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FEM ANALYSIS OF FUSELAGE FRAME USING GLASS FIBER REINFORCED POLYMER

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Abstract

In this paper analysis of fuselage frame using glass fiber reinforced polymer has been studied using FEM. When the air passes over wing, due to the pressure variation between the upper and lower surface of the wing lift force is generated this force will be distributed to fuselage frame. The aim of this present study is to analyze the fuselage frame of an airplane frame using Glass fiber reinforced polymer (GRFP) and propose suitable material for fuselage frame. The frame is designed in solid modelling software CATIA V5 R20 and analysis was done using FEM by using ANSYS. Static structural analysis of the frame is done to find total deformation and strain induced in the frame structure. Modal analysis is done to find the natural frequency of the frame to reduce the noise and avoid vibration. Finally fatigue life analysis is carried out to find out the damage, life and factor of safety of the frame due to applied pressure loads.

Introduction

The portion of the airplane which houses the passengers on payload is referred to as fuselage. Fuselage vary greatly in size and configuration. The wing reactions, landing gear reaction, empennage reaction will be subjected to large concentrated forces over fuselage . in count to these loads fuselage also subjected to inertia forces due to size and weight, internal pressures. To handle these internal pressures efficiently, a combination or circular cross section is required.

The fuselage of a modern aircraft is a stiffened shell commonly referred as semi-monocoque construction. Semi-monocoque structure is very efficient, it has a high strength to weight ratio, and it has design flexibility and can withstand local failure without total failure through load redistribution. Longitudinal elements transverse elements and its external skins were present in fuselage as beam.

The cellular components consist of thin -walled channel, T-, Z-, 'top-hat' or I-sections, provide support for internals loads were used to stiffen the structure. Structural members are known as open section beams and cellular components are termed as closed section beams. Both sections are subjected to axial, bending, shear and torsional loads.

Frequently aircraft components comprise of combination of open and closed section beams

Literature review

The fuselage of various kinds of aircraft have significant differences in their layouts, the primary role is similar in all cases. The difference is the pressurization requirement of most passenger aircraft, which affects the fuselage volumes. The structural shape of the fuselage is close to ideal. The depth and width are approximated to match the vertical and lateral bending and the reaction of the torsion. Basically, a rectangular cross-section is advantageous in terms of maximum space utilization. It is not suitable for general commercial aircraft since substantial pressure differential is required. The stresses due to internal pressure are minimized by use of circular arcs

Loads Acting on Frames

An airplane fuselage consists of number of structural rings or closed frames. Some are light and are required to maintain the shape of the body, to provide stabilizing supports for longitudinal shell stringers.

Heavy frames are observed where large concentrated loads are transferred between bodies such as tail, wing power plant, landing gear. The frames are of such shape and the load distribution, that these frames or rings undergo bending forces in transferring the applied loads to the other resisting portions of the aircraft body. These bending forces produce frame stresses, such frames are statically indeterminate relative to internal resisting stress.

]Aircraft materials

Airframe are mainly made up of light alloys, introduction of composite has made some exceptions. When two or more substances are used together in a structure it can be termed as a composite. The main material made up of strands of strong fibers stuck together with an adhesive. Composites are normally in a form of thin cloth or flat tapes, and can be easily formed into complex curved shapes of almost any size, giving very clean aerodynamically smooth surfaces. Other than embedding of fibers in a matrix, it is also possible to produce ply-type materials consisting of laminates of reinforced plastics or sometimes sandwich construction of metal and reinforced plastics. Such arrangements have advantages such as stiff materials, which have good acoustic damping properties as well. Careful selection and design of such materials can result in stronger, stiffer, and lighter aircraft structure than metal counterpart.

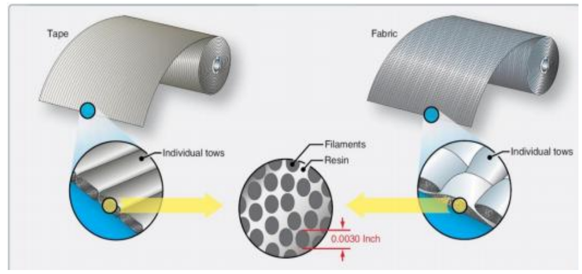

Figure.1: Schematic of basic composite material

Glass-fiber reinforcement has found widespread application in association with thermosetting resins, primarily of its low cost and ease of manufacturing. The two most common grades of fiberglass are 'E' and 'S'. E-glass provides a high strength-to-weight ratio, good fatigue resistance, outstanding dielectric properties, retention of 51% tensile strength and excellent chemical, corrosion, and environmental resistance. S-glass offers 26% more compressive strength, 40% more tensile strength, 21% more modulus and 4% low density than E-glass. Applications of glass-fiber reinforced plastics can be found as secondary structure, such as fairings and primary structure on relatively lightly loaded aircraft. Glass reinforcement used with thin aluminum sheets to form a ply material is known as GLARE. This material has considerable potential for pressurized fuselage and overcomes the poor compression properties.

Finite element Analysis

The frame dimension taken for the analysis is of aircraft the dimensions are approx. based on the basic dimensions. For analysis, the frame is considered as a circular shape than a double lobe which it usually is. The crosssection of ring is of open section 'Z' section.

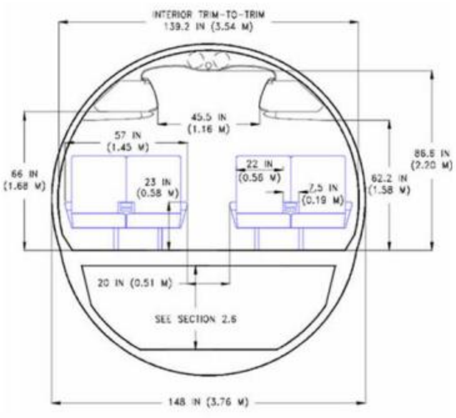

Figure .2: Dimensions of Frame section

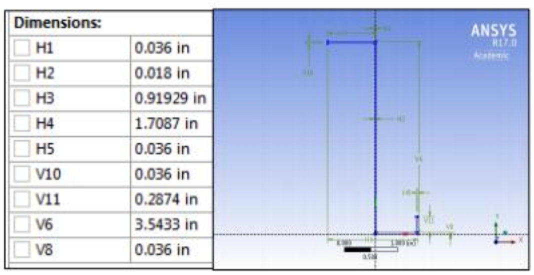

Figure.3: Dimension of Z section

Meshing

The solution timing for a dynamic analysis is mainly a function of element size and shape. To reduce the solution time. The frame body was constructed as a shell element by specifying the line element division of 240. The base impact surface is considered as solid element. The total number of element and mesh setting for dynamic analysis is as shown in the figure.4.

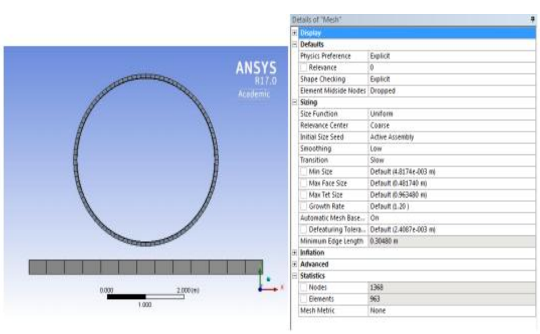

Figure: 4. Mesh setting

Results

The results are displayed in charts. The time of impact for all the materials is same i.e 0.035 sec. Since the impact velocity if different due to effect of mass. The vertical forces and de-acceleration generated are also different for different materials. The maximum de-acceleration generated is by glass fiber since the Young's modulus is very high

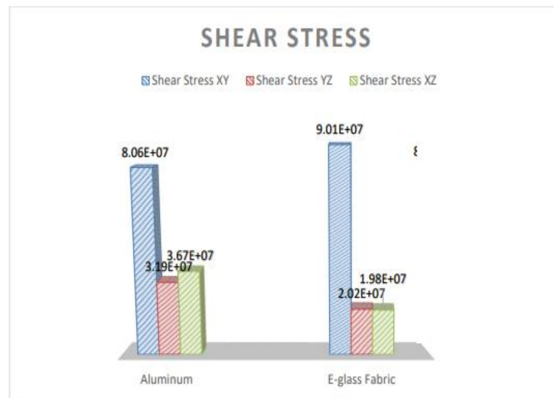

Figure: 5. Shear stress

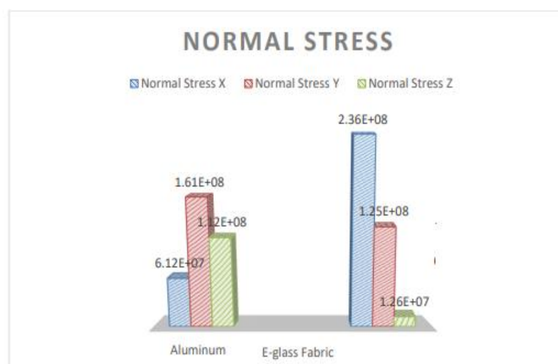

Figure: 6. Normal Stress

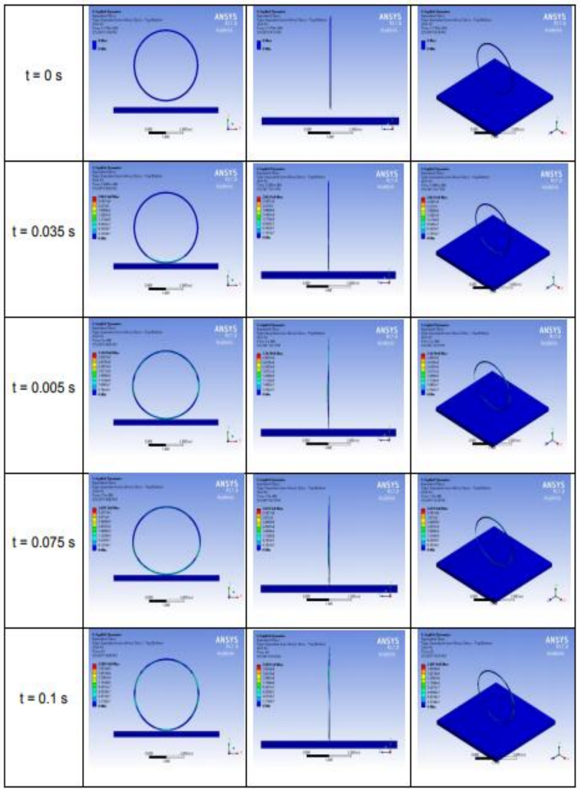

Figure: 7. Nodal Analysis of Fuselage frame

Conclusion

The results gave a good comparative material with that of current industrial material. E-glass fiber composite gives better results or approximate results similar to that of Aluminum Al-7075. Factor of safety for glass fiber fabric is higher, but fails in Z direction. Glasss fiber fabric generates less stress for given load condition. E-glass fabric can be used as composite in aircraft structure frame with more analysis in stacking to increase strength. The mass by the application of composite material decreases significantly. Glass fiber can absorb more energy during impact hence, the reduce noise and avoid vibration the high acceleration and deacceleration.

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