Static Analysis of Airframe Structure and Optmisation

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Abstract : The airframe is fundamental structure of a helicopter can be made of either metal, wood, or composite materials, or some combination of the two. Tubular and sheet metal substructures are usually made of aluminium, also stainless steel or titanium are sometimes used in areas subject to higher stress or heat. Airframe design include engineering, aerodynamics, materials technology, and manufacturing methods to achieve favourable balances of performance, reliability, and cost.A variety of Helicopter airframe and configurations are in use today

In this paper an effort has been made to carry out the analysis of helicopter airframe structure for the identification of possible failure situation, any flaws in the design stage can be identified and rectified in the analysis stage. The stress developed can be understood by maximum and minimum stress acting on the component and suitably reduce it using a better material through optimization methods.

A optimization analysis was performed on a Structure. Pre-processing and solving procedures were performed using ansys. Initially Aluminum Alloy is used and von Misses stress and deflection on the Structure ware compared with GFRP. GFRP found much better. The optimization analysis resulted in mass reduction and the processes involved.

The final part of the documentation deals with the comparison of results obtained from the use of analysis software, with the results obtained after optimization if feasible and a brief idea of the future scope of analysis using ANSYS software for the helicopter airframe structure.

Keywords : Static Analysis; Finite Element Model, airframe structure; allowable stress;

I. INTRODUCTION

A helicopter is a type of rotorcraft in which lift and thrust are supplied by rotors which rotates. This allows the helicopter to take off and land vertically, to hover, and to fly forwards, and backwards. These attributes allow helicopters to be used in congested or isolated areas where fixed-wing aircraft would usually not be able to take off or land[1]. The capability to hover efficiently for extended periods of time allows a helicopter to accomplish tasks that fixed-wing aircraft and other forms of vertical takeoff and landing aircraft cannot perform.

The main body of a plane or helicopter - the fuselage, supports the engine, passengers and cargo. So This fuselage must be able to withstand stress caused by the speed of flight, air pressure and the weight of its contents[2]. There are two primary types of fuselage construction methods used in the aircraft industry, monocoque and welded truss. A third type of fuselage, semi monocoque , is a hybrid of the two.

The FEM is a common tool for stress analysis. FEM along with required boundary conditions was used to determine critical regions in the chassis frame[4]. Static structural analysis is performed to identify critical regions and based on the results obtained design modification has been done.

2.1 Specification Of The Problem

The objective of the present work is to design and analyses of airframe which is made up of aluminium alloy and also composites. Model was created in CATIA . Then model is imported in ANSYS 14.0 for analysis by applying normal load conditions. After analysis a comparing the results between exisisting conventional aluminium alloy chassis and polymeric composite(GFRP) in terms of deflections and stresses, to choose the best one.

2.2 Composite Material

A composite material is defined as a material containing of two or more constituents mixed on a macroscopic scale by mechanical and chemical bonds.

The Composites are combinations of two materials in which one of the material is called the matrix phase which is in the form of fibres, sheets, or particles and is added in the other material called the "reinforcing phase".

Many composite materials offer a combination of strength and modulus that are either comparable to or better than any conventional metallic metals. Because of their low specific gravities, the strength to weight-ratio and modulus to weight-ratios of these composite materials are markedly superior to those of metallic materials[9].

The fatigue strength weight ratios as well as fatigue damage tolerances of many composite laminates are excellent. For these reasons now a days fibre composite have emerged as a major class of structural material and are either used as substitutions for metal in many weight-critical components in aerospace, automotive and other industries.

II. FE ANALYSIS OF CHASSIS FRAME

1.1 Modeling of airframe structure

A airframe is designed to carry the payload, passenger, engine & weights of other structural components mounted on it [4]. For carrying out the FE analysis of chassis frame has been modelled according to the dimension using CATIA V5 R19 Cad software. then it is imported to ANSYS
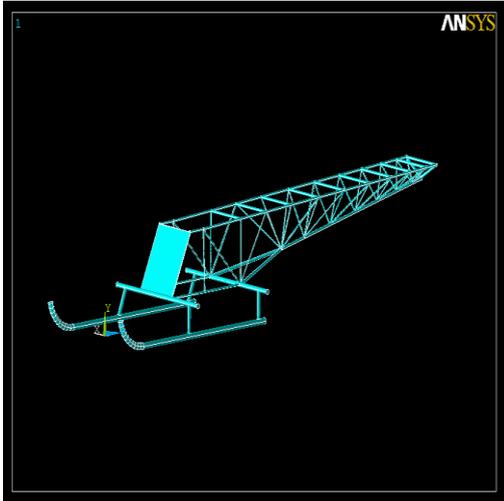

Fig.1 Airframe CAD model

3.2 Meshing of geometry:

The is done in ANSYS 14 only. Elements Used SOLID 45 Element (8 node with 3 DOF/ node) is used to mesh the airframe structure . The whole machine is free meshed. The Figure below shows the meshed views.
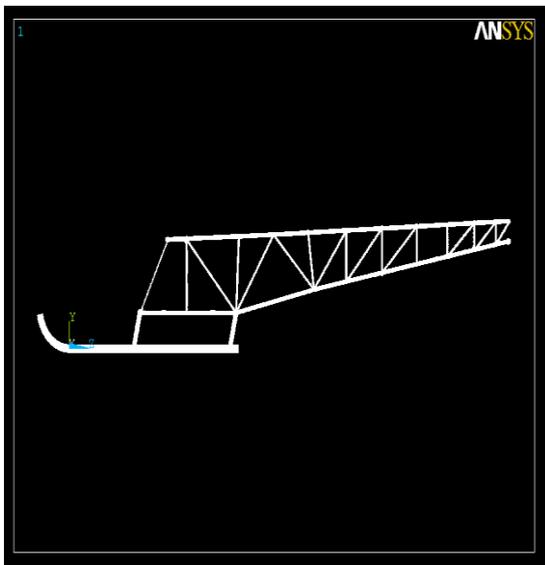

Fig 2 : Meshed helicopter airframe structure
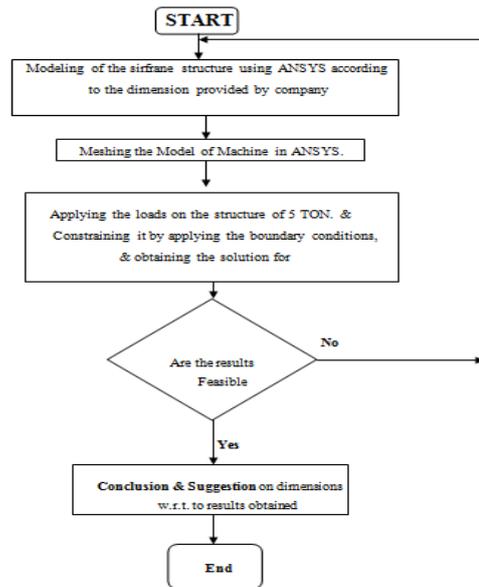
1.2 The FEA process flow chart

Fig.2 Flow chart of FEA process

1.3 Material selection

We are using two materials for the analysis

- Aluminum alloy (7075-T6)

- GFRP Laminate composite

Aluminum alloys is widely used in aerospace. Aluminum is used as a primary material to form alloys with other metals such as magnesium, silicon or zinc. This is an effective way to improve the mechanical properties of metals.

Their properties as resistive materials to high temperatures, of high strength, very great mechanical stress and finally the surface stability lead to their selection for use in jet engines, space aircrafts and general aviation.

The mechanical properties of the plastics composites determined by the characteristics of the fiber and the strength of the bond between the fiber and resin; the temperatures at which the plastic is processed and used depend on the resin.

Fiber glass reinforced plastics in which the strands are distributed at random exhibit high isotropy of mechanical properties; included here are laminates made with granular and felted molding compounds, mat-base laminates, and laminates made along with chopped strands that are sprayed onto the mold simultaneously with the resin. The tremendous progress takingplace in alloys for aerospace enables the designers to build more efficient engines.

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Table 1: material property of aluminum alloy 7075

Physical and mechanical properties	Metric unit
Density	2810 Kg/m^3
Ultimate tensile strength	572 Mpa
Tensile Yield Strength	503 Mpa
Modulus of Elasticity	71.7 Gpa
Poisson's Ratio	0.33
Thermal Conductivity	130 W/mK
Shear modulus	26.9 GPa
Shear strength	331 MPa

Table 2: material property of GFRP composite material

Modulus of elasticity	26 Gpa
Density	1800 Kg/m^3
Poison's ratio	0.28
Ultimate tensile strength	530 N/mm^2
Static bending strength	600-700 N/mm^2

III. BOUNDARY CONDITIONS:

Static analysis is used to determine the displacements, stresses, strains, and forces in structures. Boundary condition involves application of load and defining constraints in the model.

In our study Model The bottom of skid is fixed in all degree of freedom and the other symmetrical boundary condition applied. Here 5 ton load is applied in z direction.
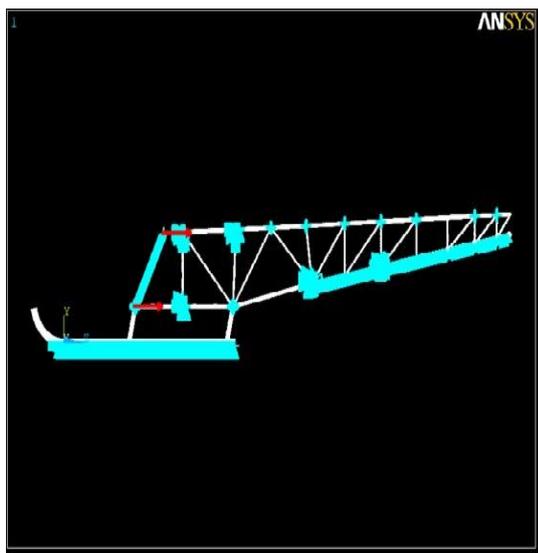

Fig.3 : Boundary condition of model

IV. FEA RESULTS

The location of maximum Von Mises stress and maximum bending stress are just near the T-joints . The maximum Von mises stress is about 192.2 MPa The Maximum Deflection for this load = 15.92 mm

The Maximum stress induced in the machine frame (192.203 MPa) is far below the ultimate stress of Aluminium alloy 7075-T6 is 570 MPa .

- factor of safety = ultimate tensile stress / Maximum stress induced in the structure
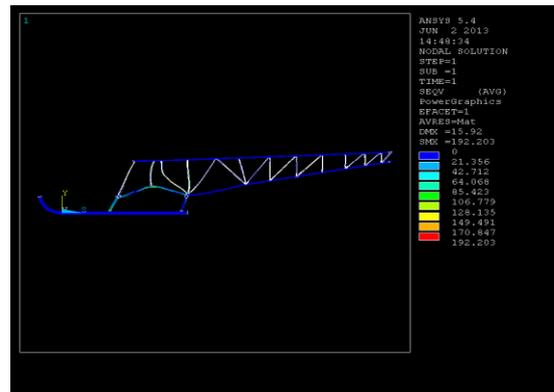
= 570/192.203

=2.96

Fig 4 : The stress induced by applying load 5 TON on structure is 192.2 N/mm^2

- Therefore we now reduce the weight of airframe, we increase strength of airframe and we go for further analysis and material optimization.

- The air frame structure is reconstructed using the COMPOSITE material GLASS FIBER RIENFORCED POLYMER (GFRP), which has density 2810 Kg/m^3 .and ultimate tensile strength of 530 N/mm^2
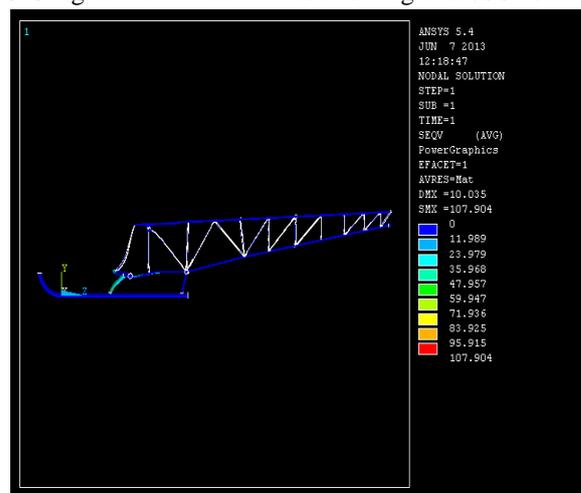
Fig 5 : The stress induced by applying load 5 TON on GFRP structure is 107.9 N/mm^2

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V. COMPARISON OF RESULTS

Table 3: comparison of result

Parameters	Before optimization (Aluminum alloy)	After optimization (GFRP composite)
1. Max stress developed (MPa)	192.203	107.904
2. Max deflection (mm)	15.92	10.035
3. Ultimate strength (MPa)	570	530
4. Factor of safety	2.965	4.912

VI. RESULT DISCUSSION

• In this bell-47 model airframe structure analysis, we used 7075 T6 aluminum alloy before optimization, so initial stress obtained is 192.203 N/mm2. later we used GRFP (glass fibber reinforced polymer) composite material. in that case we got stress as 107.90 N/mm^2. So we conclude that by material optimisation stress is much reduced in structure.

• Deflection observed in structure before optimisation is 15.92 mm. After optimisation deflection is 10.035 mm. So it is clear that deformation is also reduced.

• Factor of safety is 2.9 when aluminium alloy is used as structural material before optimisation. later we got factor of safety is 4.9 in case of GRPF composite material. so after optimisation the FOS is also increased.

• Since the density of GFRP is 1800 Kg/m^3 and density of aluminium alloy is 2710 Kg/m^3. Which shows after optimisation density of material is decreased. So there will be definitely reduction in weight of structure.

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