Optimization of Aircraft Wing using Composite Material

Nikhil J.Chaudhari[1] A.S.Rao[2] Vinaay Patil[3]
[1]P. G. Student [2]Assistant Professor [3]Manager
[1,2]Department of Mechanical Engineering
[1,2]Veermata Jijabai Technological Institute Mumbai, India [3]Vaftsy CAE, Pune, India

Abstract— In the present day, use of composite Material has been extended to a large number of aircraft components which includes structural and non-structural components. During the flight, when the maximum lift is generated, wings of the aircraft will undergo stress at the location of the attachment of wing. The attachment is used to carry all type of wing load to this frame. So, the wing root attachments should be high strength enough to carry the load transferred from wing. Weight reduction is also important factor in aircraft. Composite materials are well known for their excellent combination of high structural stiffness and low weight. The analysis conducted using ANSYS finite element package. From the results of analysis, it is estimated that replacement of Al. alloy by composites results in saving in stress at attachment of wing along with reduction in structural weight of the aircraft wing.

Key words: Composite Aircraft Wing, Finite Element Analysis, Static Structural Analysis Weight Optimization, ANSYS

I. INTRODUCTION

Wing of aircraft is the most important part in aircraft design because wings provide stability to aircraft also carries complex loads. It also helps to create maximum lift during flight. In Design and manufacturing of aircraft require more attention .High Strength and low weights are the two primary functional requirement of the aircraft wing .Traditionally aeroplane have manufactured using alloys of aluminium. Now a day's composite material is replaced by the alloys of aluminium. Use of composite help to reduce stress induced at attachment of the wing and helps to improve fuel efficiency by reducing structural weight.

II. STRUCTURAL COMPONENTS OF THE WING

In aircraft design wing is most vital component of the aircraft. 80% of total load of lift is distributed on the wing. Wing consists of various structural components which consider such as wing panel, Spars & Ribs. In this wing panel forms a impermeable surface for supporting the aerodynamic pressure distribution

Rib helps to provide the necessary aerodyanic shape which is require for generation of lift of aircraft and it also helps to distribution od the loads from wing panel to spar link. Spar is the main load carrying structural member of the aircraft wing it also carries the weight of aircraft on ground.

III. ANALYSIS METHOD

ANSYS is general purpose finite element analysis package which able to solve wide variety of problems. Model is generated and import to ANSYS Workbench for static structural analysis. Analysis can be done by assigning different material, meshing, and applying boundary conditions.

IV. MATERIAL PROPERTIES

The entire wing is considered to be made from aluminium alloy in first case and by using Graphite-epoxy composite in second case. The properties of both materials are given below in table I and table II respectively.

Description	Values
Material	7075-T6 Aluminium
Young's Modulus	71.7 GPa
Poisson's ratio	0.33
Mass Density	2800 kg/m^3
Ultimate Strength	572 MPa

Table 1: Material Properties of Al Alloys

Description	Values
Material	Gr-Ep
Young's Modulus	145 GPa
Poisson's ratio	0.25
Mass Density	1743 kg/m^3
Ultimate Strength	373 MPa

Table 2: Material Properties of Graphite- Epoxy Composite

V. MESHING OF COMPONENTS

Model is generated in ANSYS workbench and material is assigned. After that contact between the entire component such as spar, ribs are created. The meshing is done with hex dominant method using quad/ tria elements with mid-side nodes, while for spar element Tetrahedron Patch conforming method with mid-side modes. The element size for all ribs and spar is kept 5 mm. this type of meshing has significant effect on end results. The number of nodes obtained are 53899 and number of elements are 20708. Meshed aircraft wing is shown in Fig 1

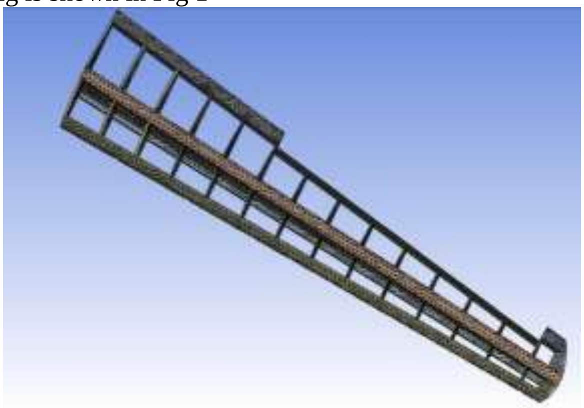

Fig. 1: Mesh Model of Aircraft Wing

VI. APPLYING BOUNDARY CONDITIONS

Advanced FEA tools can be vital in the assessment of safety and serviceability of proposed design. Wing of aircraft is connected to the fuselage so that wing structure is act as cantilever beam which is connected to the fuselage rigidly.

All components such as spar and ribs also held together by rigidly Hence one end of the wing structure is fixed and taken as a boundary condition of the model. This becomes satisfied by fixing all six degrees of freedom (translations in the nodal x, y and z directions and rotations about the nodal x, y and z axes) on the nodes corresponding to the fixing point. Also another end become free as like as cantilever beam also in this type loading is created an initial an acceleration field which is equivalent to the self-weight of the wing and is equal to the gravitational aacceleration of the aircraft wing. The structural analysis was achieved by using the ANSYS, in order to obtain stress and displacement distributions in the wings by using isotropic and composite material for find the optimum design.

VII. ANALYSIS OF AIRCRAFT WING USING ALUMINUM ALLOY

After applying boundary conditions static structural analysis is carried out for all body components of the aircraft wing. In case I aluminium alloy is assigned as a martial for all components of wing as per traditional way. From the properties of geometry of all elements of the aircraft wing using aluminium alloy total mass is obtained as 0.4758kg. Analysis is done for finding out deformation and stress distribution variation along the aircraft wing. Deformation and Equivalent (von-mises) stress plots are given below

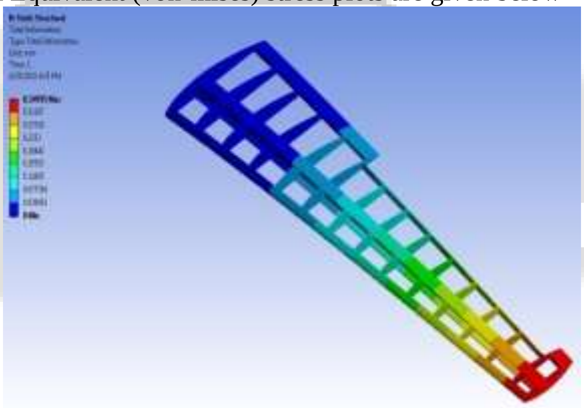

Fig. 2: Deformation Plot of Al Alloy Aircraft Wing

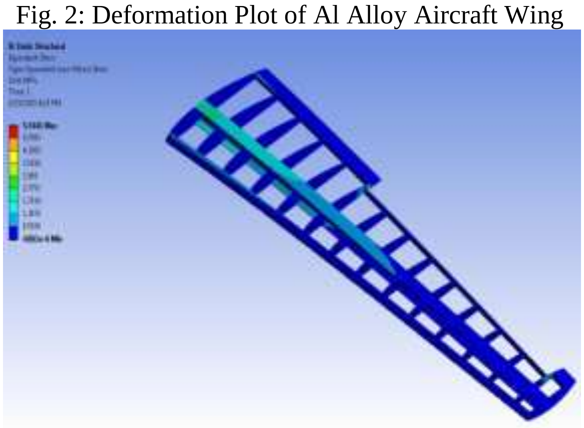

Fig. 3: Equivalent Stress Plot of Al Alloy Aircraft Wing

VIII. ANALYSIS OF AIRCRAFT WING USING GRAPHITE-EPOXY COMPOSITE

Now material is assigned in case II is composite material as per current trends i.e. Graphite-epoxy Material is assigned for all components of wing as per traditional way. From the properties of geometry of all elements of the aircraft wing using aluminium alloy total mass is obtained as 0.29939 kg. Analysis is done for finding out deformation and stress distribution variation along the aircraft wing. Deformation and Equivalent (von-mises) stress plots are given below

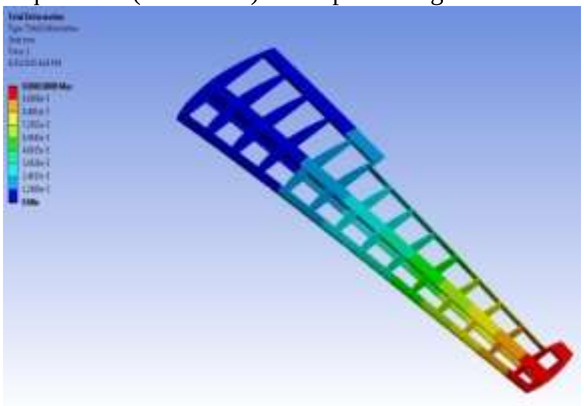

Fig. 4: Deformation Plot of Gr-Ep Composite Aircraft Wing

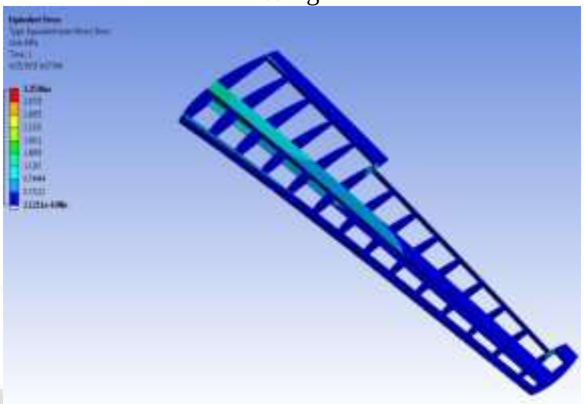

Fig. 5: Equivalent Stress Plot of Gr-Ep Composite Aircraft Wing.

IX. RESULT AND DISCUSSION

Results are analysed by the both cases mentioned above i.e.by using aluminium alloys and composite material. It is observed that the maximum deformation is reduced from 0.34995mm to 0.00010mm, by using composite material. Maximum deformation is located at free end in both cases. The maximum stress intensity obtained is 5.3341 Mpa acting on the spar of the aluminium aircraft wing is get reduced to the 3.350Mpa by use of composite aircraft wing .Composite aircraft wing also helps to reduce structural weight of the wing which gets reduced from 0.4758kg (aluminium alloy win) to the 0.29939kg (Composite wing).

X. CONCLUSION

1) Deformation gets reduced by using composite material for manufacturing aircraft wing instead of using Al alloys.
2) Stresses induced in aircraft wing during lift of flight get reduced by using composite material.
3) Important fact of aircraft wing is Weight is get reduced by shifting from Al alloys to Composite material.
4) By using composite material for manufacturing of aircraft wing high strength is obtained at lower weights

REFERENCES

[1] C.Soutis, Fibre Reinforced Composites in aircraft construction,(Progress in Aerospace sciences 41,2005)
[2] Muhammad Sohaib, Parameterized Automated Generic Model for Aircraft Wing Structural Design and Mesh Generation for Finite Element An
[3] Air frame structural design by "MICHAELCHUN-YUNG NIU"
[4] Dr. R Rajappan, V.pugazhenthi "Finite element analysis of Aircraft wing using composite structure"
[5] M.S.Prabhu, J.Naveen Raj, G.Vignesh "Optimization of unmanned aerial vehicle wing Structure"