Modeling and Analysis of Propeller Blade for its Strength

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Abstract: **Fiber reinforced composites are finding wide spread use in naval applications in recent times. Ships and under water vehicles like torpedoes submarine etc., these weapons require propeller to drive the vehicle. In general propeller will be used as propulsions and it also used to develop significant thrust to propel the vehicle at its operational speed and rpm 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 multi layer composite propeller. The present work carries out the structural analysis of a CFRP (carbon fiber reinforced plastic) propeller blade which proposed to replace the Aluminum propeller blade. The 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 hydrostatic 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 aluminum and carbon fiber reinforced plastic materials. This work 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 about Fiber Reinforced Plastic 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 aluminum and CFRP.**

Keywords: Carbon Fiber Reinforced Plastic, Aluminum alloy, CATIA software, ANSYS software.

I.INTRODUCTION

Work Material

Fiber reinforced plastics are extensively used in the manufacturing of various structures like radomes, wingtips, stabilizer tips, antenna covers, flight controls 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. Reinforced plastic has a high strength-to-weight ratio and is resistant to mildew and rot. Because it is easy to fabricate, it is equally suitable for other parts of the marine propeller. Reinforced plastic is a sandwich-type material. It is made up of two outer facings and a center layer. The facings are made up of several layers of glass cloth, bonded together with a liquid resin. The core material (center layer) consists of a honeycomb. In 1958 Roger Bacon created high-performance carbon fibers at the Union Carbide Parma Technical Center, now Graphtec International Holdings, Inc., located outside of Cleveland, Ohio. Those fibers were manufactured by heating strands of rayon until they carbonized. This process proved to be inefficient, as the resulting fibers contained only about 20% carbon and had low strength and stiffness properties.

Properties of Carbon Fiber Reinforced Plastic:

- High flexibility
- High tensile strength
- Low weight
- High resistance
- High temperature tolerance
- Low thermal expansion
- Highest strength-to-weight ratio

Aluminum alloy casting is used for the fabrication of propeller blades.

Aluminum properties

- Young’s modulus Ex = 70Gpa
- Young’s modulus Ey = 70Gpa
- Rigidity modulus C = 27Gpa
- Poisson’s ratio (μ_{xy})= 0.29
- Mass density (þ) = 2800 kg/m3
- Damping co-efficient = 0.006

Composite material properties (CFRP)

- Young’s modulus Ex = 180Gpa
- Young’s modulus Ey = l0Gpa
- Poisson’s ratio (μ_{xy})= 0.28
- Shear modulus Gxy = 7. 1 Gpa
- Mass density =1600 kg/m3
- Damping co-efficient = 0.018

Characteristics of CFRP:

Proper selection of the type, amount and orientation of fibers is very important since it influences the following characteristics of a laminate.

- Specific gravity
- Tensile strength and modulus
- Compressive strength and modulus
- Fatigue strength as well as fatigue failure mechanisms
- Damping
- Electrical and thermal conductivities
- High cost

II. LITERATURE SURVEY

Benjamin viney et. Al. [1] has presented the flow around the enshrouded marine propellers operating in the wake of an axisymmetric body is rotational and tridimensional. An inverse method based on the model of inviscid and rotational fluid and coupling two complementary steps (axisymmetric computation +3D panel method) is proposed for the design of the marine propellers. The maridional flow computation leads to the determination of axisymmetric stream sheets as well as the approximate camber surface of the blades and gives a good estimation of the surface of the free vertex wake.. **J.E Connolly et al [2]:** Address the problem of wide blades tried to combine both theoretical and experimental investigations, the author carried out measurements of deflection and stress on models blades subjected to simulated loads, with an aim to develop a theoretical model calibrated against the laboratory experiments, the model was then validated by measurements of pressure and stress distribution on the blade of a full-scale ship propeller at sea. based on the experimental results it was concluded that wide blades subject to tensile stress strength on the face and compression stress of similar magnitude in the back was pointed out that the accuracy of the prediction from the modal depends on the accuracy of the working load determined.

Terge sont vcdt et al [3] has focused on the application of finite element methods for frequency response and improve to the frozen type of hydrodynamic loading The thin shell element of the triangular type and the super parametric shell element are used in the finite element model it presents the realistic an dynamic stresses in marine propeller blades. Stresses and deformations calculated for ordinary geometry and highly skewed propellers are compared with experimental results.

Chang suppler et al [4] have investigated the main sources of propeller blade failures and resolved problem systematically. An FEM analysis is carried out to determine the blade strength in model and full-scale condition and range of safety factor for the propeller under study is determined. **S.javed jalali and farid Taheri et al [5]** Carbon fiber reinforced plastics properties were taken from journal of composite materials. A new test method for the simultaneous evaluation of the longitudinal and the shear module of CFRP was introduced under the proposed method, specimens with different span to depth ratios are subjected to three point bending method. Therefore, we name the method the varying span method. The method builds on the inherent low shear modulus characteristics of CFRP. This characteristics leads to a flexural modules which is a function of L/H. **Charles A. Harper et al [6]** Aluminum material property taken from the hand book of material and process. The non-ferrous metals and alloys offer a wide variety of physical and mechanical properties for using the many industries. Aluminum and its alloys posse’s properties which find wide use in the many industries. Favorable physical properties good strength-weight properties, good corrosion resistance, and low density. Combined with economy in material cost and fabrication cost, make this alloy family a basic material of construction for mechanical assemblies.

III. EXPERIMENTAL DETAILS

MODELING AND ANALYSIS OF PROPELLER BLADE

1. *Wireframe and Surface Modeling 3D:*

CAD programs that feature 3D wireframe and surface modeling create a skeleton-like inner structure of the object being modeled. A surface is added on later. These types of CAD models are difficult to translate into other software and are therefore rarely used anymore.

2. *Solid Modeling*:

Solid modeling in general is useful because the program is often able to calculate the dimensions of the object it is creating. Many sub-types of this exist. Constructive Solid Geometry (CSG) CAD uses the same basic logic as 2D CAD, that is, it uses prepared solid geometric objects to create an object. However, these types of CAD software often cannot be adjusted once they are created. Boundary Representation (Brep) solid modeling takes CSG images and links them together. Hybrid systems mix CSG and Brep to achieve desired design.

3. *CATIA-V5:*

- It is much faster and more accurate.
- Once a design is completed. 2D and 3D views are readily obtainable.
- The ability to changes in late design process is possible.
- It is user friendly both solid and surface modeling can be done.
- It provides a greater flexibility for change. For example if we like to change the dimensions of our model, all the related dimensions in design assembly, manufacturing etc. will automatically change.

- ➢ It provides clear 3D models, which are easy to visualize and understand.
- ➢ CATIA provides easy assembly of the individual parts or models created it also decreases the time required for the assembly to a large extent.

4. *Procedure for Propeller Blade:*

- ➢ Open CATIA V5 R16
- ➢ Close the Product Window
- ➢ Start – Mechanical Design – Wireframe and Surface Design – Enter Part Name as Propeller Blade – OK
- ➢ Now we are in a surface modeling - Select Top (XY) plane – Sketch tool
- ❖ Now we are in sketcher workbench - Draw a circle with 60mm dia – Exit workbench Fig:1
- ❖ Extrude it with 50 mm on both sides. The total 100 mm height as shown in Fig:2

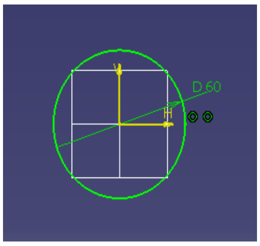


Fig.1

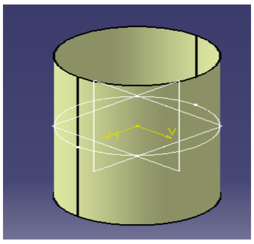


Fig 2

- ❖ Create a point on the right plane at a distance of 30 mm from vertical 4 mm from horizontal as shown in Fig:3
- ❖ Create the helix with 92 mm height and 276 pitch as shown in Fig:4

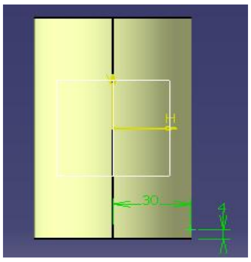


Fig.3

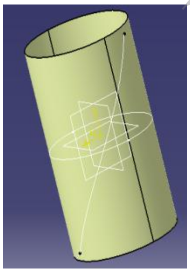


Fig.4

- ❖ 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:6

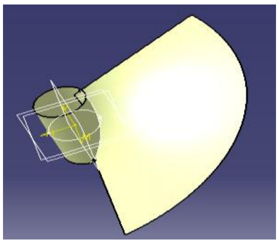


Fig.5

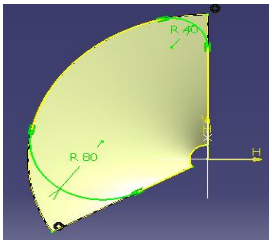


Fig .6

- ❖ Extrude the rounded sketch with supports as shown below in Fig:7

- ❖ Split it with split tool as shown below in fig:8

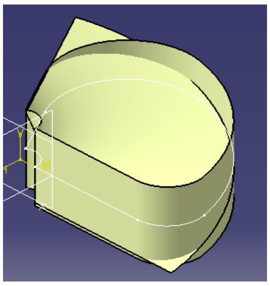


Fig.7

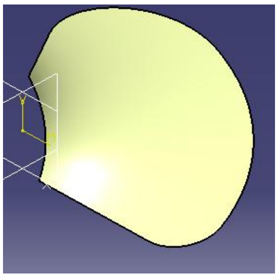


Fig.8

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

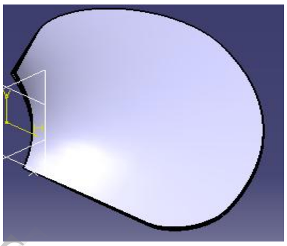


Fig.4.9

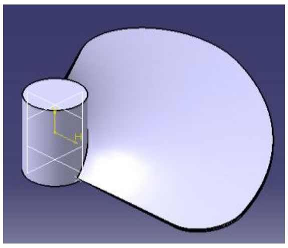


Fig4.10

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

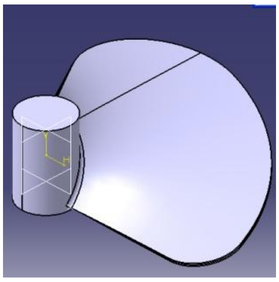


Fig.11

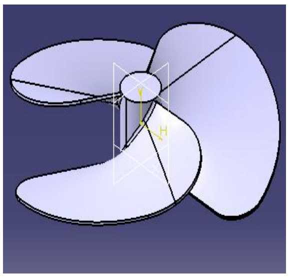


Fig.12

- ❖ Remove the material as shown in fig:13
- ❖ By using pocket tool as shown inFig:14

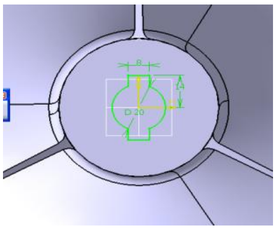


Fig.13

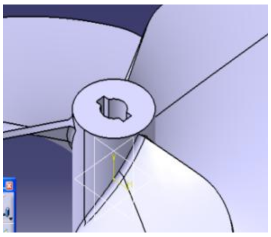


Fig.14

5. *Modeling of Propeller Blade by Using Catiav5:*

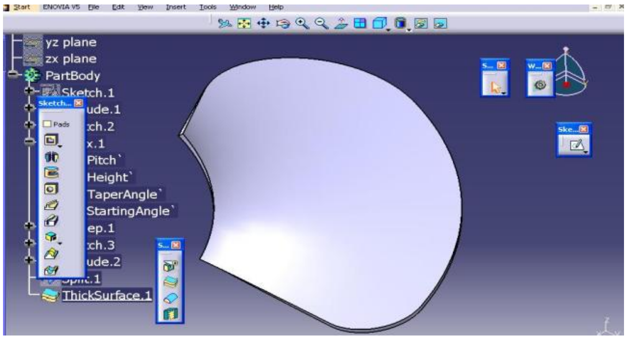


Fig.15 Modeling of Propeller Blade

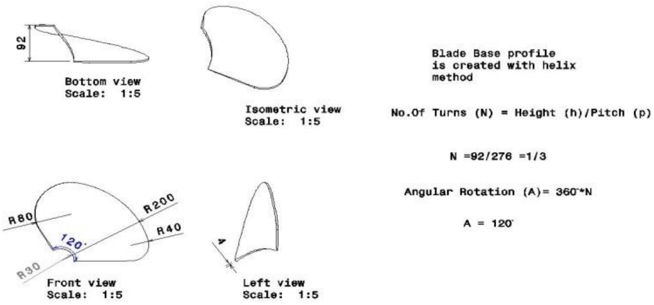


Fig.16 Propeller blade Isometric views

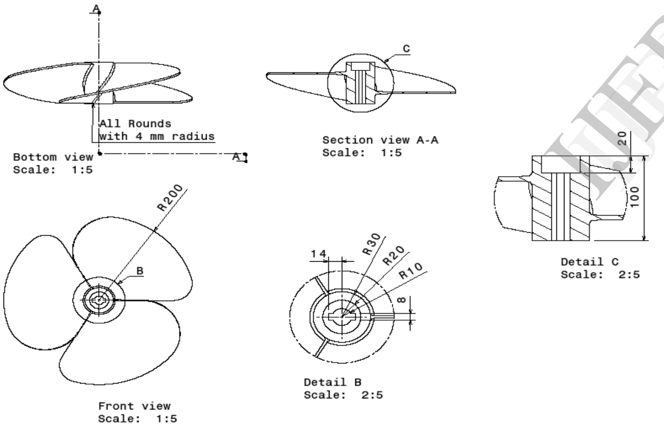


Fig.17 Propeller Blade Isometric views

6. *Model of A Propeller:*

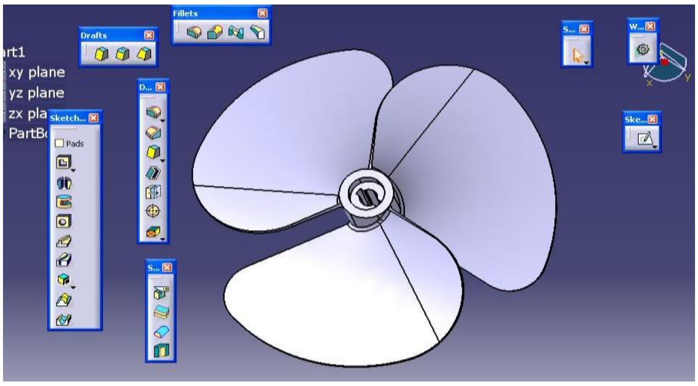


Fig.18 Modeling of Propeller

Modeling of the propeller has been done by using CATIA V5. In order to model the blade, it is necessary to have sections of the propeller at various radii. These sections are drawn and rotated through their respective pitch angles. Then all rotated sections are projected into right circular cylinder of respective radii. Finally the torpedo propeller is first modeled using four-nodded quadrilateral shell element two models are done i.e. aluminum and composite.

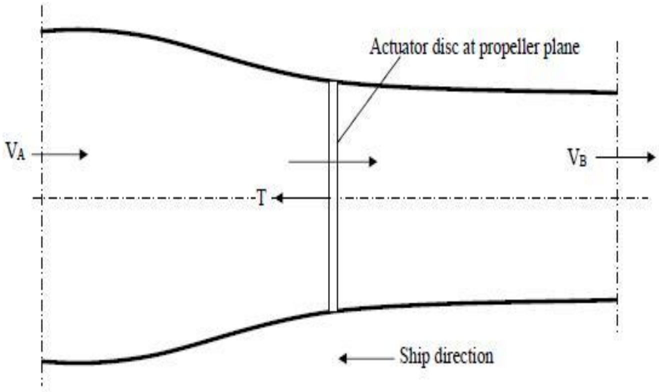


Fig.19 Actuator disc at Propeller plane

This analysis shows compatibility between different approaches to propeller modeling using blade element theory to predict the propeller forces, momentum theory to relate the flow momentum at the propeller to that of the far wake, and a vertical wake model to describe the slipstream deflection. For the axial direction, the change in flow momentum along a stream-tube starting upstream, passing through the propeller, and then moving off into the slip-stream must equal the thrust produced by this propeller. Although wake rotation is now included in the analysis, the assumption that the flow is irrotational has not been lifted. Conserving angular momentum about an axis consistent with the slip-stream’s axis of symmetry can be applied to determine the torque.

7. *Boundary Conditions and Loads:*

The hub of torpedo propeller bolted to the propeller shaft. For the purpose of simulation, around the circumference of hub all translation degrees of freedom arrested. Same boundary conditions are applied for different analysis. Loading conditions are simulated according to type of analysis. For static analysis static load is applied i.e. the load applied on the blade at *1/3* distance from trailing edge that is 4000N structure is stationary. For dynamic analysis loads are varied with time.

Table.1 Geometric characteristics of a propeller blade

r/R	Pitch/diameter	θs(deg) pitch angle	Pitch distribution
0.3	183.135	45.81294	1233.058
0.35	213.6575	43.566	1276.882
0.4	244.18	41.121	1339.383
0.45	274.7025	38.56	1376.869
0.5	305.225	35.869	1386.664
0.55	335.7575	33.413	1391.689
0.6	366.27	31.074	1386.834
0.65	396.7925	28.955	1379.402
0.7	427.315	27.048	1370.859
0.75	457.837	25.391	1365.391
0.8	488.36	23.911	1360.457
0.85	518.8825	22.461	1347.835
0.9	549.405	20.989	1324.343
0.95	579.9275	19.862	1316.302
1.00	610.45	18.814	1301.031

8. *Geometric specification of propeller*

Diameter	: 60 mm
Number of blades	: 3
Hand of operation	: Left hand
Type of propeller	: Controllable pitch propeller
Material	: Aluminum alloy casting, FRP material.
Weight of aluminum propeller	: 2.35 kg.
Weight of composite propeller	: 1.85 kg.
Root round radius on face and back	: 80mm and 40mm.
Tip thickness	: 4mm.

9. *Calculations:*

Total Area Of the circle = πR^2
$= 3.141 \times 30^2$
$= 2826.9 \text{ mm}^2$

Total Blade Area $= \pi r^2 \times$ DAR
$= 2826.9 \text{X} 0.92$
$= 2600.748 \text{ mm}^2$

(DAR = TBA/TAC = 2600.748/2826.9=92 %)
Therefore DAR = Disc area Ratio

Relationship between Pitch & Pitch Angle
Formula: Pitch(P) = 2π r X Tan a
Where: (θ) = pitch angle and r = radius and π =3.14159
Pitch Angle(θ) = 120^0
Pitch(P) = 326.318 mm

Speed = (RPM/Ratio)(Pitch/C)(1-S/100)
Speed=(1000/0.5X326.316/1)(1-0/100)
assume Ratio=1/2,
Speed = $652636\text{X}60/10^6$ 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

$= 2600.74 \times 10^{-6} \times 39.1581 \times 10^3$
$= 101.840 \text{ m}^3/\text{hr}$

Thrust (T) = m x ($V_B - V_A$) = $101.840 \times 39.1581 \times 10^3$
(T) = 3987860.9 N
(T) = 3.98 MN

IV. RESULTS AND DISCUSSION

Modal Analysis:

A Modal analysis determines the vibration charactactrartics (natural frequencies and corresponding mode shapes) of a structure or a machine component. It can serve as a starting point for other types of analysis by detecting unconstrained bodies in contact analysis or by indicating the necessary time step size for a transient analysis, for example. In addition the modal analyses results may be used in a downstream dynamic simulation employing mode. Super position methods, such as harmonic response analysis random vibration analysis or a spectrum analysis. The natural frequencies and mode shapes are important parameters in the design of a structure for a dynamic loading condition.

❖ Add a modal analysis template by dragging the template from the tool box in to the project schematic or by double clicking the template in the tool box.

❖ Load the geometry by right clicking on the geometry cell and choosing import geometry.

❖ View the geometry by right clicking on the model cell. Alternatively, you can right click the set up cell and select edit. This step will launch mechanical application.

❖ In the mechanical application window, complete modal analysis using the mechanical applications tools and features. See modal analysis in the mechanical application help for more information on conducting a modal analysis in the mechanical application.

Static Structural Analysis:

A Static structural analysis determines the stress, displacements, strains, forces in structures or components caused by loads that do not induced significant inertia and damping effects. Steady loading and response conditions are assumed; that is, the loads and the structure's response are assumed to vary slowly with respect to time.

❖ Add a static structural analysis template by dragging the template from the tool box into the project schematic or by double clicking the template in the tool bars.

❖ Load on the geometry by right clicking on the geometry cell and choosing import geometry.

❖View the geometry by right clicking on the modeling cell and choosing edit or double clicking the model cell alternatively you can right click the set up cell and select edit. This step will touch the mechanical application.

- The mechanical application window, complete static structural analysis using the mechanical applications tools and features.

Generic Steps to Solving any Problem in ANSYS:

Like solving any problem analytically, you need to define (1) solution domain, (2) the physical model, (3) boundary conditions and (4) the physical properties. You then solve the problem and present the results. In numerical methods, the main difference is an extra step called mesh generation. This is the step that divides the complex model into small elements that become solvable in an otherwise too complex situation. Below describes the processes in terminology slightly more attune to the software.

Build Geometry: Construct a two or three dimensional representation of the object to be modeled and tested using the work plane co-ordinate system within ANSYS.

Define Material Properties: Now that the part exists, define a library of the necessary materials that compose the object (or project) being modeled. This includes thermal and mechanical properties.

Generate Mesh: At this point ANSYS understands the makeup of the part. Now define how the modeled system should be broken down into finite pieces.

Apply Loads: Once the system is fully designed, the last task is to burden the system with constraints, such as physical loadings or boundary conditions.

Obtain Solution: This is actually a step, because ANSYS needs to understand within what state (steady state, transient… etc.) the problem must be solved.

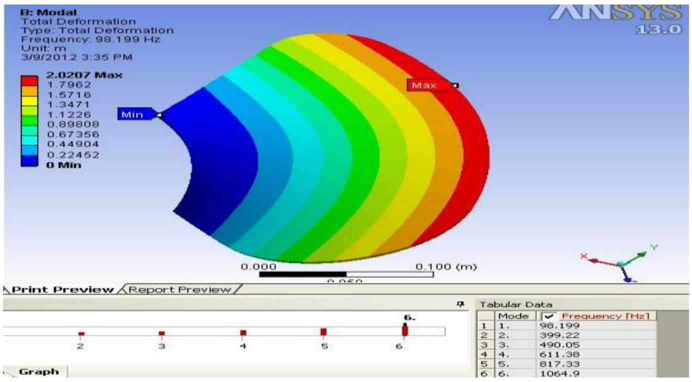
Present the Results: After the solution has been obtained, there are many ways to present ANSYS' results, choose from many options such as tables, graphs, and contour plots.

IV.1. MODAL ANALSYS

1. *ALUMNIUM*

Table IV.1 Frequency Table

S.NO	MODE	FREQUENCY(Hz)
1	1	98.199
2	2	399.22
3	3	490.05
4	4	611.38
5	5	817.33
6	6	1064.9


B: Modal
Total Deformation
Type: Total Deformation
Frequency: 98.199 Hz
Unit: m
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Tabular Data

	Mode	Frequency [Hz]
1	1.	98.199
2	2.	399.22
3	3.	490.05
4	4.	611.38
5	5.	817.33
6	6.	1064.9

Fig IV.1 Deformation of Aluminum Propeller blade

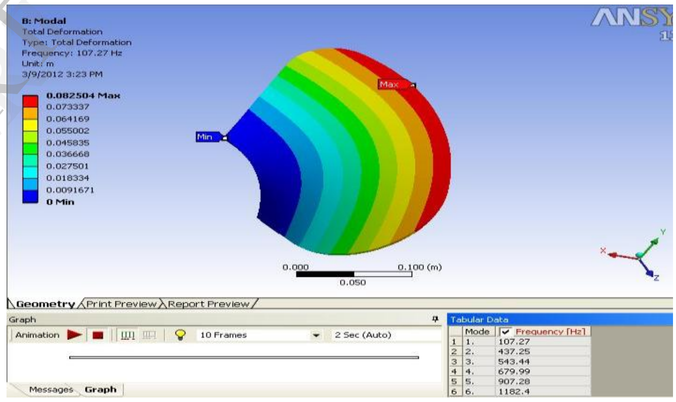
The load applied on the blade at 1/3rd distance from tip end that is 4000N as shown in Fig 5.1. The boundary conditions are Ux=0, Uy=0, Uz= 0, Mx=0, My=0, Mz=0. i.e., translation and rotation about X, Y and Z axis were fixed around the circumference of the propeller. If the propeller blade is considered as cantilever fixed at hub end and free at the other end, the deformation cantilever beam will be maximum at free end (2.02mm) and zero at the fixed end. These deformations are as shown in Fig.IV.1

Similarly the bending stress for cantilever beam will be maximum at the fixed end and minimum at the free end. It shows that the variation of stresses from tip to root. From the above stress plots it was observed that the stress developed in the propeller blade are well within the limits of yield strength of (279.3N/mm^2). So the propeller may not have elastic failure and it was also proved experimentally.

2. *Carbon Fiber Reinforced Plastic*

Table.IV.2 Frequency Table:

S.NO	MODE	FREQUENCY(Hz)
1	1	107.27
2	2	437.25
3	3	543.44
4	4	679.99
5	5	907.28
6	6	1182.4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Total Deformation
Type: Total Deformation
Frequency: 107.27 Hz
Unit: m
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Tabular Data

	Mode	Frequency [Hz]
1	1.	107.27
2	2.	437.25
3	3.	543.44
4	4.	679.99
5	5.	907.28
6	6.	1182.4

Fig IV.2 Deformation of composite Propeller blade

The load applied on the blade at 1/3rd distance from tip end that is 4000N as shown in Fig IV.2. This load can be taken from experimentally proved results. The boundary conditions are translation and rotations about X, Y and Z axis were fixed around the hub circumference of the propeller. Similarly the composite propeller blade was considered as cantilever that is fixed at one end and free at other end. Since the bending stress for cantilever beam will be max at the free end (0.082 mm) and zero minimum at the fixed end. Bending stresses obtained for composite propeller as shown in Fig IV.2

Similarly the bending stress for cantilever beam will be maximum at the free end and minimum at the fixed end. It shows that the variation of stress from tip to root. Static analysis of propeller blade the stress obtained in each lamina was less than the allowable working stresses of CFRP laminate. A stress (181.6N/mm2) comes within the limits of allowable working stresses i.e. the propeller was safe and it was also proved experimentally.

DEFAULT MESH:

1. ALUMINIUM

Table IV.3 Stress and strain values

ELEMENTS: 15130

NODES: 36035

GRAPHS:

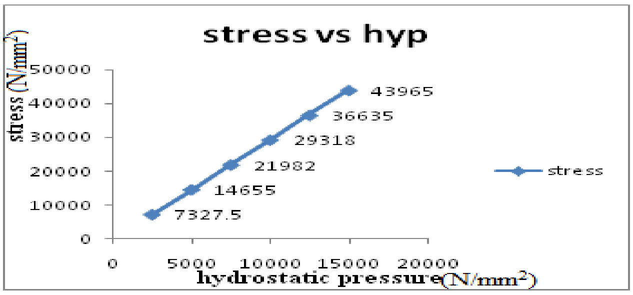


Figure IV.3 Stress Vs hydrostatic pressure profiles

The aluminum propeller in which the hydrostatic pressure is gradually applied as in the above Figure. The centrifugal and gravity body forces are applied once at the start of the loading. In this large strain nonlinear analysis, the size of the time steps for applying the load increments is calculated iteratively to satisfy the convergence criterion. Figure 5.3 shows the distribution of von-Mises stress of aluminum propeller over the face of the blade.

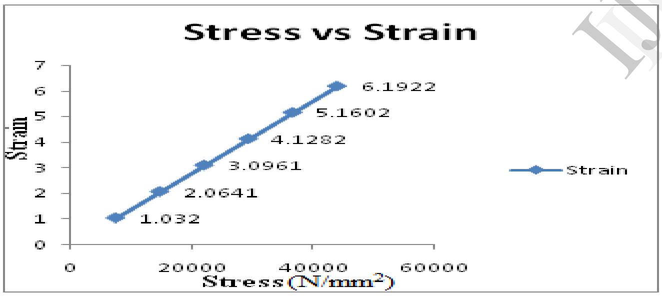


Figure IV.4 Various points of stress strain curve

The stress-strain curve characterizes the behavior of the material tested. It is most often plotted using engineering stress and strain measures, because the reference length and cross-sectional area are easily measured. Stress-strain curves generated from tensile test results help gain insight into the constitutive relationship between stress and strain for a particular material.

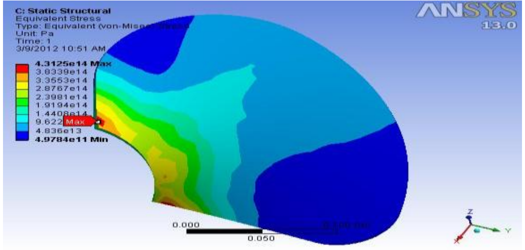


Fig IV.5 Von-Mises stresses of Aluminum Propeller blade

The load applied on the blade at 1/3rd distance from tip end that is 4000N. The boundary conditions are translation and rotations about X, Y and Z axis were fixed around the hub circumference of the propeller. Similarly the composite propeller blade was considered as cantilever that is fixed at one end and free at other end. Since the bending stress for cantilever beam will be max. At the fixed end and minimum at the free end. Bending stresses obtained for composite propeller as shown in Fig IV.5.

2. CARBON FIBER REINFORCED PLASTIC:

Table IV.4 Stress and strain values

1.ALUMINIUM		
Hydrostatic pressure (N/mm^2)	Stress (N/mm^2)	Strain
2500	7327.5	1.032
5000	14655	2.0641
7500	21982	3.0961
10000	29318	4.1282
12500	36635	5.1602
15000	43965	6.1922

GRAPH:

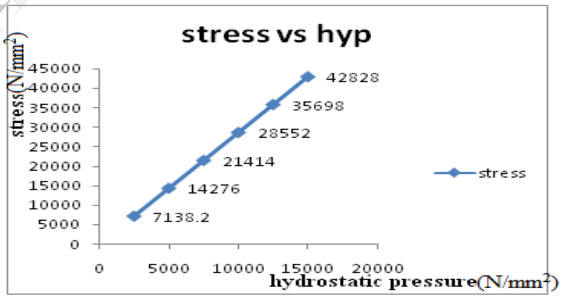
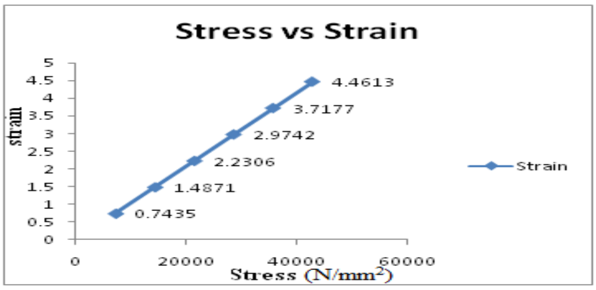


Figure IV.6 Stress Vs hydrostatic pressure profiles

This shows the severity of the hydrodynamic pressure on the surface piercing propeller. Since the stress hardening behavior of stainless steel is taken into account, the stress exceeds the yield strength when the plastic strain occurs due to the increase of the load. The yielding of some small regions on the edges of the blade does not mean the failure of the blade but it may cause the gradual failure of the blade as fatigue cracking. The maximum deformation of the blade at full pressure.



FigureIV.7 Various points of stress strain curve

The stress-strain curve characterizes the behavior of the material tested. It is most often plotted using engineering stress and strain measures because the reference length and cross-sectional area are easily measured. Stress-strain curves generated from tensile test results help gain insight into the constitutive relationship between stress and strain for a particular material. Distribution of displacement over the back of the blade at full pressure on the leading edge. It is observed that the maximum stress at some small regions of the trailing and leading edges surpasses the yield strength of the metal.

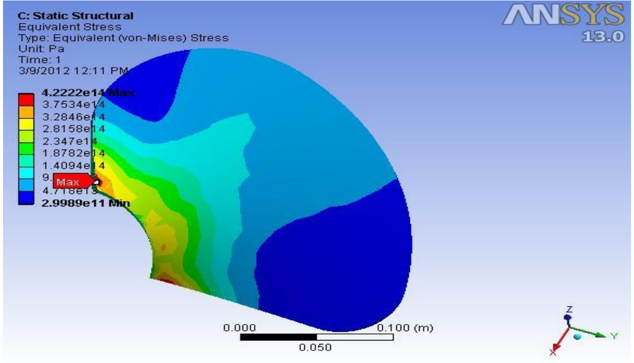


Fig IV.8 Von-Mises stresses of composite Propeller blade

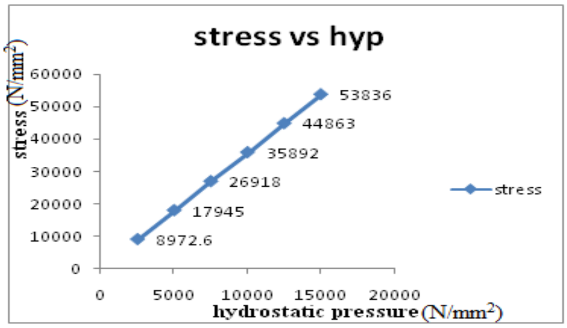
The von-Mises bending stresses shown in Fig5.8. It shows that the variation of stress from tip to root. Static analysis of propeller blade the stress obtained in each lamina was less than the allowable working stresses of CFRP laminate. A stress comes within the limits of allowable working stresses i.e. the propeller was safe and it was also proved that.

<u>AT MESH.1</u>

1. ALUMINIUM:

Table IV.5 Stress and strain values

GRAPH:



FigureIV.9 Stress Vs hydrostatic pressure profile

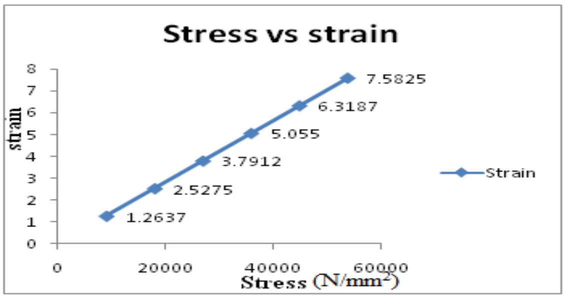


Figure.IV.10 Various points of stress strain curve

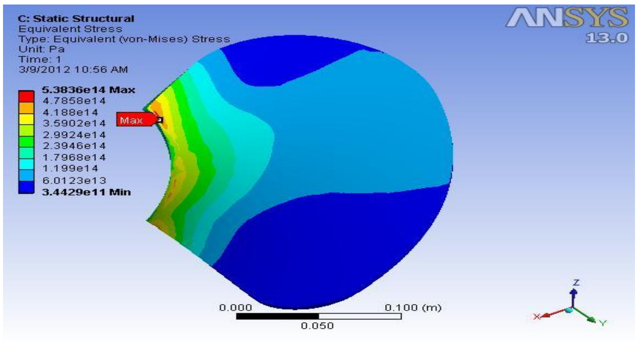


Fig IV.11 Von-Mises stresses of Aluminum Propeller blade

2. CARBON FIBER REINFORCED PLASTIC:

Table IV.6 Stress and strain values

ELEMENTS: 71430

NODES: 147120

<table>
<tr><td>Hydrostatic pressure (N/mm²)</td><td>Stress (N/mm²)</td><td>Strain</td></tr>
<tr><td>2500</td><td>9019.8</td><td>939.56</td></tr>
<tr><td><table>
<tr><td>Hydrostatic pressure (N/mm²)</td><td>Stress (N/mm²)</td><td>Strain</td></tr>
<tr><td>2500</td><td>8972.6</td><td>1.2637</td></tr>
<tr><td>5000</td><td>17945</td><td>2.5275</td></tr>
<tr><td>7500</td><td>26918</td><td>3.7912</td></tr>
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<tr><td>12500</td><td>44863</td><td>6.3187</td></tr>
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GRAPHS:

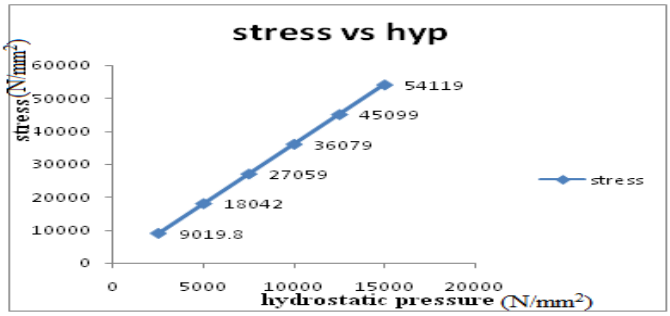

Figure IV.12 Stress Vs hydrostatic pressure profiles

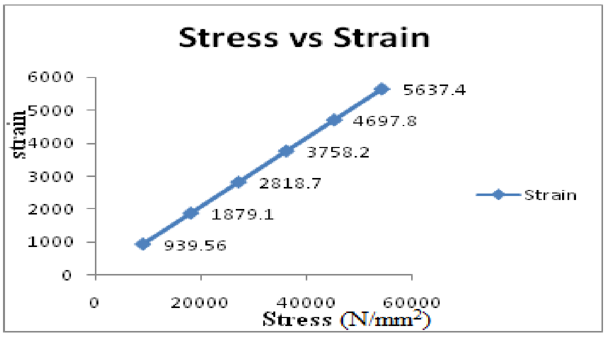

Figure IV.13 Various points of stress strain curve

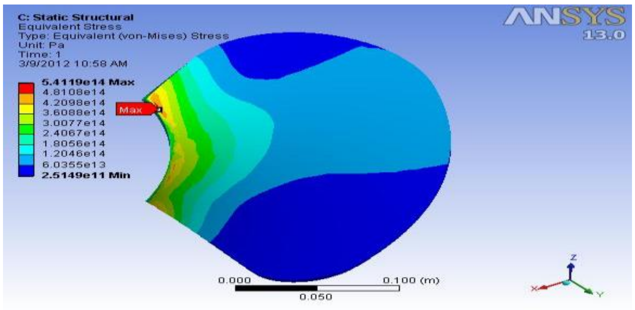

Fig IV.14 Von-Mises stresses of composite Propeller blade

AT MESH.2

1. ALUMINIUM

Table IV.7 Stress and strain values

ELEMENTS: 88373

NODES: 180862

1.ALUMINIUM		
Hydrostatic pressure (N/mm^2)	Stress (N/mm^2)	Strain
2500	8434.7	1188
5000	16869	2376
7500	25304	3564
10000	33739	4752
12500	42174	5940
15000	50608	7128

GRAPHS

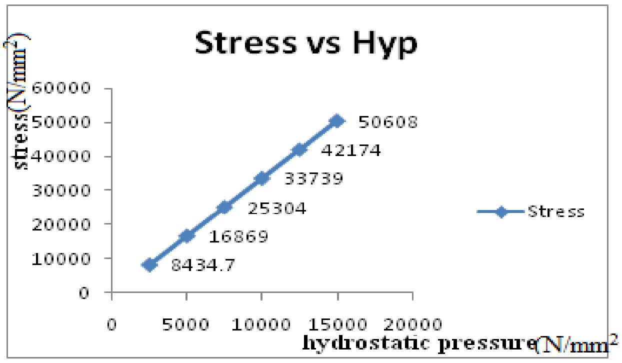

Figure IV.15 Stress Vs hydrostatic pressure profiles

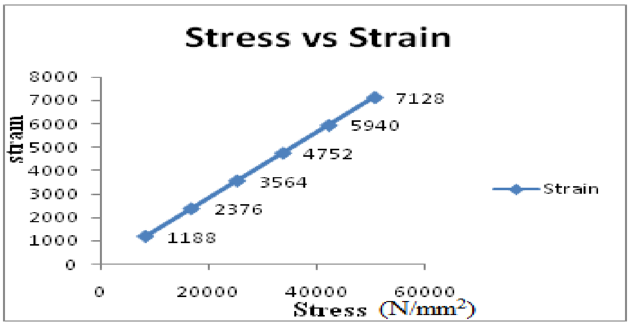

Figure IV.16 Various points of stress strain curve

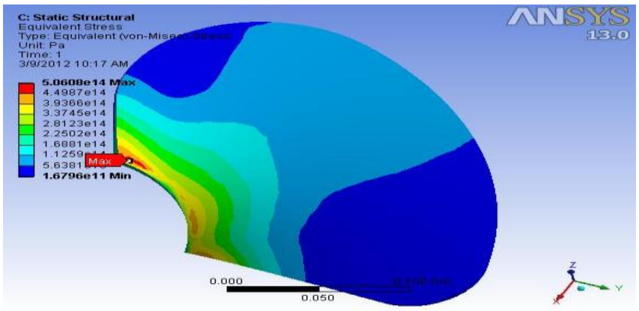

Fig IV.17 Von-Mises stresses of Aluminum Propeller blade

2. CARBON FIBER REINFORCED PLASTIC:

Table IV.8 Stress and strain values

ELEMENTS: 88373

NODES: 180862

Hydrostatic pressure(N/mm^2)	Stress (N/mm^2)	Strain
2500	8376.28	872.52
5000	16752	1745
7500	25129	2617.6
10000	33505	3450.1
12500	41887	4362.6
15000	50257	5235.1

GRAPHS:

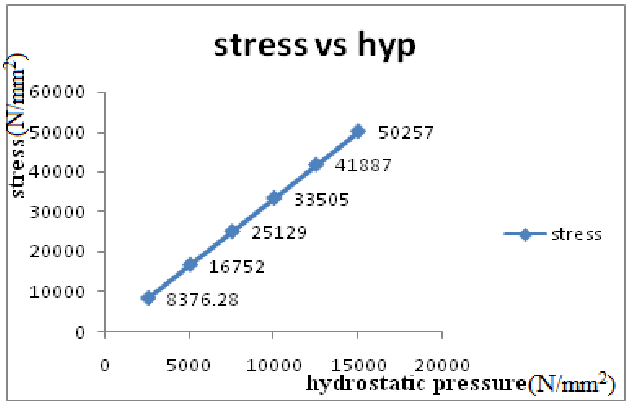

Figure IV.18 Stress Vs hydrostatic pressure profiles

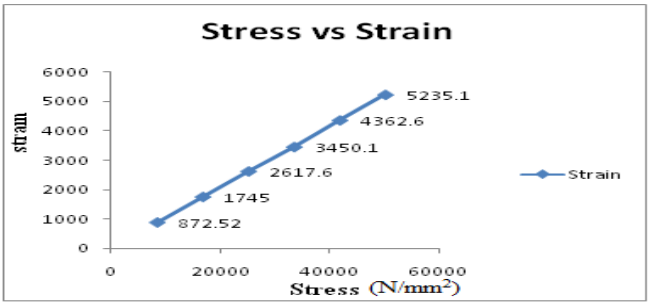

Figure IV.19 Various points of stress strain curve

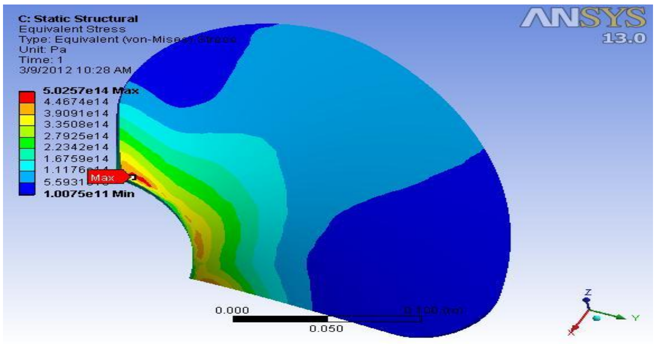

Fig IV.20 Von-Mises stresses of composite Propeller blade

V.CONCLUSIONS

From the output results of structural static analysis and modal analysis of propeller blade, it is concluded as follows.

1. The boundary conditions which was taken correct as per the values of bending stress and deformations. The deformations for cantilever beam will be maximum at free end and zero at the fixed end. It was assumed that the blade was cantilever beam fixed at the hub end.

2. Model analysis is carried out on both aluminum and composite propellers it was observed maximum displacement for composite propeller is less than the Aluminum propeller.

3. Structural analysis is carried out on both aluminum and composite propellers it was observed maximum displacement for composite propeller is less than the aluminum propeller.

4. The natural frequencies of aluminum and composite propeller were compared. The natural frequencies of Aluminum propeller were found 9 % more than the composite propeller.

Frequency obtained from FEA analysis Aluminum=98.19 Hz

Frequency obtained from FEA analysis Composite=107.27 Hz

5. From the above results the design values taken are satisfying the conditions the same blade parameters can be used for the strength analysis of CFRP material propeller.

6. From the stress plots it is observed that the stress developed in aluminum propeller blade are well within the limits of yield strength for isotropic materials (279.3N/mm^2). So that the propeller may not have elastic failure and it was also proved experimentally.

7. From static analysis of CFRP propeller blade the stress obtained in each lamina was less than the allowable working stress of CFRP laminate (181.6N/mm^2). So that propeller was safe for giving static load.

8. The weight of the composite propeller is 42% less than the aluminum propeller.

Aluminum propeller weight=2.35Kgs
Composite propeller weight= 1.8Kgs

9. We concentrated on the metal and composite strength analysis of the propeller blade carried out by using the finite element method.

Future Scope of Work:

1. The present work consists only structural static analysis and modal analysis, which can be carried for dynamic analysis like frequency spectrum. In case of both aluminum and composite materials to find out the noise reduction.

2. There is also a scope of future work to be carried out for different types of materials. For present purpose only analysis of a propeller blade is carried only for CFRP materials.

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