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Modelling and Analysis of Propeller Blade with Different Materials Using Fea

G.Rajesh
M.Tech, Machine Design,
Nova College of Engineering and Technology, A.P-India.

Jithendra
Associate Professor & HOD,
Dept of Mechanical Engineering,
Nova College of Engineering and Technology, A.P-India.

ABSTRACT:

Composites are finding wide spread use in naval applications in recent times. Ships and under water vehicles like torpedoes Submarines etc. Torpedoes which are designed for moderate and deeper depths require minimization of structural weight for increasing payload, performance/speed and operating range for that purpose Aluminum alloy casting is used for the fabrication of propeller blades. In current years the increased need for the light weight structural element with acoustic insulation, has led to use of fiber reinforced multilayer composite propeller. The present work carries out the structural analysis of a propeller blade which proposed to replace the Aluminum propeller blade. Propeller is subjected to an external hydrostatic pressure on either side of the blades depending on the operating depth and flow around the propeller also result in differential hydrodynamic pressure between face and back surfaces of blades.

The propeller blade is modeled and designed such that it can with stand the static load distribution and finding the stresses and deflections for both materials. This works basically deals with the modeling and design analysis of the propeller blade of a torpedo for its strength. A propeller is complex 3D model geometry. This requires high end modeling CATIA software is used for generating the blade model. This report consists of brief details materials and the advantages of using composite propeller over the conventional metallic propeller. By using ANSYS software modal analysis and static structural analysis were carried out for both metal matrix composite and nibral.

Introduction:

Marine propeller is a component which forms the principal part of ships since it gives the required propulsion. Metal matrix composite material is extensively used in the manufacturing of various structures including the marine propeller. The hydrodynamic aspects of the design of composite marine propellers have attracted attention because they are important in predicting the deflection and performance of the propeller blade. For designing an optimized marine propeller one has to understand the parameters that influence the hydro-dynamic behavior. Since propeller is a complex geometry, the analysis could be done only with the help of numerical tools. Most marine propellers are made of metal material such as bronze or steel. The advantages of replacing metal with an composite are that the latter is lighter and corrosion-resistant.

Another important advantage is that the deformation of the composite propeller can be controlled to improve its performance. Propellers always rotate at a constant velocity that maximizes the efficiency of the engine. When the ship sails at the designed speed, the inflow angle is close to its pitch angle. When the ship sails at a lower speed, the inflow angle is smaller. Hence, the pressure on the propeller increases as the ship speed decreases. The propulsion efficiency is also low when the inflow angle is far from the pitch angle. If the pitch angle can be reduced when the inflow angle is low, then the efficiency of the propeller can be improved. Traditionally marine propellers are made of manganese-nickel-aluminum-bronze (MAB) or nickel-aluminum-bronze (NAB) for superior corrosion resistance, high-yield strength, reliability, and

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affordability. More over metallic propellers are subjected to corrosion, cavitations damage; fatigue induced cracking and has relatively poor acoustic damping properties that can lead to noise due to structural vibration. Moreover, composites can offer the potential benefits of reduced corrosion and cavitation's damage, improved fatigue performance, lower noise, improved material damping properties, and reduced lifetime maintenance cost. In addition the load-bearing fibers can be aligned and stacked to reduce fluttering and to improve the hydrodynamic efficiency.

INTRODUCTION TO CATIA

CATIA-V5 is the industry's de facto standard 3D mechanical design suit. It is the world's leading CAD/CAM /CAE software, gives a broad range of integrated solutions to cover all aspects of product design and manufacturing. Much of its success can be attributed to its technology which spurs its customer's to more quickly and consistently innovate a new robust, parametric, feature based model. Because that CATIA-V5 is unmatched in this field, in all processes, in all countries, in all kind of companies along the supply chains. Catia-v5 is also the perfect solution for the manufacturing enterprise, with associative applications, robust responsiveness and web connectivity that make it the ideal flexible engineering solution to accelerate innovations. Catia-v5 provides easy to use solution tailored to the needs of small medium sized enterprises as well as large industrial corporations in all industries, consumer goods, fabrications and assembly. Electrical and electronics goods, automotive, aerospace, shipbuilding and plant design. It is user friendly solid and surface modeling can be done easily.

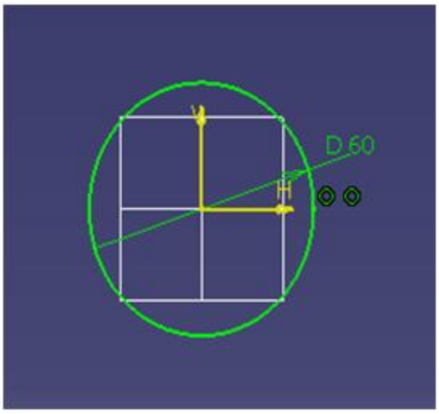

Fig:1

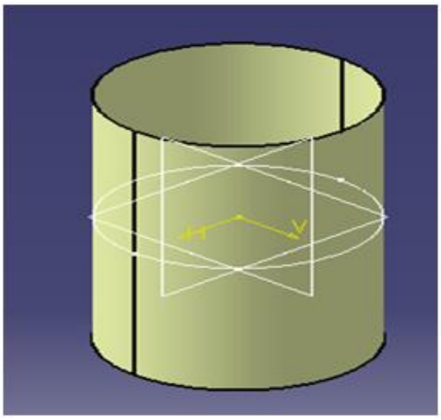

Fig:2

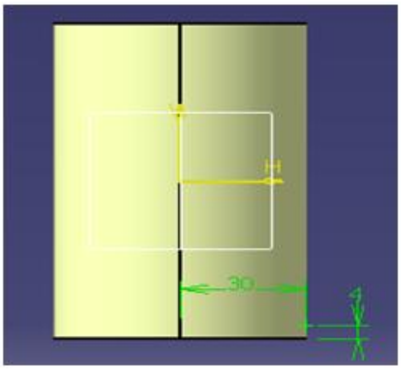

Fig:3

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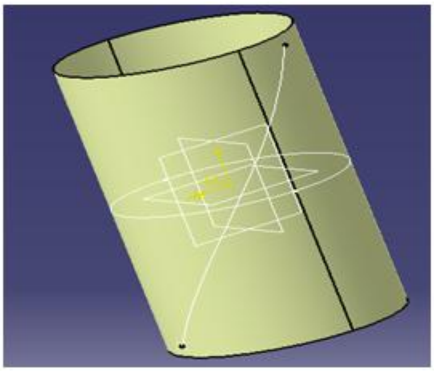

Fig:4

- Create the blade as shown below in Fig:5 by using sweep tool, round the corners with corner tool with R 80 and R 40 as shown below in

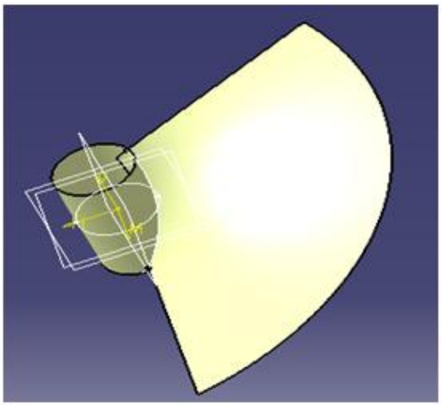

Fig:5

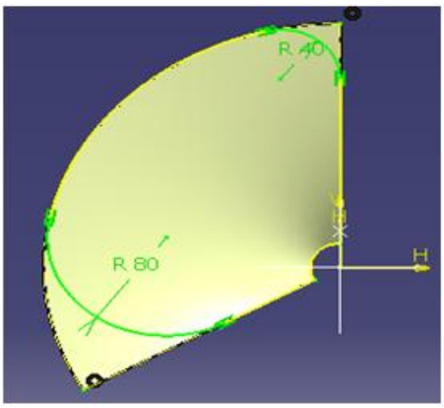

Fig:6

- Extrude the rounded sketch with supports as shown below in Fig:7, split it with split tool as shown below in

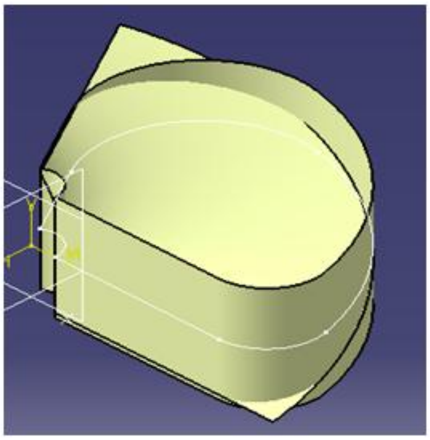

Fig:7

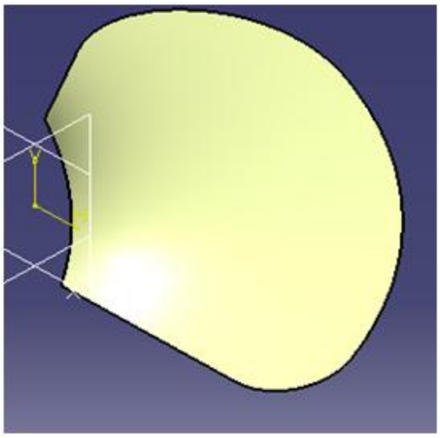

Fig:8

- Now enter into part modeling to add thickness to the blade, by using thick surface tool add the thickness 4 mm (Fig:9), Convert fig:3 surface into solid using close surface tool (Fig:10).

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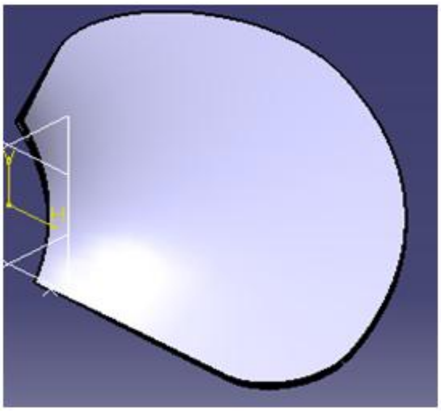

Fig:9

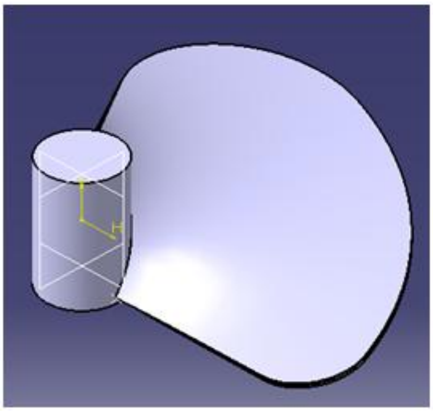

Fig:10

- Using edge fillet tool add round at joining location of blade and hub Fig:11
- Pattern blade as shown in Fig:12

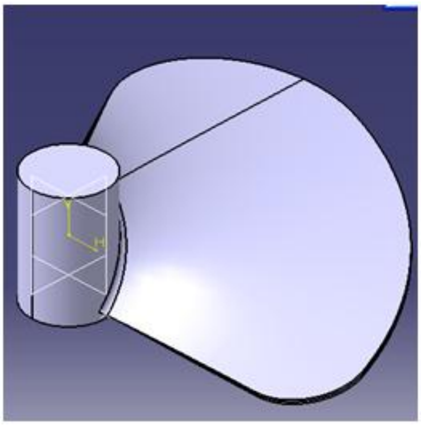

Fig:11

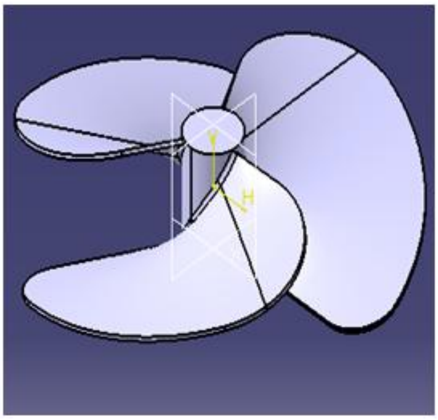

Fig:12

- Remove the material as shown in fig:13 and Fig:14 by using pocket tool

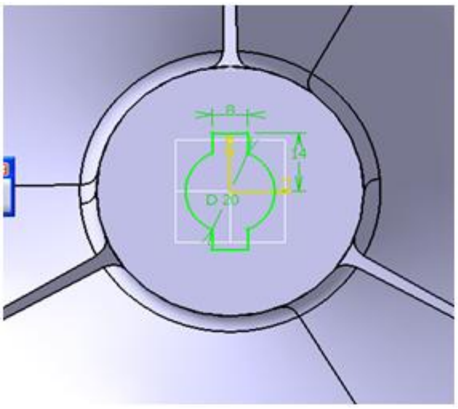

Fig:13

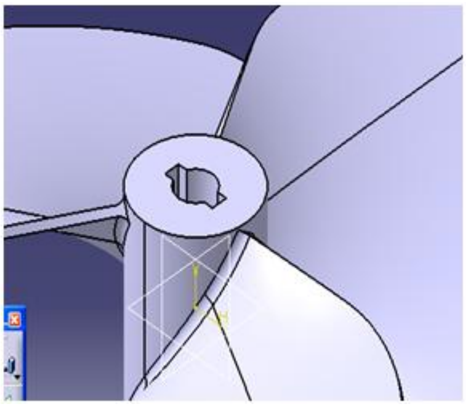

Fig:14

MODELING OF PROPELLER BLADE BY USING CATIAV5

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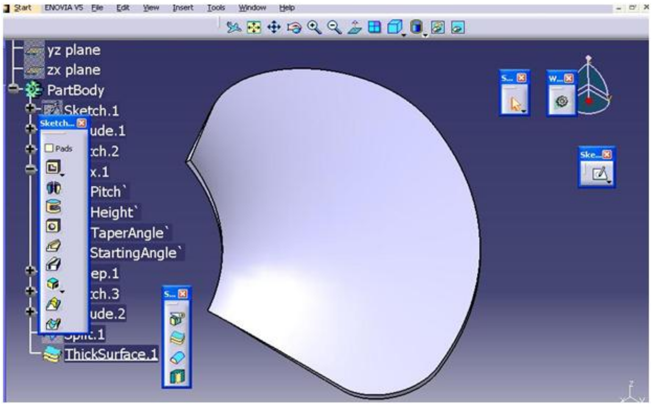
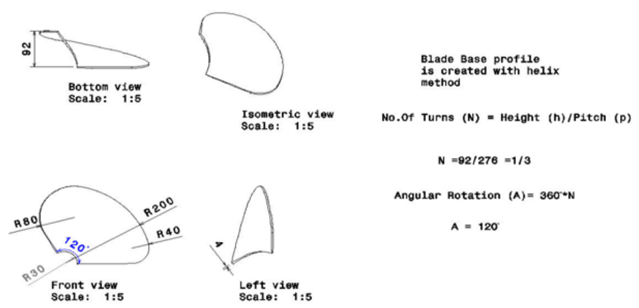
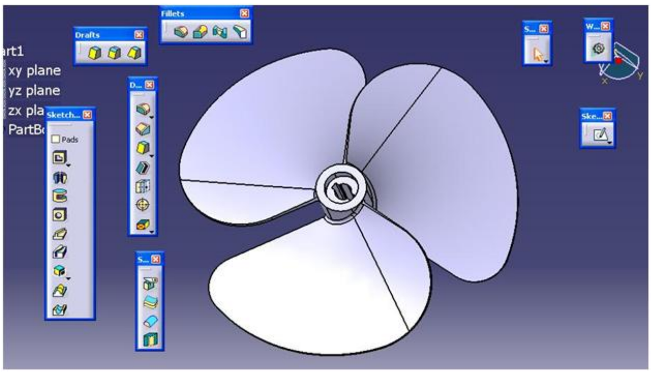
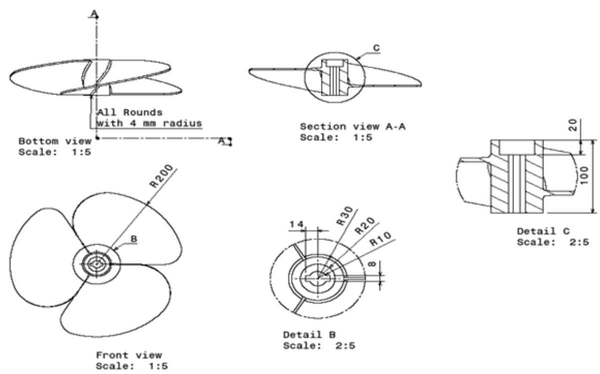




MODEL OF A PROPELLER





CALUCULATIONS:

Total Area Of the circle $=\pi R^2$

$= 3.141X30^2$

$= 2826.9\ mm^2$

Total Blade Area $= \pi\ r^2\ X\ DAR$

$= 2826.9X0.92$

$=2600.748\ mm^2$

(DAR = TBA/TAC = 2600.748/2826.9=92 %)

Relationship between Pitch & Pitch Angle

Formula: Pitch $= 2\pi\ r\ X\ Tan\ a$

Where: a = pitch angle and r = radius and π=3.14159

Pitch Angle = 120

Pitch = 326.318 mm

Speed = (RPM/Ratio)(Pitch/C)(1-S/100)

Speed = (1000/0.5X326.316/1)(1-0/100) assume Ratio=1/2,

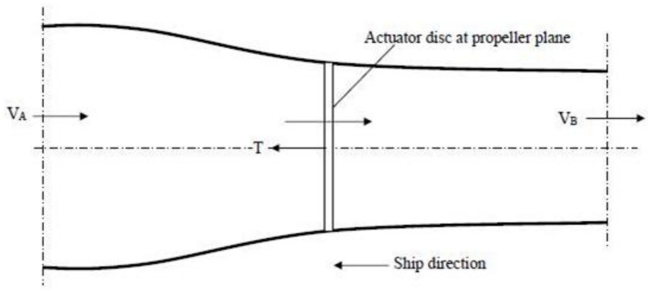
$= 652636X60/10^6$

Gear ratio(C) = 1

=39.1581km/hr

Slip(S)=0

Boat Speed V_B = 24.3317 mile/hr; (1 mile = 1.609344 kilometers)



The thrust (T) is equal to the mass flow rate (.m) times the difference in velocity (V).

$T = m \times (V_B - V_A)$

Mass Flow Rate per hr (m) = area of blade x speed of the boat

$= 2600.74 \times 10^{-6} \times 39.1581 \times 10^{3}$

$= 101.840\ m^{3}/hr$

Thrust (T) $= m \times (V_B - V_A) = 101.840 \times 39.1581 \times 10^{3}$

= 3987860.9 N

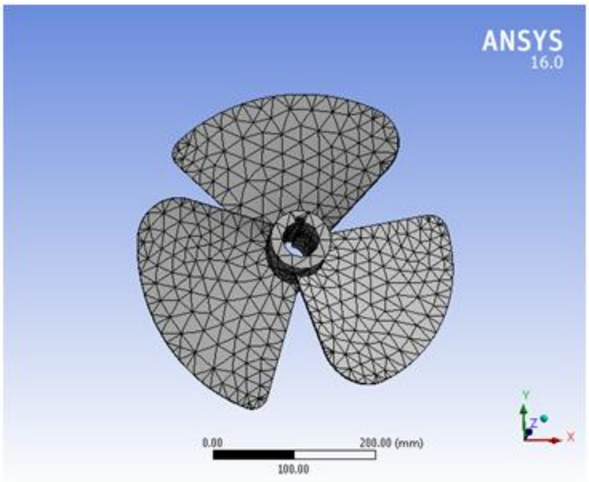
= 3.98 MN

- ANSYS

- **Model (A4)**
  - Geometry
    - Part 1
  - Coordinate Systems
  - Mesh
  - **Static Structural (A5)**
    - Analysis Settings
    - Loads
    - Solution (A6)
    - Solution Information
    - Results

- **Material Data**
  - MMC

FIGURE 1Model (A4) > Mesh > Figure



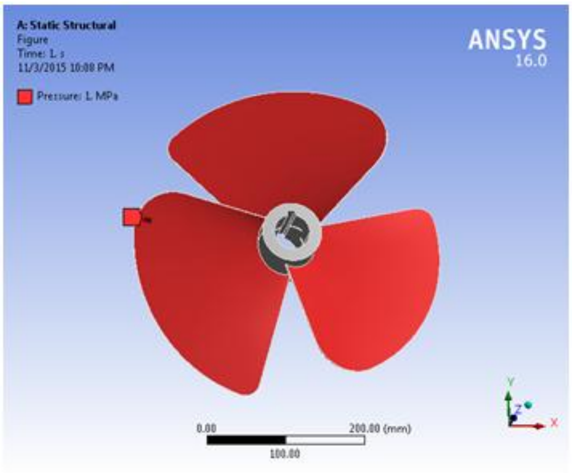
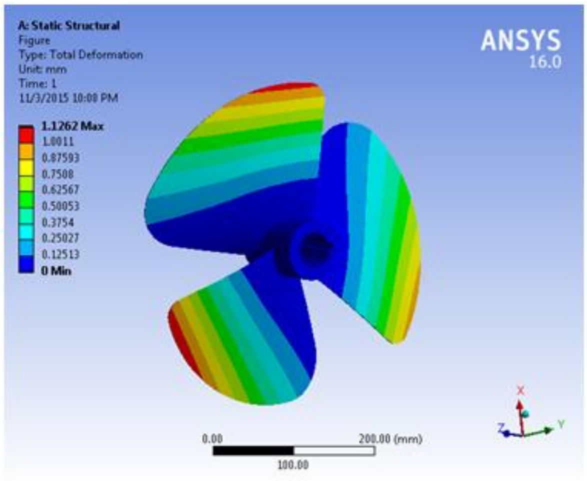


FIGURE 5 Model (A4) > Static Structural (A5) > Solution (A6) > Total Deformation > Figure



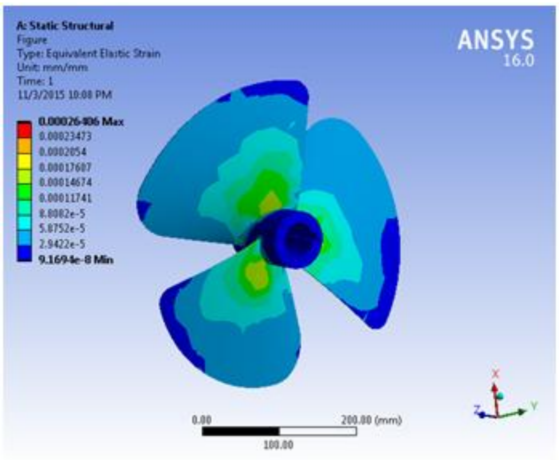


FIGURE 8 Model (A4) > Static Structural (A5) > Solution (A6) > Equivalent Stress

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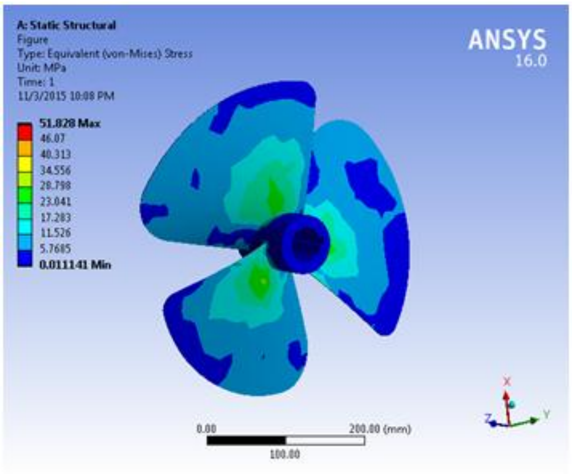
FIGURE 9 Model (A4) > Static Structural (A5) > Solution (A6) > Equivalent Stress > Figure



- **Material Data**
  - nibral

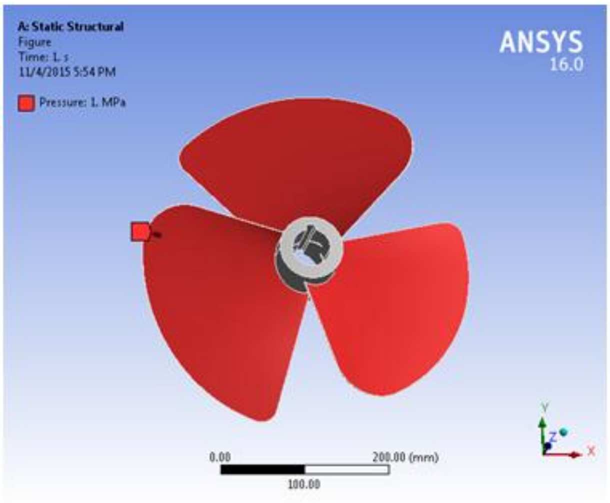


FIGURE 5 Model (A4) > Static Structural (A5) > Solution (A6) > Total Deformation > Figure

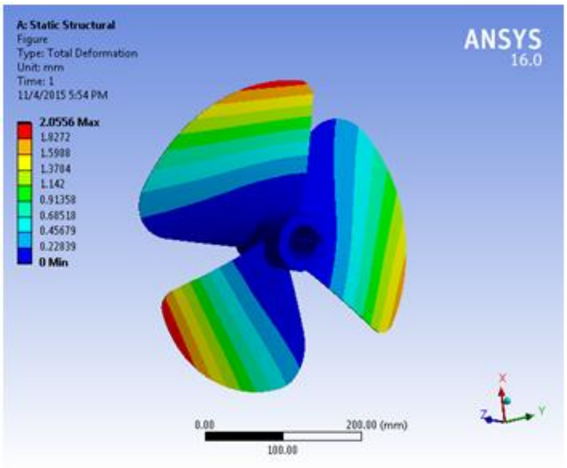


FIGURE 7 Model (A4) > Static Structural (A5) > Solution (A6) > Equivalent Elastic Strain > Figure

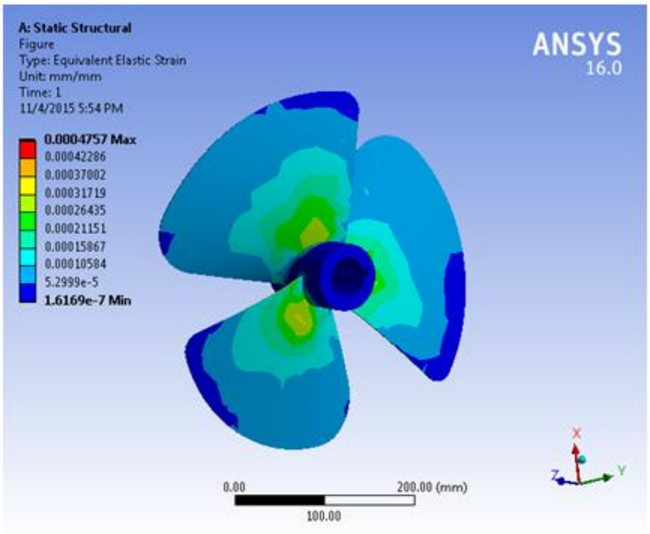


FIGURE 9 Model (A4) > Static Structural (A5) > Solution (A6) > Equivalent Stress > Figure

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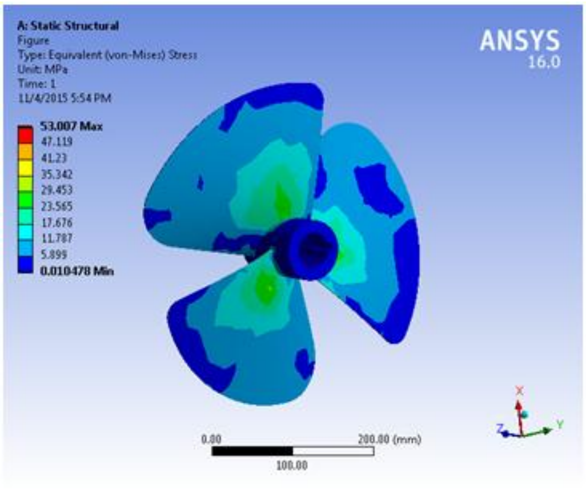

CONCLUSION:

We conclude that Metal matrix composite propellers have more advantages over the conventional metallic propellers. We concentrated on the metal and composite strength analysis of the propeller blade carried out by using the finite element method and there the best results are obtained for Metal matrix Composite than steel by using FEA method.

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