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DESIGN AND ANALYSIS OF HELICOPTER ROTOR BLADE

CHELLURI ASHOK KUMAR (1), PASALA DURGA PRASAD (2)

1 Dept., of Mechanical Engg. M-Tech Student (Machine Design), KAKINADA INSTITUTE OF ENGINEERING AND TECHNOLOGY

2 Dept., of Mechanical Engg. Assistant Professor (Machine Design), KAKINADA INSTITUTE OF ENGINEERING AND TECHNOLOGY

ABSTRACT: Rotor blade structure consists of skin, ribs and spar sections. The spar carries flight loads and the weight of the rotor blades while on the ground. Other structural and forming members such as ribs are attached to the spars, with stressed skin. The rotor blades are the most important lift- producing part of the aircraft. The design of rotor blades may vary according to the type of aircraft and its purpose.

In this thesis, project detailed design of trainer aircraft rotor blade structure made by using CREO PARAMETRIC SOFWARE. Then stress analysis of the rotor blade structure is carried out to compute the stresses at rotor blade structure. The stresses are estimated by using the finite element approach with the help of ANSYS to find out the safety factor of the structure. In a structure like airframe, a fatigue crack may appear at the location of high tensile stress. Life prediction requires a model for fatigue damage accumulation, constant amplitude S-N (stress life) data for various stress ratios and local stress history at the stress concentration. The response of the rotor blade structure will be evaluated.

In this thesis, the trainer aircraft rotor blade structure with skin, spars and ribs is considered for the detailed analysis. The rotor blade structure consists of 15 ribs and two spars with skin. Front spar having „I" section and rear spar having „C" section. Stress and fatigue analysis of the whole rotor blade section is carried out to compute the stresses and life at spars and ribs due to the applied pressure load.

INTRODUCTION

A fixed-rotor blade aircraft is an aircraft, such as an aeroplane. A fixed rotor blade aircraft is capable of flight using rotor blades by generating lift caused by the vehicle's forward air speed and the shape of the rotor blades. Fixed-rotor blade aircraft are different from rotary-rotor blade aircraft, in which the rotor blades form a rotor mounted on a spinning shaft, in which the rotor blades flap in the same manner to a bird.

Glider fixed-rotor blade aircraft, including free-flying gliders of various kinds and tethered kites, can use moving air to gain height. Powered fixed-rotor blade aircraft gains forward thrust from an engine (aeroplanes) that include powered paragliders, powered hang gliders and some ground effect vehicles.

Classes of fixed rotor blade aircraft

Airplane/aeroplane

An aeroplane (known as an airplane or simply a plane) is a powered fixed-rotor blade aircraft that is moved forward by thrust from a jet engine or propeller. Planes come in a variety of sizes, shapes, and rotor blade configurations. The broad uses for planes include recreation, transportation of goods and people, military, and research.

Seaplane

A seaplane is a type of fixed-rotor blade aircraft capable of landing (alighting) and taking off on water. The Seaplanes that operate from dry land are a subclass called as amphibian aircraft. These aircrafts are also called as hydroplanes.[21] Based on their technological characteristics Seaplanes and amphibians are usually divided into two categories: they are floatplanes and flying boats.

- A floatplane design is similar to a land-based aeroplane, with a generally unmodified fuselage from as compared to its landplane version, except that the

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wheels at the base of the undercarriage. The wheels at the base of undercarriage are replaced by floats, to allow the craft to operate from water than from dry land.

- A flying boat is a seaplane with a watertight hull forming the lower (ventral) areas of its fuselage, resting directly on the surface of the water. It does not need additional floats for buoyancy i.e., it differs from float plane, although it may have small underrotor blade floats or fuselage-mount sponsons to stabilize it on the water. Large seaplanes are usually flying boats, with most classic amphibian aircraft designs using some form of flying-boat design for their fuselage/hull.

Powered gliders

By adding a small power plant many forms of gliders may be modified. These include:

Motor glider – when a flight performance is to incresed then a conventional glider or sailplane with an auxiliary power plant that may be used.

Powered hang glider - a hang glider with a power plant added.

Powered parachute - a parachute is a type of paraglider with an integrated airframe, seat, undercarriage and power plant hung under it.

Powered paraglider or paramotor – it is a paraglider with a power plant suspended behind the pilot.

Ground effect vehicle: A ground effect vehicle (GEV) is also aircraft that attains level flight near the surface of the earth, by making the use of ground effect. ground effect is defined as the aerodynamic interaction between the rotor blades and the earth's surface. Some GEVs are called as powered fixed-rotor blade aircraft because they able to fly higher out of ground effect (OGE) when required.

Rotor blade configuration

The number and shape of the rotor blades varies widely on different types. A given rotor blade plane may be full-span or divided by a central fuselage into port (left) and starboard (right) rotor blades. Occasionally even more rotor blades have been used, with the three-rotor bladeed triplane achieving some fame in WWI. The four-rotor bladeed quadruplane and other Multiplane (aeronautics) designs have had little success **Materials used in the design of aircraft**

The design of the aircraft has to meet specific requirements which influence the complexity of its structure and the materials used in its construction. A wide range of materials may be used in the design of the aircraft to make use of properties such as strength, elasticity, specific weight and corrosion resistance.

Different materials can also be used in the design of specific parts of the aircraft, as a function of the initial req.

The Introduction of Metals

The metals used in the aircraft manufacturing industry include steel, aluminium, titanium and their alloys. Aluminium alloys are characterised by having lower density values compared to steel alloys (around one third), with good corrosion resistance properties.

However, steel alloys have a greater tensile strength, as well as a higher elastic modulus. As a result, steel is used in the parts of aircraft for which strength is very important, such as in the design of landing gears.

The Future of Aircraft Rotor blade Design

The previous examples of novel concepts for the design of aircraft rotor blades demonstrate that different types of materials may be used in the future as demand increases for lighter structures characterized by non-conventional aerodynamics and highly complex geometries. However, the aerospace industry is underpinned by rigorous safety testing and regulations that must be applied to the innovative technologies which are continuously being developed. As a result, long periods of time often pass before a novel concept is introduced into the mainstream aircraft manufacturing industry, imposing strict limitations to the use of the next generation materials.

LITERATURE REVIEW

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Design and Structural Analysis of the Ribs and Spars of Swept Back Rotor blade

The aim of this paper work is to design and analyse the ribs and spars of a 150 seater regional aircraft for the stresses and displacements due to the applied loads. For this we did a comparative study on particular 150 seater regional aircraft. The optimum design parameters are suitably selected and then the model was designed using the CATIA software. The airfoil coordinates for the model to be designed, were generated by design foil software. The major rotor blade design parameters were explained in detail and the rotor blade configuration has been described. Different types of loads acting on the aircraft and the rotor blade are determined and the moments, displacements, etc., are also determined. The rotor blade structure was also explained and functions of each component and their arrangement are also studied. The methodology of finite element method and the detailed description about various FEM tools have been studied and implemented in this work.

INTRODUCTION TO CAD

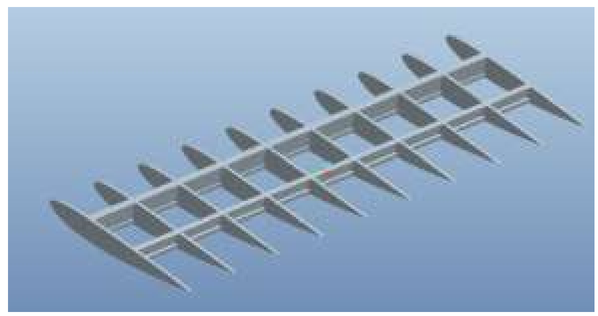
Computer-aided design (CAD), also known as computer-aided design and drafting (CADD), is the use of computer technology for the process of design and design-documentation. Computer Aided Drafting describes the process of drafting with a computer. CADD software, or environments, provide the user with input-tools for the purpose of streamlining design processes; drafting, documentation, and manufacturing processes. CADD output is often in the form of electronic files for print or machining operations. The development of CADD-based software is in direct correlation with the processes it seeks to economize; industry-based software (construction, manufacturing, etc.) typically uses vector-based (linear) environments whereas graphic-based software utilizes raster-based (pixelated) environments.

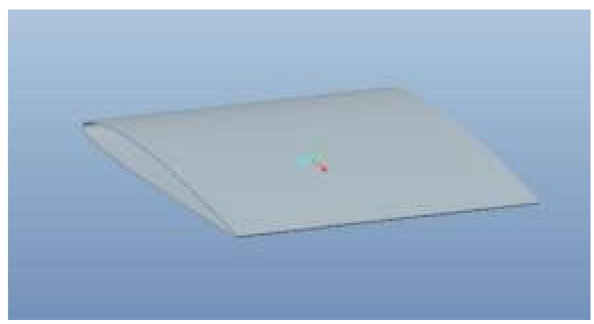
INTRODUCTION TO PRO/ENGINEER

Pro/ENGINEER Wildfire is the standard in 3D product design, featuring industry-leading productivity tools that promote best practices in design while ensuring compliance with your industry and company standards. Integrated Pro/ENGINEER CAD/CAM/CAE solutions allow you to design faster than ever, while maximizing innovation and quality to ultimately create exceptional products.

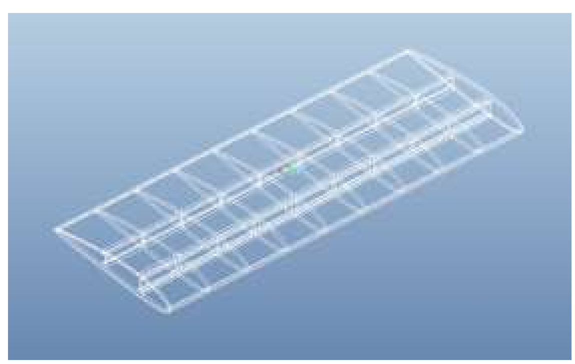
Customer requirements may change and time pressures may continue to mount, but your product design needs remain the same - regardless of your project's scope, you need the powerful, easy-to-use, affordable solution that Pro/ENGINEER provides.

3D MODAL OF AIRCRAFT ROTOR BLADE





Assembly



INTRODUCTION TO FEA

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Finite Element Analysis (FEA) was first developed in 1943 by R. Courant, who utilized the Ritz method of numerical analysis and minimization of variational calculus to obtain approximate solutions to vibration systems. Shortly thereafter, a paper published in 1956 by M. J. Turner, R. W. Clough, H. C. Martin, and L. J. Topp established a broader definition of numerical analysis. The paper centered on the "stiffness and deflection of complex structures".

STATIC ANALYSIS OF FOUR WHEELER STEERING SYSTEM

USED MATERIALS

ALUMINUM 6061-T8, S2 GLASS AND CARBON EPOXY

MATERIAL PROPERTIES

ALUMINUM 6061-T8

Density = 2.7g/cc

Young's modulus = 69.0GPa

Poisson's ratio = 0.33

S2 GLASS

Density = 2.46g/cc

Young's modulus = 86.9GPa

Poisson's ratio = 0.28

CARBON EPOXY

Density = 1.60g/cc

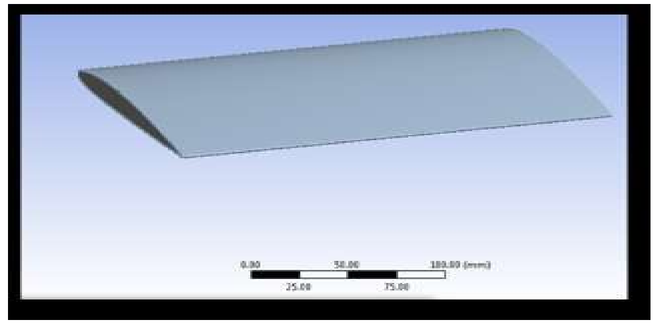
Young's modulus = 70.0GPa

Poisson's ratio = 0.3

Used software for this project work bench

Open work bench in Ansys 14.5

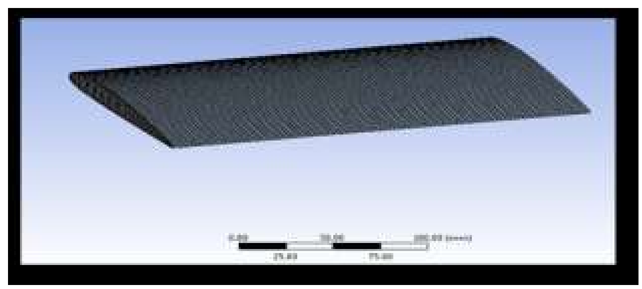
Select static structural>select geometry>import IGES model>OK



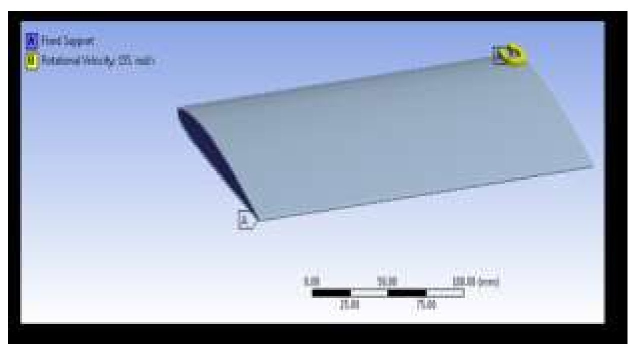
Click on model>select EDIT

Select model >apply materials to all the objects (different materials also)

Mesh> generate mesh>ok



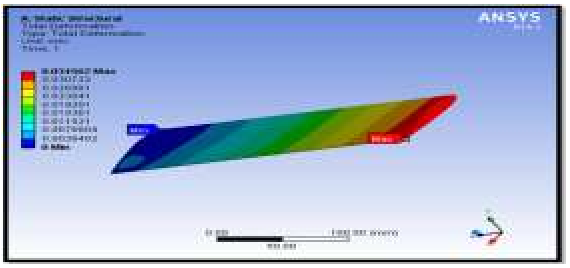
Static structural A5>insert>select .displacement>select fixed areas>ok >Select pressure>select pressure areas> enter pressure value >Select rotational velocity>select axis>enter speed value



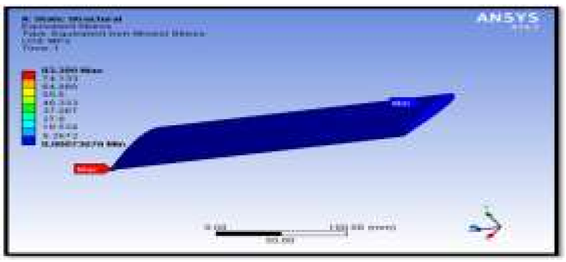
Speed – 400km/hr

Material- aluminum 6061-T8

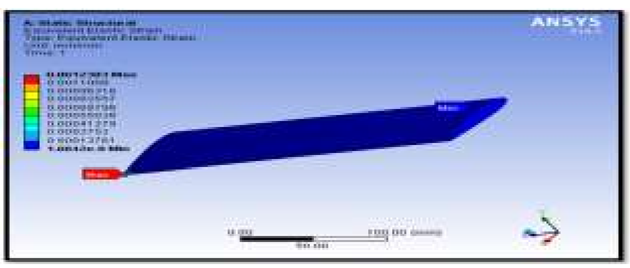
Deformation



Stress

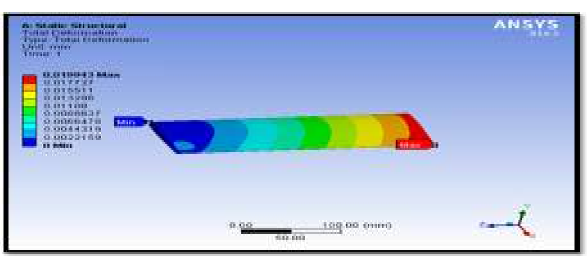


Strain

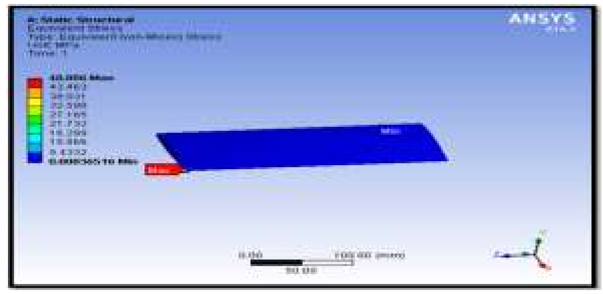


Material- carbon epoxy

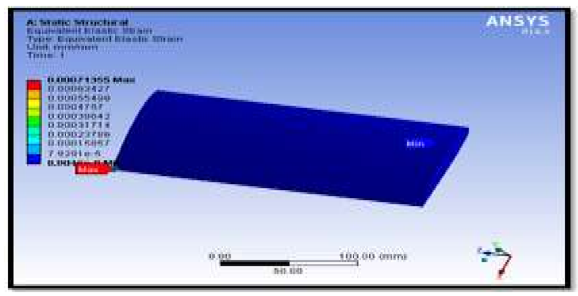
Deformation



Stress



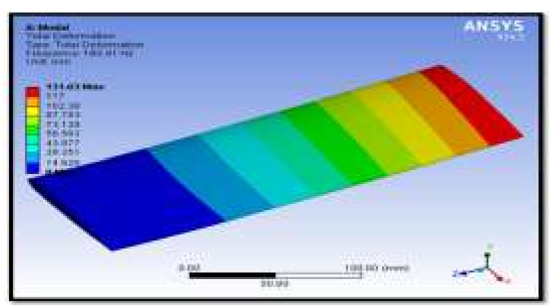
Strain



MODAL ANALYSIS OF AIRCRAFT ROTOR BLADE

Material- aluminum 6061-T8

1st mode shape deformation



2nd mode shape deformation

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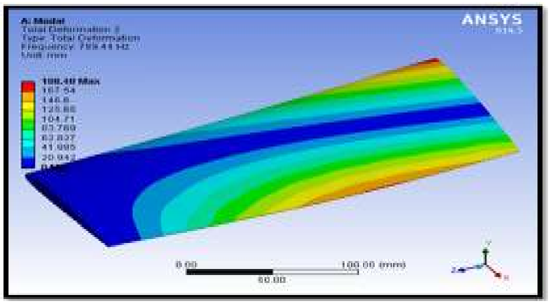
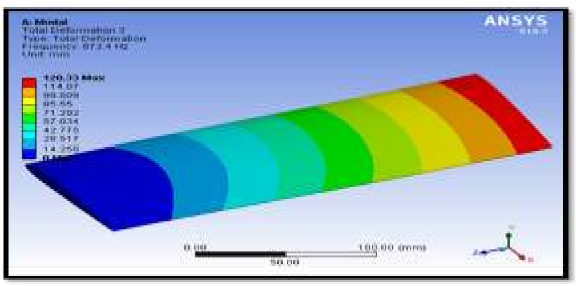
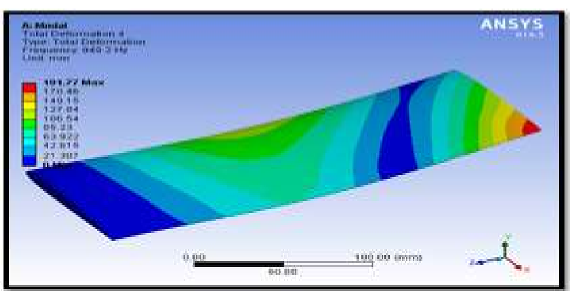


3rd mode shape deformation



4rth mode shape deformation



RESULT TABLE

STATIC ANALYSIS RESULT TABLE

material	Speed km/hr	Deformation(mm)	Stress(MPa)	strain
aluminum 6061-T8	400	0.034562	83.399	0.0012383
	600	0.045865	110.68	0.0016433
	800	0.081535	196.75	0.0029214
s2 glass	400	0.027463	83.545	0.00098035
	600	0.036445	110.87	0.001301
	800	0.064789	197.09	0.0023128
carbon epoxy	400	1.9943e-5	48.896	0.00071355
	600	0.026808	65.726	0.00095914
	800	0.04706	116.85	0.0017052

CONCLUSION

In this thesis, the trainer aircraft rotor blade structure with skin, spars and ribs is considered for the detailed analysis. The rotor blade structure consists of 15 ribs and two spars with skin. Front spar having „I" section and rear spar having „C" section. Stress and fatigue analysis of the whole rotor blade section is carried out to compute the stresses and life at spars and ribs due to the applied pressure load.

By observing the static analysis of aircraft rotor blade, the stress values are increases by increasing the speed (400,600 & 800 km/hr) of the air craft rotor blade, the less stress value for carbon epoxy than s2-glass and aluminum alloy 6061-T8. Carbon epoxy material has more strength because it is a composite material.

By observing the modal analysis of aircraft rotor blade, the deformation and frequency values are more for carbon epoxy material. By observing the fatigue analysis of aircraft rotor blade, the safety factor value is more for carbon epoxy material.

So it can be conclude, the carbon epoxy material is better material for aircraft rotor blade.

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CHELLURI ASHOK KUMAR [1],

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