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Design and Analysis of Composite Propeller Blade for Aircraft

V. Sivaprasad[1], Raghuram Pradhan[2], and K. Srinivas Rao[3]

[1,2,3]Department of Mechanical Engineering, Pace Institute of Technology and Sciences (Autonomous), Ongole, Andhra Pradesh, India

Correspondence should be addressed to; sivaprasad_v@pace.ac.in

ABSTRACT - The work in this paper primarily focuses on the modelling and analysis of a plane's propeller blade for strength. The geometry of a propeller blade is a sophisticated 3D model. CATIA V5 R20 is utilised to generate the blade model, which necessitates the usage of high-end modelling CAD software. This document provides a brief overview of Fiber Reinforced Plastic materials as well as the benefits of employing composite propellers over traditional metallic propeller blades. The purpose of this research is to use finite element analysis to analyse the metal and composite strength of the propeller blade. We conducted static and modal analysis for isotropic materials using ANSYS software, as well as linear layer analysis for orthotropic materials. FEA methods were used to investigate two distinct types of propellers, namely aluminium, E-glass, and carbon fibre.

KEYWORDS –Propeller CATIA, Isotropic.

I. INTRODUCTION

The purpose for the propeller is to give a method for impetus so the plane can push ahead thru the air. The real propeller incorporates of at least edges related together with the aid of a focal center point that joins the cutting edges to the motor shaft. The propeller edges are fashioned comparable as a wing of an plane, using the revolution force of a motor turns the propeller sharp edges produce raise (this carry is alluded to as driven) which pushes the plane ahead. The essentials at the back of how propellers paintings are linked with the fabric science hypotheses of movement created pretty a long term again through Sir Isaac Newton. All the more explicitly his Third Law, that is for every pastime, there may be an equal and inverse response (Sir Isaac Newton, 1687).Keeping this hypothesis as a primary situation, the propeller of an plane is utilized to alternate the rotational force of a motor into forward push. The propeller works via dislodging the air hauling it in the back of itself (the hobby), this development of air then, at that factor, brings approximately the aircraft being pushed ahead from the following tension evaluation (the opposite reaction). The greater air this is pulled behind the propeller the greater driven or ahead pressure is produced. Propellers can be constructed from wherever from a solitary sharp area to at least six sharp edges according with the proficiency desires of numerous aircraft. Airplane execution requirements and motor energy are the fundamental determining elements in the amount of propeller edges. As motor energy expands, greater edges are expected to use the elevated degree of pressure efficiently. The point of a propeller's sharp edges and its trendy size and form (along the force of the motor) impact how a good deal push produced.

Propeller edges are constructed likewise to a wing, as such they are based upon a portion of similar streamlined powers like drag and lift (with wings that is carry, with propeller it is referred to as driven). The factor that subjects is that a propeller has the more powers of rotational pace and ahead performing pressure.

Divergent Forces. The divergent electricity is the power experienced with the aid of the propeller sharp edges whilst turning at velocity. This power is successfully pulling them from the plane.

Divergent And Aerodynamic Twisting. Any deviated turning object creates a diffusive bending force, the propeller is the identical with the electricity of its turning interest contorting the edges to a great pitch.

Vibration. The vibration of the propeller reducing edges is delivered about by unsettling influence is the optimum layout of the propeller because it is going via the air, and near the wings and fuselage in addition to motor sorts.

II. LITERATURE REVIEW

O. Barannyk et al. [1] tentatively researched the impetus association of a wavering adaptable plate with the mixture impact of hurl interpretation and pitch pivot. The concept comes from caudal vicinity of a fish and objective increase via a no. Of trial at numerous profundity of decrease and estimating the electricity. A degree rectangular plate with obtuse driving and following is keep in mind as an impetus framework and deliberating recurrence and sufficiency of pitch and hurl as a boundary of sinusoidal motion a hydrodynamic wavering pressure is addressed. Adaptability part made by way of poly diethylsiloxane (PDMS). Sinusoidal motion made by parker HV23 stepper engine. 16 cycle advanced facts procurement board table became applied with three pivot load cell to quantify power and recurrence with Lab View code. Mat Lab likewise help inside the recording of statistics. Stream layout saw via molecule photograph velocimetry and from trial end

result it's miles seen that push co-powerful increment extraordinarily with harmony sensible adaptability. A. Mazumder and H.H Asada [2] researched on a spheroid sans appendage submerged automobile to study the atomic reactor overview and other cause. Mostly they zeroed in on minimized, multi DOF impetus framework and a high steady manipulate framework. For that a non immediately hydrodynamic model is produced and dissected its controllability and dependability by way of the utilization of water circulate with Coanda impact valve and one among a type bidirectional radial siphon which create four directional streams. In view of the examination statistics a robot model deliberate which used to created PD regulator. T. I. Fossen and M. Blanke [3] suggest a non direct end result enter regulator for UUV propeller. This is completed from the grievance of assessed pivotal movement velocity. Utilizing single propeller the reproduction make experience of greater genuine outcome. Lyapunov balance hypothesis carried out right here. Accepting propeller insurgency and pivotal stream speed have similar signs two speculation of world amazing strong (GES) laid out. Aggravation made on push and pressure by way of pivotal movement velocity pay off with the aid of assessed final results which is so enormous in line with distinctive attitude. C. Y. Hsu et al. [4] focused on the strain fixation effect due to the entrances in the stress body of a profound jumping subs and its foundational layout. For that author studies on shallow tube shaped shell by way of Hibbitt and Karlsson's philosophy of FEM and take a look at the arch impact and sadness modes on round profound leaping vehicle under outer anxiety. Stress dissemination at diverse bended factor of a round opening assists with fostering a plan an data. For the investigation of elastro-plastic way of behaving of cloth Von Mise's Yield guidelines are utilized. Coinciding is completed with the aid of 9 hubs doubly bended slender shell issue and thinks about five DOF. M. A. MacIver et al. [5] plan submerged vehicle in mild of pitifully electric fish tactile framework, impetus plan and body plan guideline. Here they use an in demand ellipsoidal frame version, Kirchhoff's circumstance and ideal manipulate calculation for creating guidelines. By making use of counterfeit electro tactile around the AUV an Omni directional detecting quantity made.

A. Mehanical Properties of Materials

The static analysis of different materials as shown in table 1.

Table 1: Static analysis of materials

Materials	Young's modulus(Mpa)	Tensile strength(Mpa)	Poisson's ratio	Density(kg/mm3)
Aluminium 7075	71700	280	0.33	0.00000028
Carbon fiber	70000	3900	0.30	0.00000020
E-glass fiber	76000	3455	0.31	0.00000258

B. Propeller Design Efficiency

Propeller plan proficiency is decided by the valuable power yield it produces. For instance, the valuable power yield for a fan is the means by which rapidly the fan can speed up the encompassing wind stream. Because of their dynamic nature, propellers' effectiveness is rather estimated by pushed created on the edges and how this powers the individual framework, whether it be a boat, plane, or other application. To sort out the genuine productivity, the accompanying condition is utilized:

$$Efficiency,\ \eta = \frac{Useful\ Power\ Output}{Shaft\ Power\ Input} = \frac{Thrust \times Axial\ Speed\ of\ Fluid}{Resistive\ Torque \times Rotational\ Speed}$$

Where:

Thrust in N
Axial Speed in m/s
Resistance torque in Nm
Rotational Speed rev/s

III. DESIGN OF A PROPELLER

Plan obstacles can have an effect on the presentation of the propellers or fanatics. These factors can contain the quantity of reducing edges required, the dimensions of the outside size, the pitch-influencing technique, in addition to the main and following aspect point alongside several others. propeller design efficiency factor

A. The Number of Blades

Expanding the quantity of edges will surely lessen the effectiveness of the propeller but with a larger wide variety of sharp edges there is a advanced conveyance of driven supporting with retaining the propeller adjusted, eventually a compromise have to be laid out.

B. The Diameter

The breadth of the propeller basically impacts its effectiveness. Bigger propellers have the capability to make more strength and push on a bigger liquid volume. However, most plans face restrictions on the subject of measurement, so improvement have to appear elsewhere.

C. Speed of Flow

The assumed speed of the liquid stream, whether it be air or water, is one more significant variable to recall. This strength, alongside the speed of revolution (RPM) decides the pitch dissemination of the framework. Enormous propeller plans can grow to be less successful operating on the pivotal speed. The simplest plans are the ones which maintain a pitch to measurement percentage of one:1.

D. Stream Density

While the genuine thickness of the liquid influences the effectiveness of the framework, it assumes a part in characterizing the form and size inside the beginning level of the plan cycle. For instance, an air propeller applied for planes and robots may have a more face than its oceanic companions, because the liquid thickness is much less. The figure 1 shows the model 3D propeller blade.

The figure 2 shows the 2D model for aircraft blade.

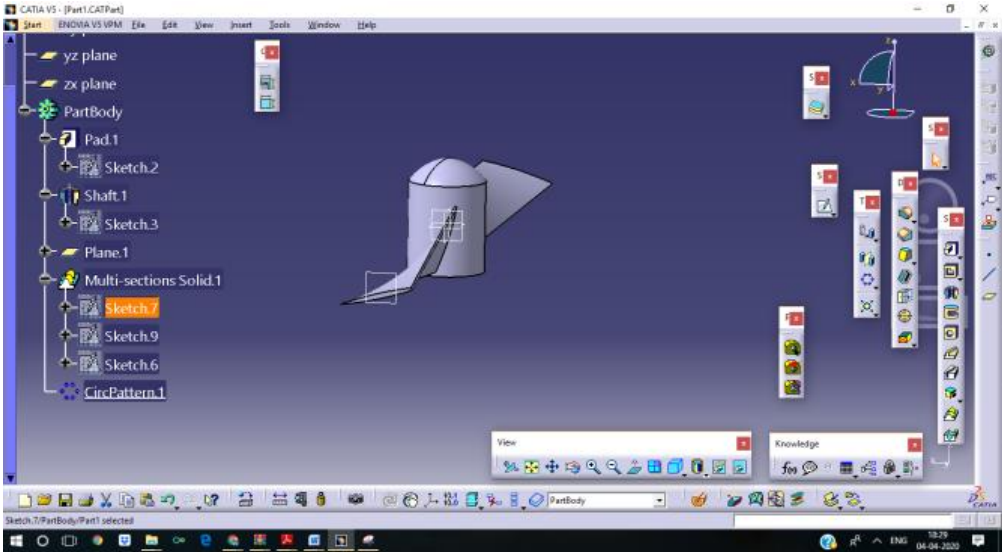
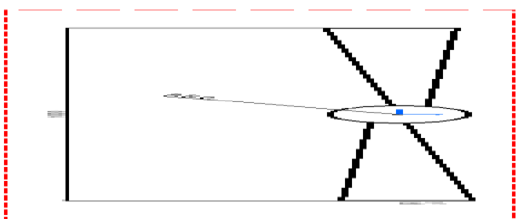


Figure 1: 3D model of propeller blade



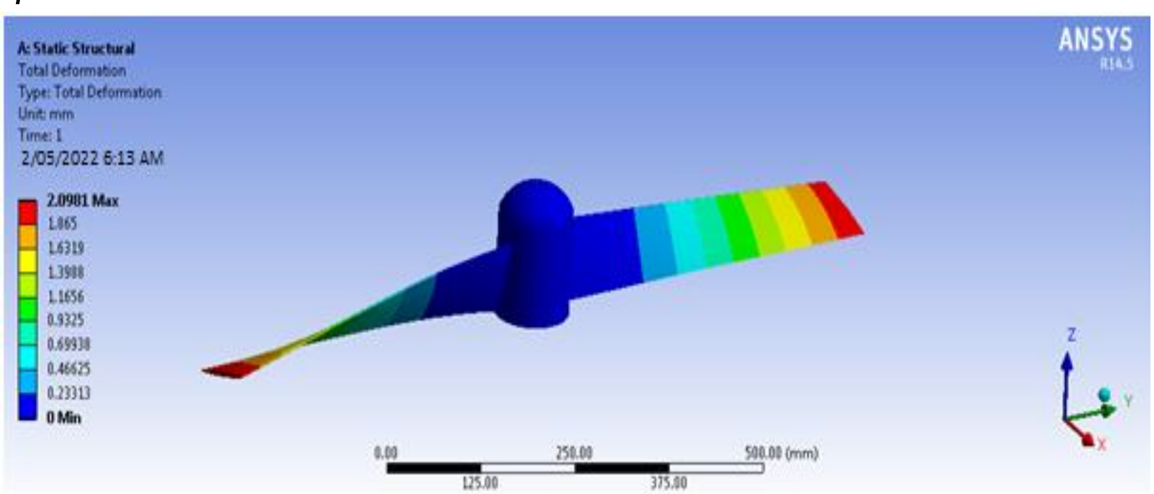
S.No	Parameters
1	2bladed propeller
2	Radius of hub = 50 mm
3	Radius of Propeller = 500mm

Figure 2: 2D Model FOR Aircraft Blade

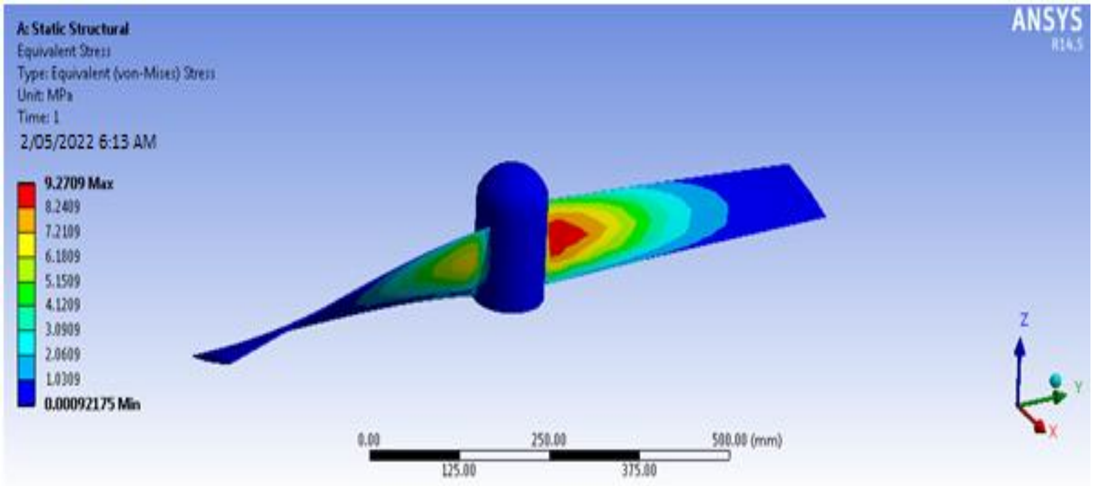
IV. STATIC ANALYSIS OF PROPELLER BLADE

The analysis of the propeller blade of Von-Mises stress and Von-Mises strain is shown in figure 2. The model analysis deformation of different stages is shown in figure 3.

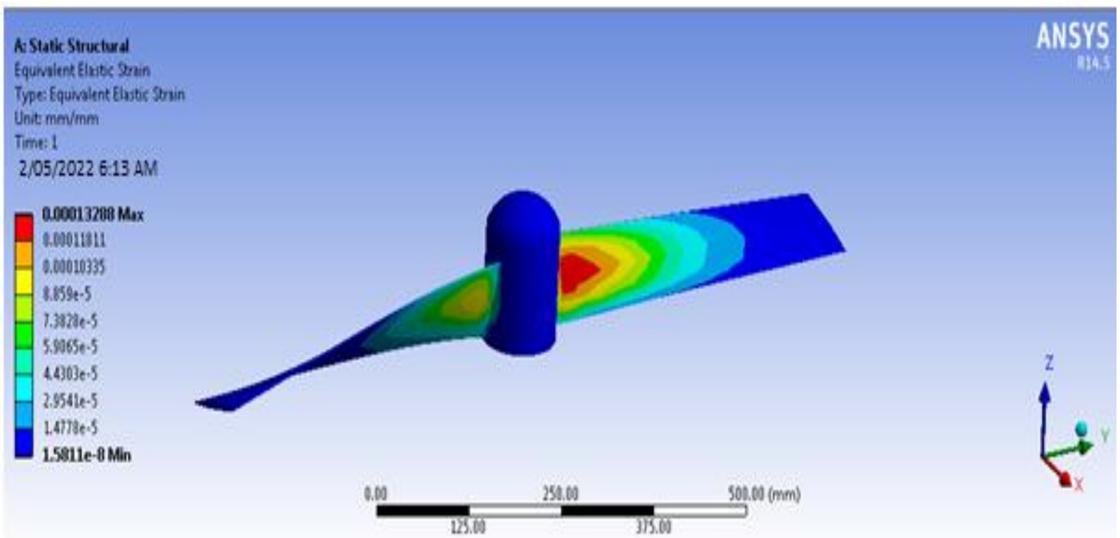
A. Total Deformation



a) Figure 2 Von-Mises Stress



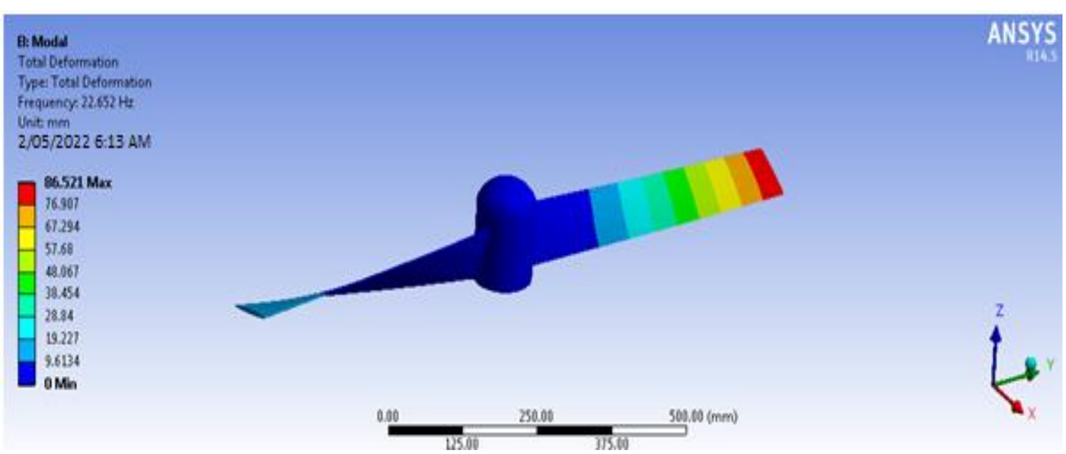
b) Von-Mises Strain



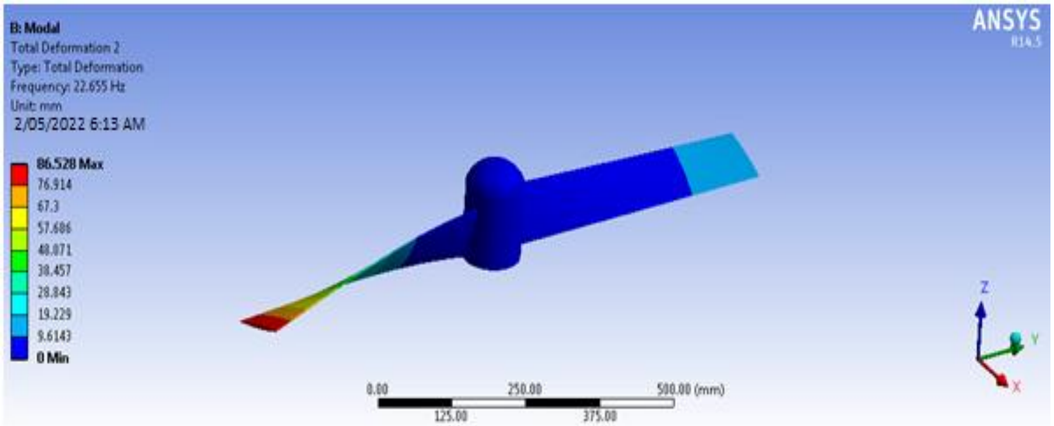
c) Total Deformation 1

Figure 2: Static analysis of propeller blade

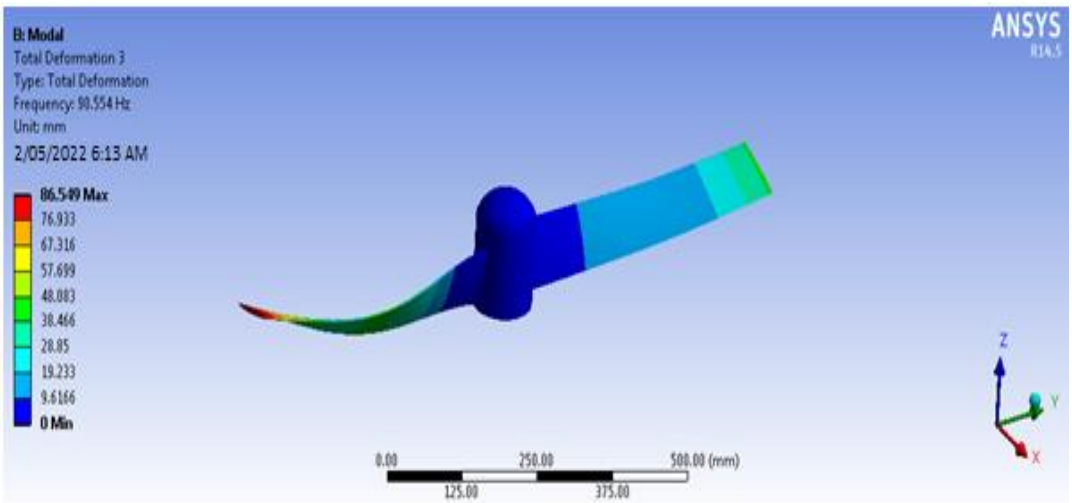
V. MODAL ANALYSIS



a) Total Deformation 2



b) Total Deformation 3



c)

Figure 3(a) (b) (c): Model analysis of different deformation levels

VI. RESULTS AND DISCUSSIONS

Table 2: Static Analysis Results

MATERIAL	SPEED(RPM)	DEFORMATION (mm)	STRESS (N/mm^2)	STRAIN
Aluminum alloy 7075	7000	2.8494	12.767	0.00018045
	9000	4.6523	20.845	0.00029462
Carbon fiber	7000	2.0981	9.2709	0.00013288
	9000	3.4257	15.137	0.00021695
E-glass fiber	7000	2.4886	11.937	0.00015759
	9000	4.0632	19.489	0.00025729

By noticing the table.2 and table.3, static investigation performed on the propeller edge at various materials (al 7075, carbon fiber and E glass fiber) and different propeller speeds i.e 7000 and 9000 RPM. The most extreme pressure worth of 20.845 N/mm2 with aluminium amalgam 7075 at 9000 Rpm and least pressure worth of 9.2709 N/mm2 with material of carbon fiber at speed 7000 Rpm.

Table 3: Model analysis

MATERIALS	FREQUENCEY (HZ)	MODE 1	FREQUENCEY (HZ)	MODE 2	FREQUENCEY (HZ)	MODE 3
Aluminum alloy 7075	25.145	104.06	28.148	104.07	111.81	104.08
Carbon fiber	22.652	86.521	22.655	86.528	90.554	86.549
E-glass fiber	23.224	98.58	23.22	91.583	98.5	95.77

VII. CONCLUSION

In primary investigation, the carbon fiber and E-glass fiber composite design is utilized to persevere through successfully different rates. To assess the planned construction, underlying investigation is performed utilizing the limited component examination. By noticing the static investigation of airplane propeller edge, the pressure values are increments by speeding up (7000 and 9000 Rpm) of the airplane propeller cutting edge, the less pressure an incentive for carbon fiber than E-glass and aluminium amalgam. Carbon epoxy material has more strength since it is a composite material. By noticing the direct layer investigation, the pressure values les for 3 layers with orthotropic materials when we contrasted with static examination results. So it very well may be presumed that layer composite materials appropriate for air create propeller sharp edge.

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ABOUT THE AUTHORS

V. Sivaprasad a Post graduate in CAD/CAM from Jawaharlal Nehru Technological University, Kakinada. He presented 10 papers in various International and National conferences He has contributed a good number of research papers in indexed Journals.

Raghuram Pradhan, a Post graduate in Machine Design from Bharath University, Chennai. He has published more than 40 Papers and 5-Patents and member of different Professional bodies. He has contributed a good number of research papers in Scopus indexed Journals.

K. Sreenivasarao a Post graduate in CAD/CAM from Jawaharlal Nehru Technological University, Kakinada. He presented 3 papers in various International and National conferences .He has contributed a good number of research papers in indexed Journals.