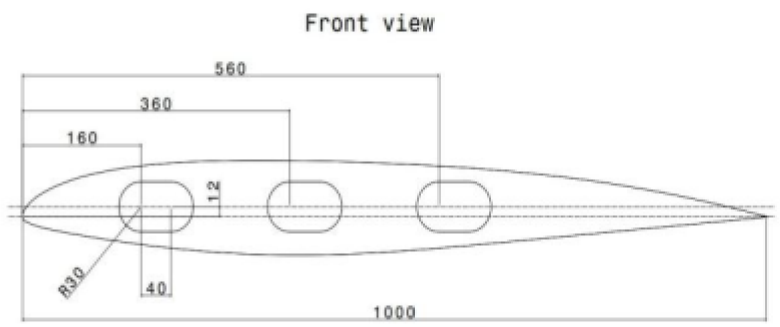
PROCEDURE OF GEOMETRY AND MODELLING

Firstly, to have a very smooth curved line of BOEING BACXXX airfoil,the point co-ordinates were exported from the airfoil tools and UIUC airfoil Coordinates Database. It is much accurate compared to sketching the curved line of BOEING BACXXX airfoil.. The first step is to get the airfoil shape in the CATIA workbench. As we are considering that wing is designed with only one airfoil throughout, it has to be scaled down accordingly to getthe required shape of awing profile

- **Coordinate points taken from the existing Naca table**

- Secondly, spars and holes are sketched at the front plane. The dimensions of main spars, secondary spars, and holes are shown in figure below.



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- **Dimensions of front view**

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4. CHAPTER INTRODUCTION TO CATIA V5R20

4.1 INTRODUCTION

Welcome to **CATIA (Computer Aided Three Dimensional Interactive Application)**. As anew user of this software package, you will join hands with thousands of users of this high-end CAD/CAM/CAE tool worldwide. If you are already familiar with the previous releases, you can upgrade your designing skills with the tremendous improvement in this latest release.

4.1.2SKETCHER WORKBENCH**:**

The Sketcher workbench is a set of tools that helps you create and constrain 2D geometries. Features (pads, pockets, shafts, etc...) may then be created solids or modifications to solids using these 2D profiles. You can access the Sketcher workbench in various ways. Two simple ways are by using the top pull down menu (Start – Mechanical Design – Sketcher), or by selecting the Sketcher icon. When you enter the sketcher, CATIA requires that you choose a plane to sketch on. You can choose this plane either before or after you select the Sketcher icon. To exit the sketcher, select the Exit Workbench icon. The Sketcher workbench contains the following standard workbench specific toolbars.

• **Profile toolbar:** The commands located in this toolbar allow you to create simple geometries (rectangle, circle, line, etc...) and more complex geometries (profile, spline, etc...).

• **Operation toolbar:** Once a profile has been created, it can be modified using commands such as trim, mirror, chamfer, and other commands located in the Operation toolbar.

5.1 PROGRAM ORGANIZATION:

The ANSYS program is organized into two basic levels:

- Begin level
- Processor (or Routine) level

5.1.1MATERIAL MODELS:

ANSYS allows several different material models like:

· Linear elastic material models (isotropic, orthotropic, and anisotropic).

· Non-linear material models (hyper elastic, multi linear elastic, inelastic and

Visco elastic)

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LOADS: The word loads in ANSYS terminology includes boundary conditions and externally or internally applied forcing functions, as illustrated in Loads. Examples of loads in different disciplines are:

Structural: displacements, forces, pressures, temperatures (for thermal strain),Gravity.

Thermal: temperatures, heat flow rates, convections, internal heat generation,Infinite surface.

· Coupled-field loads are simply a special case of one of the above loads, where results from one analysis are used as loads in another analysis. For example, you can apply magnetic forces calculated in a magnetic field analysis as force loads in a structural analysis.

6.CHAPTER FINITE ELEMENT METHOD

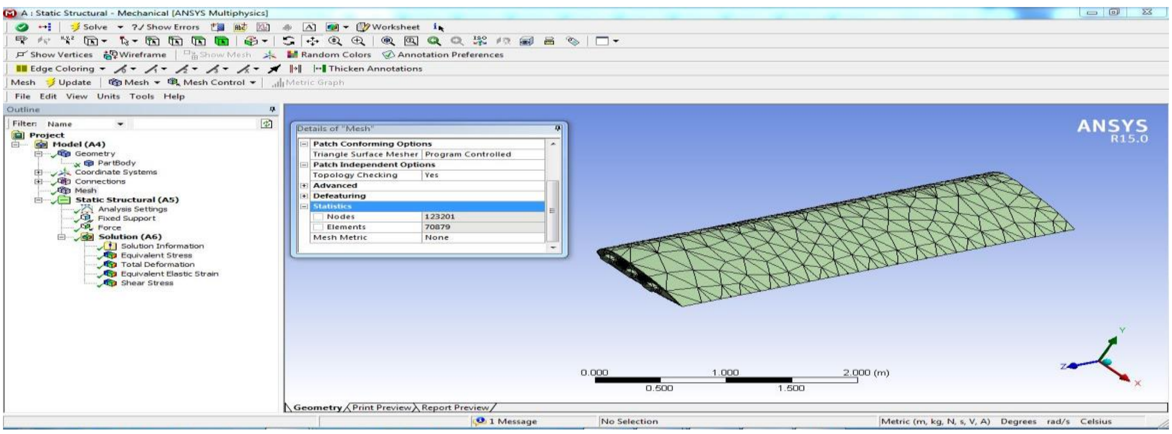
6.1 INTRODUCTION

The Basic concept in FEA is that the body or structure may be divided into smaller elements of finite dimensions called "Finite Elements". The original body or the structure is then considered as an assemblage of these elements connected at a finite number of joints called "Nodes" or "Nodal Points

6.2 STATIC STRUCTURAL ANALYSIS

The static structural analysis calculates the stresses, displacements, shear stress and forces in structures caused by a load that does not induce significant inertia and damping effects. Steady loading and response conditions are assumed; that the loads and the structure's response are assumed to change slowly with respect to time.

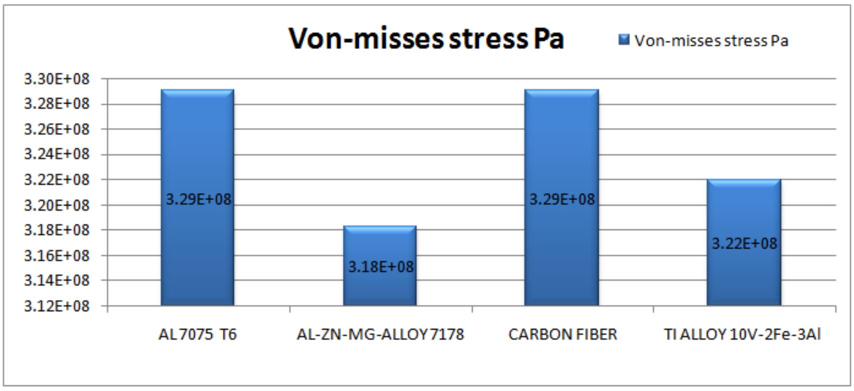
MESH:



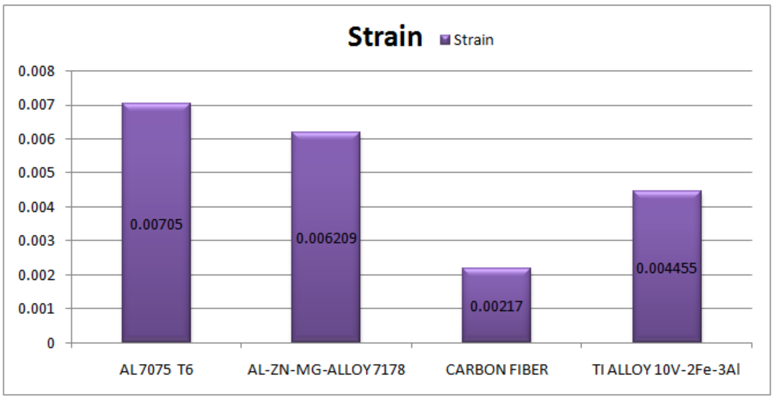
Mesh: Nodes:123201, Elements:70879

VON-MISSES STRESS GRAPH:

The below graph shows that Von-misses stresses of aircraft wing using various materials **AL 7075 T6 , AL-ZN-MG-ALLOY 7178, CARBON FIBER, TITANIUM ALLOY 10V-2Fe-3Al,** Finally least Von-misses stresses, carbon Fiber, **AL-ZN-MG-ALLOY 7178** compared to another materials as shown below graph.



Von-misses stress graph



MODAL ANLAYSIS:

Observed the Below results carbon fiber materials taken 3 modes At mode 1 Frequency 4.9047Hz and Deformation 0.0464mm and At mode 2 Frequency 29.375Hz and Deformation 0.0458mm and At mode 3 Frequency 30.408Hz and Deformation 0.0457mm.

8.CONCLUSION

Modelling and Static and modal analysis is done design process is done in Catia and analysis process in Ansys we are taking 3 different materials **AL 7075 T6 , AL-ZN-MG-ALLOY 7178, CARBON FIBER, TITANIUM ALLOY 10V-2Fe-3Al .**

- Static analysis is done on the wing by applying lift force on three materials. By observing the analysis results, the von-misses stress, strains, deformations, shear stresses are less for wing with ribs and spars of carbon fiber material than compared with another material.

Modal analysis is done on the aircraft wing to determine the frequencies. By observing the results, the frequencies are more for modified model but deformations are less. So the vibrations are more for modified model. The frequencies are less for carbon fiber when fixed with left side Observed carbon fiber materials taken 3 modes At mode 1 Frequency 4.9047Hz and Deformation 0.0464mm and At mode 2 Frequency 29.375Hz and Deformation 0.0458mm and At mode 3 Frequency 30.408Hz and Deformation 0.0457mm and

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