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Research Paper

MODELING AND STRUCTURAL ANALYSIS ON A300 FLIGHT WING BY USING ANSYS

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The A300 is currently the largest aircraft in commercial operation and one of the most advance planes in the world. Designs of airplanes depend on their wings for flight. The wing of a airplane is one of the most important and complicated elements of a design airplane. A wing is a type of fin with a surface that produces aerodynamic force for flight through the atmosphere. When a force acts on a body, the latter will of these forces are generated by the relative movement of the air compared to the plane. The first one is the lift. This force is directed upwards and is acting perpendicular to the displacement of the wing and second one is drag. It is exerted in the direction opposed to the displacement of the plane. In this conventional type of wing is used with two material, they are AL alloy and AL alloy 7068. Because of its versatility in many flight roles and situations. It is generally not limited to certain flying levels or airspeeds and is extremely useful. The main purpose of this project is to find out which material (AL alloy and Al alloy 7068) is best suited for making wing of flight. In this the CAD model of A300 wing with spares and ribs using the modelling software CATIA V5 R20 and later we made modelling and structural analysis on wing Skelton structure by using ANSYS WORKBENCH.

Keywords: A300 flight, Conventional type wing, Aluminum alloy, Aluminum alloy 7068, Model and static structural analysis

INTRODUCTION

There are a variety of parts that work together to make an airplane fly. While they all are unique in function and design, the different structures all work to create lift. The different movable parts of the airplane cause the airplane to turn, climb or descend by changing the direction of lift on the wings.

Fuselage

The fuselage is the main body of the aircraft that houses the passengers, flight crew and luggage. Some airplanes carry the fuel in the fuselage; others carry it in the wings.

Wing

Wings play a key role in wing design. Wings generate the lift required to keep airplanes in

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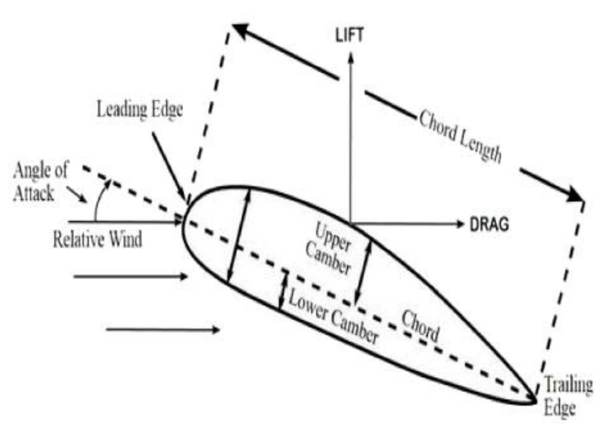
Figure 1: Aerodynamic Forces Acting on Wing



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. Which cause the air on top to move faster, the faster moving air on top of the wing creates a low pressure that lifts while the higher pressure on the bottom of the wing.

MATERIAL SELECTION

While most of the fuselage is aluminum alloy, materials comprise more than 20% of the A300 airframe. Carbon-fiber reinforced plastic, glass-fiber reinforced plastic and quartz-fib reinforced plastic extensively in wings, fuselage sections (such as the undercarriage and rear end and Tail surfaces). Most cases AL alloy is used for making of wing. In this project two materials are used, they are AL alloy and AL 7068, both materials have some characteristics.

AL Alloy: It is easily machined in certain tempers, and it has good strength as well as having high hardness. Mainly this material used in aerospace industry.

Each material has some chemical composition. The Table 1 represents the composition of aluminum alloy and aluminumalloy7068.

Table 1: Composition of AL Alloy and AL Alloy7068

Chemical (%)	AL Alloy	AL 7068
Aluminum (AL)	95-99	96-99
Magnesium (Mg)	0.05	3
Manganese (Mn)	0.05	0.1
Silicon (Si)	0.25	0.12
Copper (Cu)	0.05	2.4
Chromium (Cr)	0.80	0.05
Iron (Fe)	0.40	0.15
Titanium	0.03	0.1
Zinc (Zn)	0.05	8.3

AL 7068: Aluminum 7068 is medium to high strength heat-treatable alloy with strength more than aluminum alloy. It has very good corrosion resistance and good weld ability although reduced strength in the weld zone. It has medium fatigue strength and good cold formability. It is typically used for heavy duty structures like truck frames, aerospace applications including helicopter rotor skin etc.

Aircraft type model : A300 – 600R

Wing span : 22.84 m

Wing area : 260 m^2

Taper ratio : 0.3

Aspect ratio : 7.73

Each material has some properties. The Table 2 represents the properties of AL alloy and AL alloy 7068.

PROBLEM SPECIFICATION

In this project we find which material is best suited for making of wing (AL alloy and AL alloy 7068). For wing Skelton structure we use

Table 2: Input Values

Material	AL Alloy	AL 7068
Density (kg/m^3)	2770	2850
Young's modulus (Gpa)	71	73.1
Poisson's ratio	0.33	0.33
Mass (kg)	24653	25365
Volume (m^3)	8.9	8.9
No. of nodes	13390	13390
No. of elements	6269	6269

NACA 64-215 co-ordinates. We apply the boundary conditions on top of the wing. We fixed one end of the wing and we will apply the pressure 500 pa on the top of wing. We are interested to find out the 6 modes of vibration and structural parameters like total deformation, equivalent stress, max principle stress, stress intensity, and also shear stress.Comared to the two materials which material (AL alloy and AL 7068) has low deformation and stress values that material is best for making of wing.

WING DESIGN PROCEDURE

The Figure 2 shows the A300 wing geometry. The amount of lift produced by an airfoil depends upon many factors. They are. Angle of attack, the lift devices used (like flaps), the density of air, the area of wing, the shape of wing, the speed at which the wing is travelling.

Some Factors affecting wing size they are cruise drag, stall speed, take off and landing distance. The first step is to get the airfoil shape in the CATIA V5 R20 part design. As we are considering that wing is designed with only one airfoil throughout, it has to be scaled down accordingly to get the required shape of a wing profile, volume, hanger size.

The Figure 3 shows the NACA64-215 Airfoil generation. For wing Skelton structure we use NACA64-215 co-ordinates. Import the co-ordinates to catia v5 R20 through Microsoft excel then the airfoil shape is generated in catia v5 R20.

The Figure 4 shows the Airfoil sizing. As the mid wing span is 22.42 m we divide the airfoil in 23 sections. Each Section placed at an equal distance from the reference. The distance between the two planes is 1000 mm.

The above Figure 5 shows the complete design of A300 wing Skelton structure design

Figure 2: A300 Wing Geometry

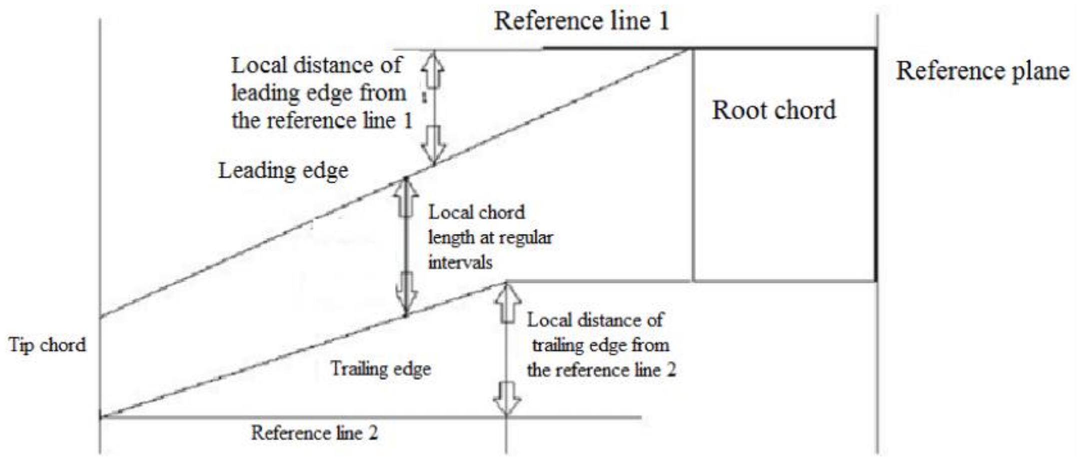


Figure 3: NACA64-215 Airfoil Generation

Figure 4: Airfoil Sizing

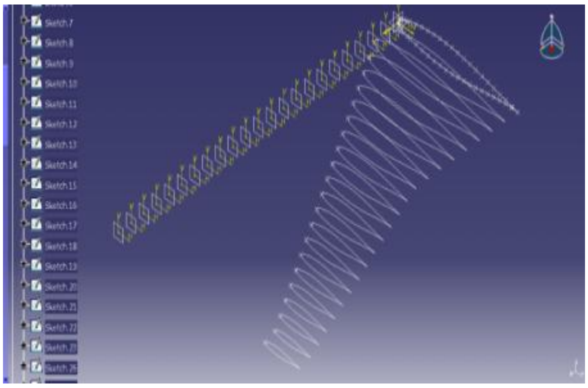
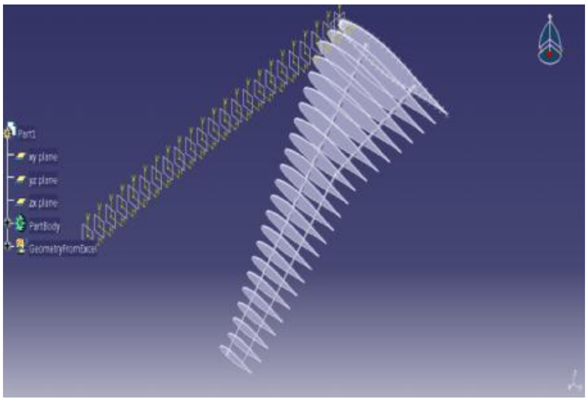


Figure 5: Wing Skeleton Structure



with spars and ribs. In the wireframe and surface design workbench, the surface for the following sections has been generated accordingly. Each section is padded 50 mm mirror extended so that the airfoil section is converted into the rib section with a thickness of 100 mm. The spars and holes are being created in the wing design as per our assumptions respectively. The complete design of the wing skeleton structure is formed.

Before importing the CAT file to the Ansys workbench, the file has to be converted into IGS format.

SOLUTIONS AND DISCUSSIONS

In static structural analysis we are interested to find the total deformation, Von Misses stress which is also known as equivalent stress, shear stress and stress intensity induced in the Skelton structure of the wing.

Structural Analysis with Al Alloy

The Figure 6 shows the deformation value of wing at pressure load. We fixed one end of the wing and we applied pressure 500 Pa on the top of the wing. The Figure 6 shows the deformation of aluminum alloy at pressure load 500 Pa, it shows the max value of deformation is 0.44915 m.

The Figure 7 shows the equivalent stress value of aluminum alloy at pressure load 500

Figure 6: Deformation Distribution

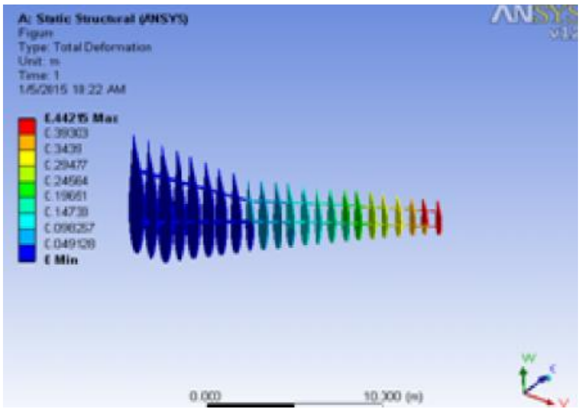
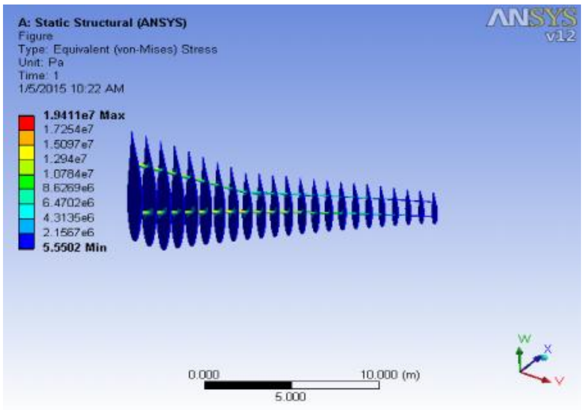


Figure 7: Equivalent Stress



Pa, it shows the max value of Equivalent stress is 1.9411e7 Pa.

The Figure 8 shows the max principle stress distribution of the wing with aluminum alloy at pressure load 500 Pa. We fixed one end of the wing and we will apply the pressure 500 Pa on top of the wing. It shows the max value of max principle stress is 1.504e7 Pa.

The Figure 9 shows the stress intensity value of wing. We fixed one end of the wing and we will apply the pressure 500 Pa on top of the wing. The Figure 9 shows the stress intensity of AL alloy at pressure load 500 Pa, it shows the max value of stress intensity is 4.856e6 Pa.

Figure 8: Max Principle Stress Distribution

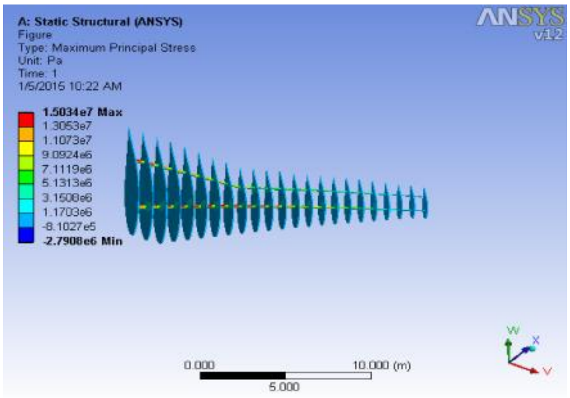


Figure 9: Stress Intensity

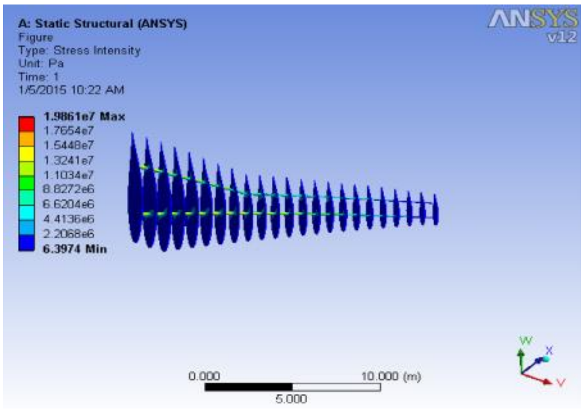
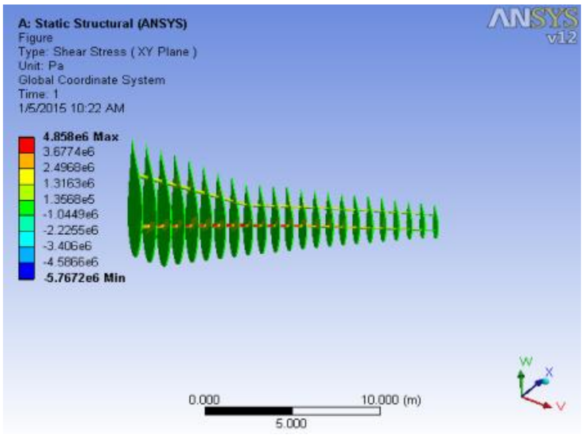


Figure 10: Shear Stress Distribution

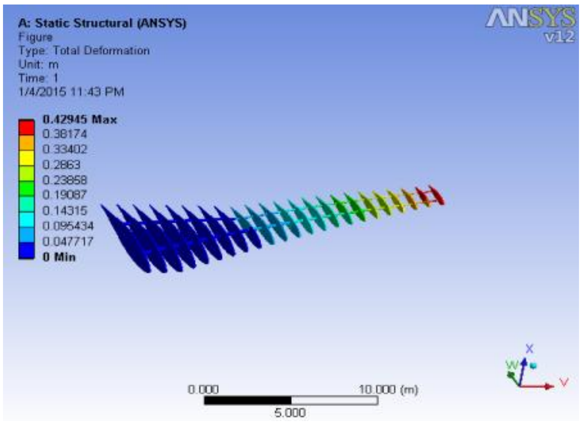


The Figure 10 shows the shear stress value of wing with aluminum alloy at pressure load 500 Pa. We fixed one end of the wing and we will apply the pressure 500 Pa on top of the wing. It shows the max value of shear stress is 1.9881e7 Pa.

Structural Analysis with Al Alloy 7068

In this analysis we fixed one end of the wing and we applied pressure 500 Pa on the top of the wing with in uniform temperature. The Figure 11 shows the maximum deformation of Al alloy 7068 at Pressure load 500 Pa it shows the max value of deformation is 0.44215 m.

Figure 11: Deformation of AL Alloy 7068



The Figure 12 shows the Equivalent stress of Al alloy 7068 at Pressure 500 Pa. We fixed one end of the wing and we applied pressure 500 Pa on the top of the wing within the uniform temperature, it shows the max value of equivalent stress is 1.9411e7 Pa.

The Figure 13 shows the maximum principle stress of Al alloy 7068 at Pressure 500 Pa it shows the max value of max principle stress is 1.500e7 Pa.

The Figure 14 shows the shear stress of Al alloy at Pressure load 500 Pa. We fixed one end of the wing and we applied pressure 500 Pa on the top of the wing within the uniform temperature. It shows the max value of shear stress is 1.9861e7 Pa.

Figure 12: Equivalent Stress Distribution

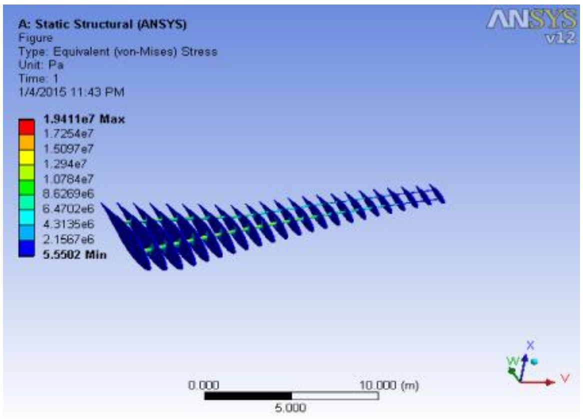


Figure 13: Maximum Principle Stress

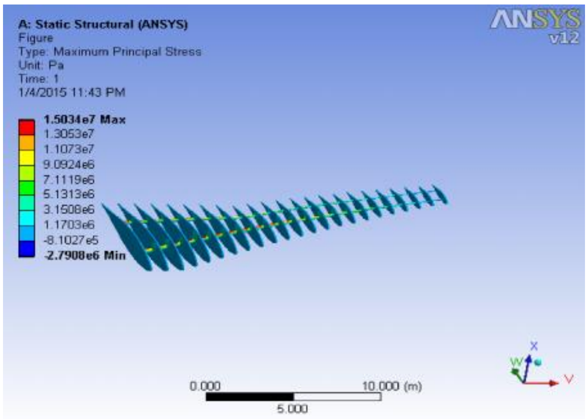


Figure 14: Shear Stress Distribution

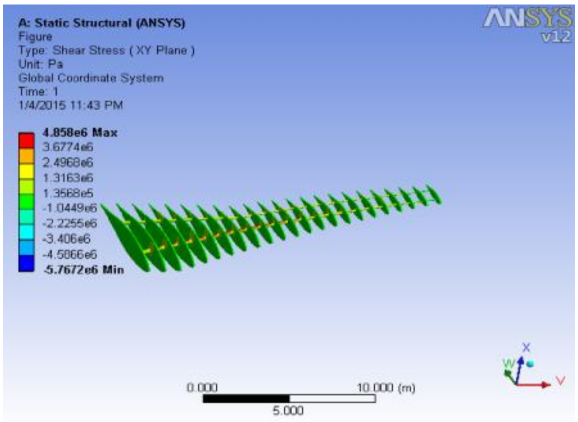
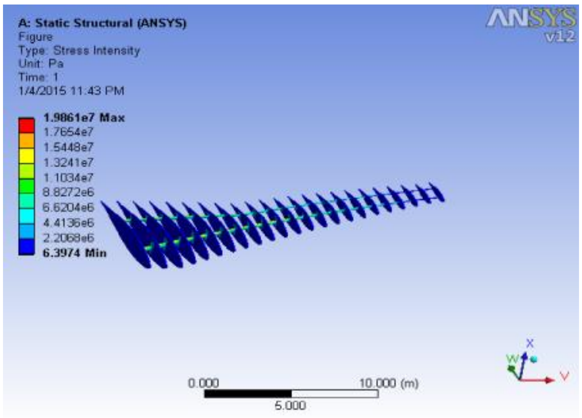


Figure 15: Stress Intensity Distribution



The Figure 15 shows the stress intensity of Al alloy 7068 at Pressure 500 Pa. We fixed one end of the wing and we applied pressure 500 Pa on the top of the wing within the uniform temperature. It shows the max value of stress intensity is 4.856e6 Pa.

RESULTS

Results for the Model Analysis

The Tables 3 and 4 shows the values of deformation with six modes of vibration.

Table 3: Modal Analysis with AL Alloy

S. No.	Mode Shape	Natural Frequency (Hz)	Max Amplitude (m)
1.	1	0.22186	0.025295
2.	2	0.74861	0.029754
3.	3	1.6713	0.027436
4.	4	2.8019	0.032163
5.	5	3.0379	0.026360
6.	6	3.0721	0.029194

Table 4: Modal Analysis with AL Alloy

S. No.	Mode Shape	Natural Frequency (Hz)	Max Amplitude (m)
1.	1	0.22186	0.025295
2.	2	0.74861	0.029754
3.	3	1.6713	0.027436
4.	4	2.8019	0.032163
5.	5	3.0379	0.026360
6.	6	3.0721	0.029194

Table 5: Results for the Structural Analysis

Material	Al Alloy	Al Alloy 7068
Deformation (m)	0.44915	0.42945
Equivalent stress (Pa)	$1.941e^{7}$	$1.9411e^{7}$
Shear intensity (Pa)	$4.856e^{6}$	$4.859e^{6}$
Shear stress (Pa)	$1.9861e^{7}$	$1.9861e^{7}$

Results for the Structural Analysis

The Table 5 shows the values of deformation, equivalent stress, max principle stress, stress intensity, shear stress with aluminum alloy and aluminum alloy 7068.

CONCLUSION

From the above results we can conclude that the difference between the values of deformation, equivalent stress, max principle stress, stress intensity and shear stress with Al alloy and Aluminum alloy7068 are minimal. The results obtained are validated and verified

As the difference between the two result values are minimal. We can use aluminum alloy 7068 instead of using aluminum alloy in order to give the more strength to the structure. The effect of pressure during take-off condition is more for Aluminum and less for Aluminum alloy 7068 which is strongest and light weight, and also reduces the weight of the wing. The ultimate strength of the material used is Aluminum alloy 7068 is 290 MPa and results obtained with aluminum alloy 7068, i.e., equivalent stress, max principle stress ,stress intensity and shear stresses are below 290 mpa.

Thus we can conclude that at the above assumed loading conditions and constraints A300 flight wing structure will not fail due to material properties. We can conclude that aluminum 7068 can be replaced with aluminum alloy.

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