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Structural, Critical Load and Thrust Analysis on Ship Propeller

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ABSTRACT

A propeller is a sort of fan that communicates power by changing over rotational movement into push. A weight contrast is created between the forward and back surfaces of the airfoil- formed sharp edge, and a liquid, (for example, air or water) is quickened behind the sting. Propeller elements can be demonstrated by both Bernoulli's rule and Newton's third law. A marine propeller is in some cases casually known as a screw propeller or screw. Marine ducted propellers are pivoting conduit fan that are utilized on pulls and fishing boats which makes a more noteworthy propulsive push power to drive over a water medium on overwhelming working condition in harbor. This paper advances with thorough data of marine ducted propeller. Which sharp edge made of aluminium composite and channel of amalgam steel is planned and dissected with different cutting edge developments 3-edge, 4-balde, 5-edge and 6-edge independently. The exhibitions of every sharp edge independently to show which cutting edge performs productively better with greatest speed rate under smooth out movement on water at dynamic condition. Ducted propeller is demonstrated in strong works. Hydrostatic and hydrodynamic investigations of every sharp edge are performed with ANSYS workbench. The current work is coordinated towards the investigation of marine propeller working and its wording, reproduction and stream re-enactment of marine propeller has been performed. The von misses stresses, resultant miss happening, strain and zones underneath factor of security has been shown.

1. Introduction

A propeller is a pivoting fan like structure which is utilized to move the boat by utilizing the force created and communicated by the primary motor of the boat. The communicated power is changed over from rotational movement to create a push which gives energy to the water, bringing about a power that follows up on the boat and pushes it forward.

A boat moves based on Bernoulli's guideline and Newton's third law. A weight contrast is made on the forward and toward the back side of the sharp edge and water is quickened behind the edges.

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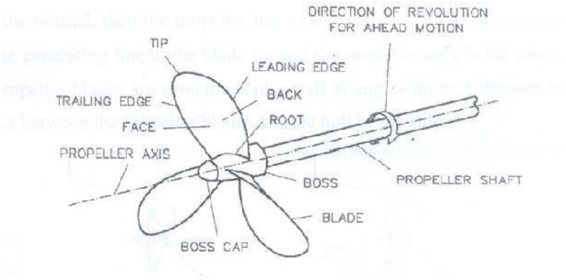
1.1 Description of Propeller



1.2 Basic Definitions of Propeller

Propeller: The propeller is that segment of the boat which changes over the motor force into the main impetus of the boat.

Propeller Blades Twisted balances or thwarts that jut from the propeller center. The state of the sharp edges and the speed at which they are driven directs the force a given propeller can convey.

Center The center of a propeller is the strong focus plate that mates with the propeller shaft and to which the edges are appended. In a perfect world the center ought to be as little in measurement as conceivable to get most extreme push.

Sharp edge Root The base of a propeller edge is the place the edge joins to the center.

Sharp edge Tip. The tip is the peripheral edge of the cutting edge at a point uttermost from the propeller shaft.

Chief: The supervisor is the focal some portion of a propeller to which the sharp edges are connected.

Face: The essence of a sharp edge is viewed as the high-pressure side, or weight face of the edge. This is the side that faces rearward (in reverse) and pushes the water when the vessel is in forward movement. The substance of a propeller sharp edge is the surface seen when seen from toward the back.

Back: The rear of the sharp edge is the low weight side or the attractions face of the cutting edge. This is the side that faces upstream or towards the front of the vessel. the contrary surface of the face is known as the rear of the propeller.

Driving edge: the main edge of the sharp edge is that edge which drives the edge through the water while creating ahead push.
Following edge: The contrary edge to the main edge is named as the following edge.

Tip: The tip of a sharp edge is the point on the edge found farthest from the focal point of the propeller.

Propeller width: The propeller distance across is the breadth of the chamber which contains the propeller and has its pivot incidental with the propeller hub.

Pitch: Advance per unrest of the helical surface characterizing the substance of the propeller is known as its (face) pitch. The pitch of a propeller is characterized comparatively to that of a pitch of machine screw. It demonstrates the separation the propeller would "drive forward" for each full pivot. The separation the boat is pushed forward in one propeller pivot is in reality not exactly the pitch. The contrast between the ostensible pitch and the genuine separation went by the vessel in one revolution is called slip.

Plate territory: The plate region is the zone of the hover going through the tips of the sharp edges in a plane typical to propeller hub.

Harmony: The separation between the main edge (nose) and the following edge (tail) estimated along the standard of the area of the propeller sharp edge at any sweep, of a hydrofoil or aerofoil.

Camber: The most extreme separation between the camber line and a line joining the main edge (nose) and the following edge (tail) of the segment a propeller cutting edge at any span, of a hydrofoil or aerofoil.

Camber line: The middle or mean line between the face and the rear of the segment of a propeller edge at any sweep, or of a hydrofoil or aerofoil.

Root: The segment at which the propeller sharp edge is connected to chief or center of the propeller.

2. DESIGN OF MARINE SHIP PROPELLER

Propeller structure examination planned for acquiring least force necessities, cavitations, commotion, vibration and greatest effectiveness conditions at a sufficient upset. Two strategies are typically utilized in propeller plan:

a. Use of charts acquired from untamed water propeller tests for precise propeller arrangement.

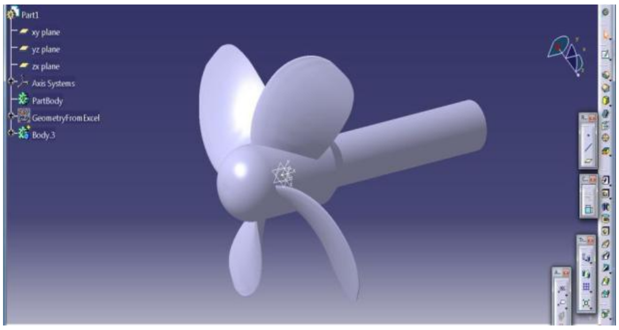
b. The utilization of numerical strategies (Lifting line, lifting surface, vertex cross section, limit component technique) in view of flow hypothesis. This work covers the principal plan technique as it were.

2.1 Practical Design Approach for 4-Blade Propeller

The initial design variable requirements of the propeller are given below:

1. Delivered power (KW)
2. Propeller rate of rotation (rpm)
3. Speed of ship (m/s)
4. Number of blades
5. Taylor's wake friction (*w*).

3. MODELING OF PROPELLER



Before utilizing sketch select the plane of the CATIA show and afterward go to outline. So that producing of face should be possible in CATIA. Draw the drawing which is having an exact measurement at that point convert to three dimensional strong.

Displaying of the propeller is finished utilizing CATIA V5-6 R 2016. So as to show the sharp edge, it is important to have segments of the propeller at different radii. These areas are drawn and pivoted through their separate pitch edges. At that point every single turned area is anticipated onto right round chambers of particular radii as appeared in above. Presently by utilizing multi segment surface choice, the sharp edge is displayed.

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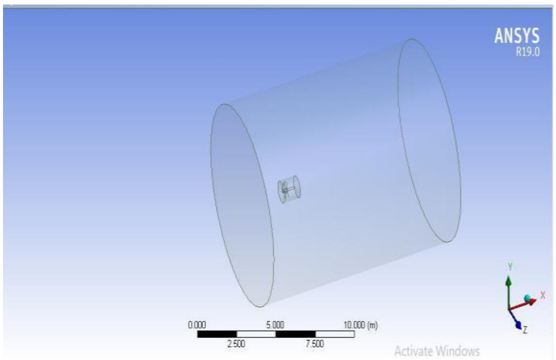
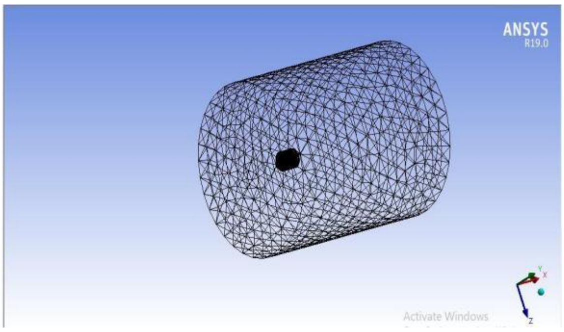
4. ANALYSIS OF SHIP PROPELLER

After the modelling is completed, then the drawn model is imported to ansys.



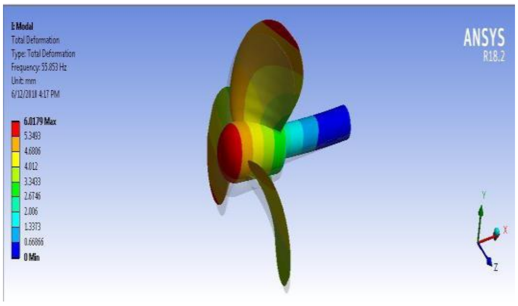
Fluid domain created in ANSYS



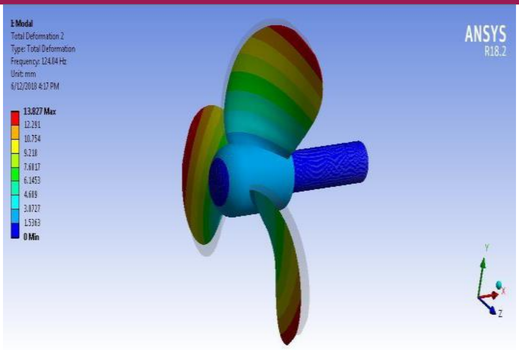
Solid Mesh

Solid mesh 200 elements are used to divide the geometric body in to small strips (Finite elements). In the present work, the entire ship propeller components are divided into 20276 tetrahedron elements and 5261 nodes.

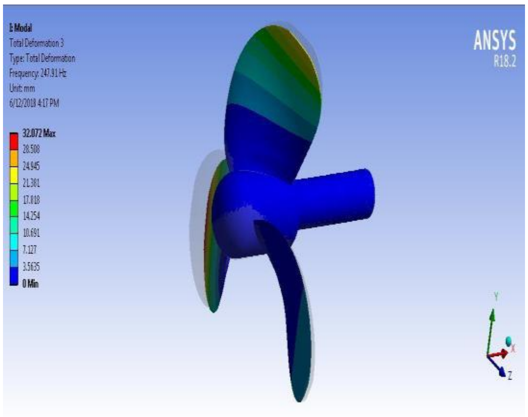
5. MODAL ANALYSIS



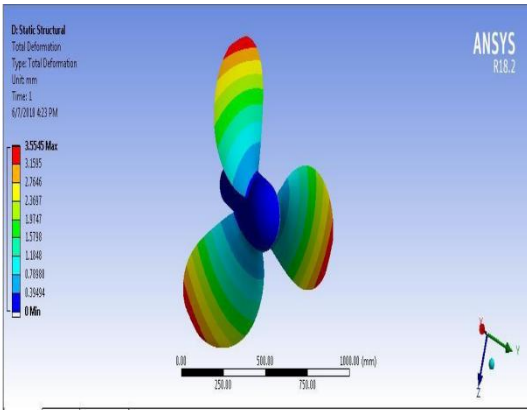
1stmode of 3blade ship propeller



2nd mode of 3 blade ship propeller



3rd mode of 3 blade ship propeller



Deformation on 3 blade ship propeller

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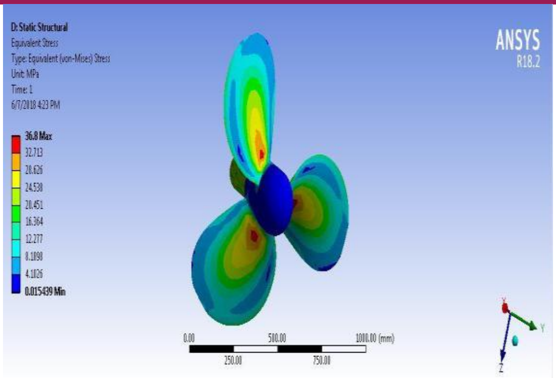
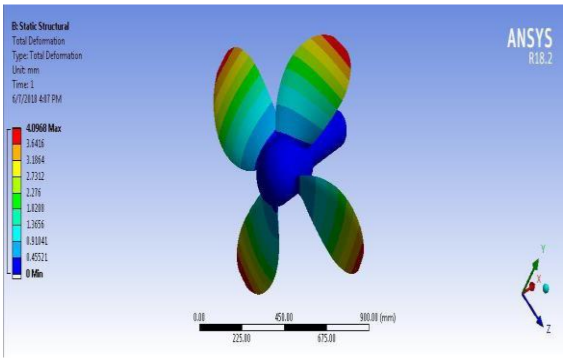
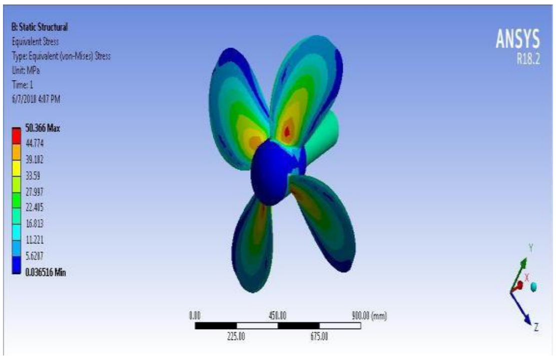


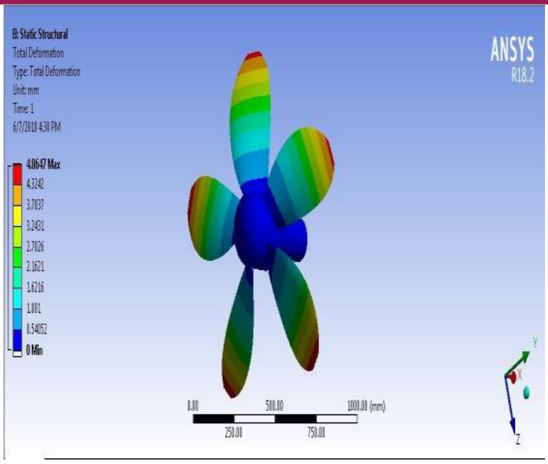
Stresses on 3 blade ship propeller



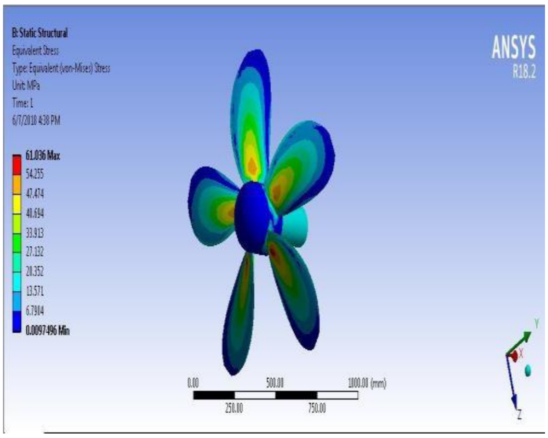
Deformation on 4 blade ship propeller



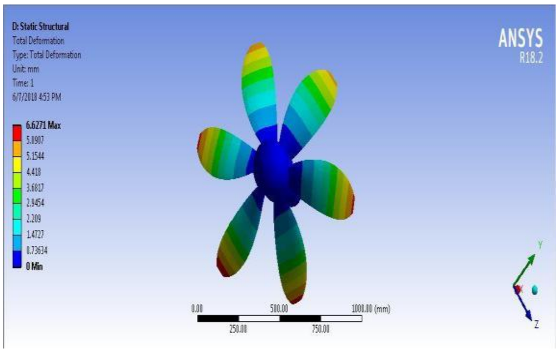
Stresses on 4 blade ship propeller



Deformation on 5 blade ship propeller



Stresses on 5 blade ship propeller



Deformation on 6 blade ship propeller

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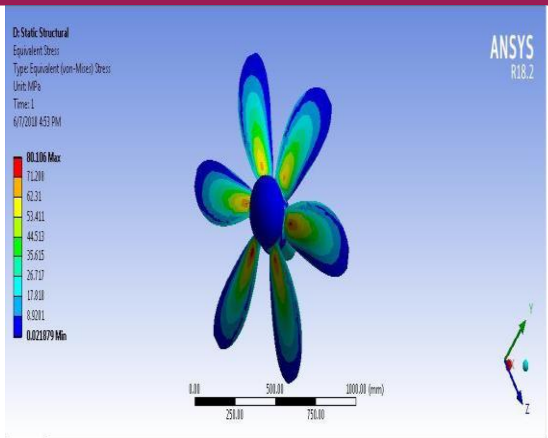


Stresses on 5 blade ship propeller

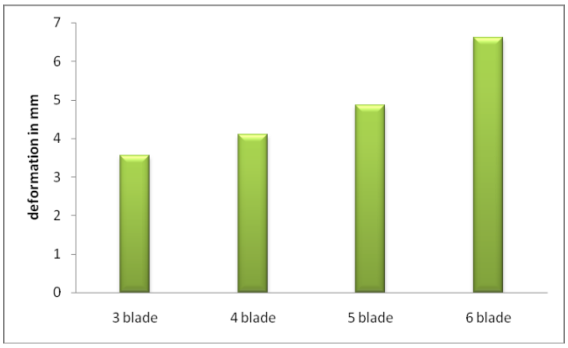
6. RESULTS AND DISCUSSION

Dynamic hydraulic pressure loading is considered such as 0.3 MPa. In static structural analysis

results	3 blade	4 blade	5 blade	6 blade
deformation	3.55	4.09	4.86	6.62
stress	36.8	50.36	61	80.1

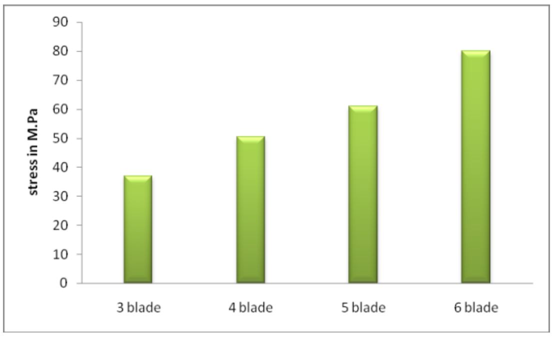
The above table shows the maximum deformation and von-mises stresses of ship propeller due to hydro dynamic pressure. Here maximum deformation occurred at tip of blade.

Maximum stresses are available at hub support of propeller



Graph 1:deformation of ship propeller

The above graph shows the deformation of ship propeller at different number of blades. Here if we increase the number of blades the deformation increases. And maximum deformation is observed at 6 number of blade as 6.62 mm. deformation increase as 13%, 26 % and 46.3% for four, five and six blades as compared to three blades.



Graph 2: von-mises stresses of ship propeller

The above graph shows the stress of ship propeller at different number of blades. Here if we increase the number of blades the stress also increases. And maximum stress is observed at 6 number of blade as 80 M.Pa . Deformation increase as 26%, 39 % and 54% for four, five and six blades as compared to three blades.

no blades	mass flow	inlet velocity	outlet velocity	Thrust
3 blade	6515	8.3	6.12	14202.7
4 blade	6515	8.3	6.09	14398.15
5 blade	6515	8.3	6.06	14593.6
6 blade	6515	8.3	6.04	14723.9

Thrust results for propeller blades

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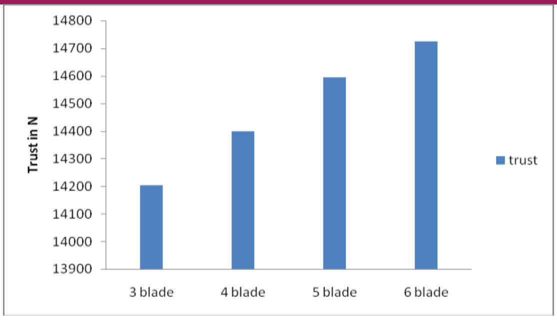
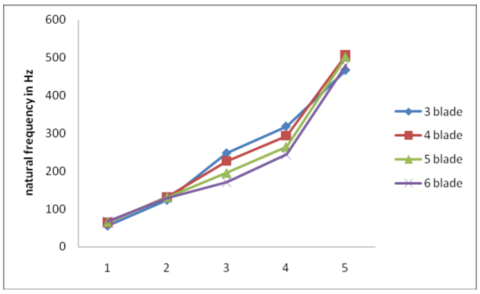


Thrust results for propeller blades

The above graph shows the Thrust calculations of ship propeller at different number of blades. Here if we increase the number of blades the Thrust also increases. And maximum Thrust is observed at 6 number of blade as 14.7 KN

mode no	3 blade	4 blade	5 blade	6 blade
1	55.8	64	65.4	66.7
2	124	131.9	130.8	128.7
3	247.9	226.7	195	170.6
4	318.3	293.7	263.9	243.2
5	466.3	506.8	501.4	479.6

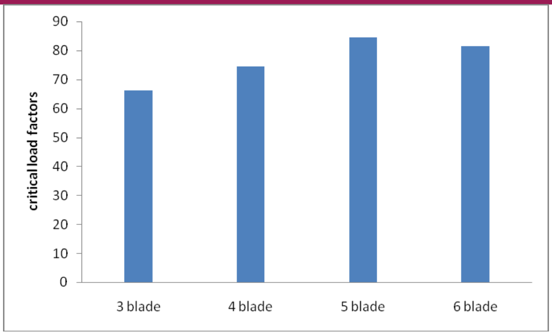
Natural frequencies of propeller blades.



Natural frequencies of propeller blades

blade no	critical load
3 blade	66.1
4 blade	74.47
5 blade	84.5
6 blade	81.4

Critical load multipliers of propellers



Critical load factors

7. CONCLUSION

In this present work, the analysis of ship propeller is concluded as following steps

1. Design
2. Hydrodynamic Pressure
3. Structural analysis
4. Modal analysis
5. Critical load analysis
6. Thrust analysis

1. Design

Design plays a very important role in propeller because it has complex shapes and from the reviewed articles the thickness of each cross section at different percentage of radius is calculated and the maximum thickness has been observed at root of blade that is 25mm . Thickness is mainly considered to reduce or increase the weight and strength of propeller with reference to theoretical calculations in considerable limits.

2. Hydrodynamic Pressure

Fluent analysis has been performed in the present work by creating a water domino around the propeller. To analyze the pressure on the propeller blades at operating conditions propeller is made to rotate at 500 rpm and a fluid velocity that is speed of advancement of ship is given as 8.33m/s. It is observed that about 0.3 Mpa of Dynamic pressure was acting on face of propeller.

3. Structural Analysis

Structural analysis explains the behavior of blades upon applying dynamic pressure. The stresses induced due to dynamic pressure in x,y,z directions are within safe limits. Von-mises stresses seemed to be same on the face of propeller, but more stresses were available on the edges due to stress concentration. Upon neglecting stress concentration and minimum number of blades are required.

4. Modal Analysis

Modal analysis is performed to find out natural frequencies of different number blade propellers. Here five mode shapes have been considered and it is observed that deformation is occurring at the blade tips with starting frequency 52 Hz, so it is noted that these propeller must avoid running frequency or artificial frequency 52Hz to avoid resonance phenomenon to improve the life of propeller. six bladed propeller having maximum value of natural frequencies.

5. Critical load analysis

Critical load analysis is performed to find out critical strength of different number blade propellers. Here first mode shapes have been considered and it is observed that deformation is occurring at the blade tips with starting 81 times of applied load, so it is noted that these propeller is in the safe limit for present loading condition.

6. Thrust Analysis

Thrust calculation is main important parameter in ship propeller. Here input velocity has taken as 8.33 m/sec. and output velocity of domain is changes according to number of blades. Here if number of blades increases Thrust power also increases slightly.

Finally from the present work it is concluded that according to structural analysis minimum number of blades required as well as according to Thrust calculations more number of blades having better performance. So the four bladed propellers are considered as optimum model for better performance as well as more life.

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