International Journal of Engineering Research-Online
A Peer Reviewed International Journal
Articles available online http://www.ijoer.in; editorijoer@gmail.com

Vol.6., Issue.4, 2018
July-Aug.

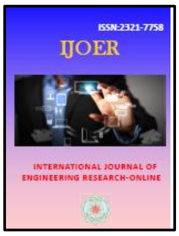
RESEARCH ARTICLE

ISSN: 2321-7758

DESIGN AND OPTIMIZATION ON NYLON BUCKET THROUGH FINITE ELEMENT ANALYSIS

U.NAGENDRA[1], A.V.HARI BABU[2], J.A.SANDEEP KUMAR[3]

[1]P.G.Scholar,Mechanical Department, SVR Engineering College , Nanayal, A.P, India
[2]HOD & Associate Professor, SVR Engineering College, Nandayal, A.P, India
[3] Assistant Professor, Mechanical Engineering, SVR Engineering College, Nandayal, A.P, India



ABSTRACT

Ships and under water vehicles like submarines, torpedoes and submersibles etc., uses propeller with buckets for propulsion. The blade geometry and its design are more complex involving many controlling parameters. The strength analysis of such complex 3D buckets with conventional formulae will be difficult and more time taken processes. In such cases finite element analysis gives accurate results. The present idea of thesis deals with modeling and FEM analysis of the propeller blade of underwater vehicles for its strength. The propeller is a complex geometry which requires high end modeling software. The solid model of the propeller is developed using solid works. The materials used for buckets are aluminum, composite propeller which is consisting of NFRP (Nylon Fiber Reinforced Plastic) and CFRP (Carbon Fiber Reinforced Plastic) materials. FEM analysis of both aluminum and composite propeller are carried out in ANSYS WORK BENCH. Inter laminar stresses are calculated for aluminum and composite propeller. Based upon the results we are suggested which materials will gives best and accurate results to improve the strength of propeller.

Keywords: ANSYS-WORKBENCH, CFRP, NFRP & Propeller Blade.

INTRODUCTION

Ships and submerged vehicles like submarines, torpedoes and submersibles and so on utilizes propeller for propulsion. The force is produced against the flow of water which is called as thrust force. The propeller is the most important device to run ship safely at sea. In the present analysis the propeller sharp edge material is changed over from aluminum metal to fiber fortified composite material for submerged vehicle propeller.

PRINCIPLES OF SHIP PROPULSION

A ship travels through the water through pushing gadgets, for example, oar wheels or propellers. These gadgets gives speed to a section of water and moves it the other way in which it is sought to move the ship. The principle shaft reaches out from the fundamental diminishment rigging shaft of the lessening apparatus to the propeller. It is upheld and held in arrangement by the spring heading, the stern tube course, and the strut bearing.

Types of Propeller

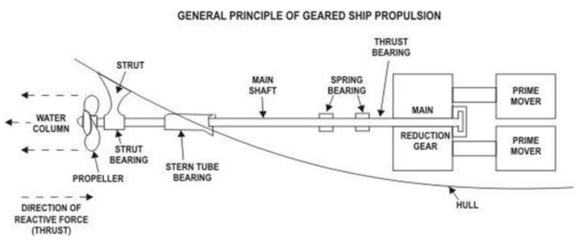


Figure1. General principle of a geared ship propeller

In the field of rapid marine specialty like the hydrofoil create, conventional non-cavitating propellers can't be utilized as a result of unavoidable cavitations. In such a circumstance, super cavitating propellers which are outlined deliberately to work in cavity stream, discover prepared application. A configuration technique is discovered by Tachmindji & Morgan (1958).

LITERATURE REVIEW

V. Ganesh, K. Pradeep, K. Sreeninivasulu [2014] [1] reported on the two distinguished materials for its strength. Aluminum and CFRP are considered for model and static analysis. The high end software for modeling was chosen CATIA and for analyzing ANSYS software was used. The results are compared with the experimental values. By the results the CFRP gives the best one.

RaminTaheri, Karim Mazaheri [2013] [2] to optimize the shape and efficiency of two propellers. The design methods based on Vortex Lattice algorithm is developed and two gradients based and non-gradient based optimization algorithms are implemented. By implementing a computer code, vortex lattice method was used. From the analysis , approximately 13% improvement in efficiency and approximately 15% reduce in torque coefficient for first propeller and approximate 10% improved for efficiency of the next propeller can be possible.

N. Balasubramanyam [2015] [3] carried out ANSYS test on both Aluminum and composite propeller. The composite propeller is GFRP. Static and Dynamic analysis are carried out on both the materials. For solid modeling and meshing CATIA-V5 R17 software is used and for analysis ANSYS is used. The results are compared with the Tsai-Wu failure theory and concluded that they are within the safe limits.

Aditya Kolakoti, T.V. Bhanupraksh, H.N. Das [2013] [4] analyzed on a controllable pitch propeller using CFD. For hydrodynamic designs CFD becomes more encouraged software. For modeling and meshing CATIA – V5 is used. The flow analyses are carried out in three stages. (1) CFD analysis of bare hull (2) open water analysis (3) flow characteristics of propeller when fixed back of the ship hull. Experimental values and CFD results are compared and got approximate variation in results.

COMPUTATIONAL DESIGN

Determining the internal stress in a propeller would be a difficult task containing many reasons. The load on it can be maximum or minimum, distribution of load on the surface of the blades is typical to determine and the geometry of the blade is also complex. Based on the practical experience simple methods are used to calculate the stresses and adopt an enormous factor of safety.

Calculations

Diameter = 227.27 mm

Number of blades = 4

Propeller Model = INSEAN E779A

Type of propeller = Controllable pitch propeller

Material = Aluminum and CFRP

Total area of the circle =$\prod R^2$

=40567.113mm^2

Total blade area = total area of the circle X disc area ratio

Given disc area ratio = 0.689

Total blade area =40567.113 x 0.689

= 27950.66mm^2

Relation between pitch & pitch angle

Formulae; pitch (p) = 2∏r x tan a

Where @=pitch angle and r= radius and ∏

Pitch angle =120

Pitch=2 x ∏ x 113.635 x tan120

= 1236.66

=1237mm

Speed=(RPM/Ratio) x (pitch/c) x (1-s/100)

= [(1000/0.5) x (1237/1) x (1-0/100) Assume Ratio=1/2; gear ratio(c)=1;slip=0

=762636 x 60/106

=45.75816km/hr

Boat speed = Vb = 45.75186/1.6093 mile/hr

= 28.4328 mile/hr

Mass flow rate/hr = total blade area* speed of the boat

The thrust (T) is equal to the mass flow rate (m) times the difference in the velocity (v) T = m (Vb – Va)

Thrust = 2102.097 N

Modeling of a Propeller

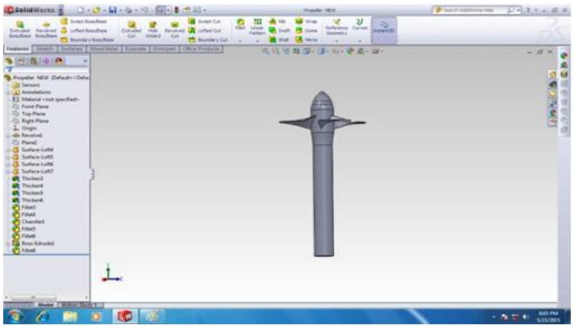


Figure2. Front view of Solid Model of a propeller

The propeller is modeled by using SOLID WORKS. To model a propeller, it may be necessary to have sections of the propeller at different radii. With respect the pitch angles these sections are considered and rotate. Then all rotated sections are executed onto right circular cylinders with respective to radii. Strong displaying (or demonstrating) is a steady arrangement of standards for numerical and PC demonstrating of 3D solids. Strong demonstrating is recognized from related ranges of geometric displaying and PC representation by its accentuation on physical fidelity. Together, the standards of geometric and strong displaying shape the establishment of PC helped configuration and when all is said in done backing the creation, trade, perception, activity, examination, and annotation of computerized models of physical items.

Meshing of Propeller Blade

The solid model is transfer to the ANSYS WORK BENCH software. With the required commanding the mesh is generated for the model. Generally there two types of meshes are there they are

(i) Tetrahedral mesh

(ii)Hexahedral mesh

The tetrahedral mesh is a polygon consists of four triangular faces three of them are meet at a point called as vertex. It has 6 edges and 4 vertices. In case of hexahedral mesh it has 12 edges and 8 vertices. For the accuracy of the solution hexahedral gives the exact result. In the ANSYS software the internal command setting can be available for mesh generation.

Figure3. Fine meshed model of propeller

FEM Analysis of Propeller Blade

Figure4. Step by step procedure of propeller Blade Analysis in ANSYS.

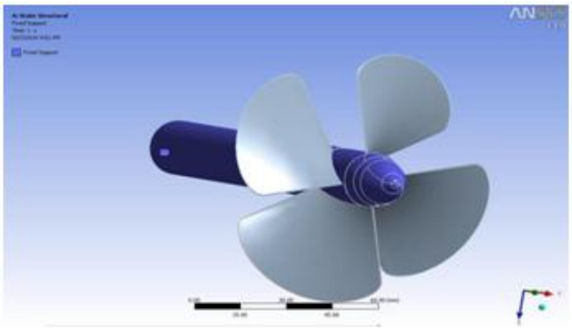


Figure5. Boundary conditions applied to the marine propeller blade in ANSYS. Applied load=2102.1 N

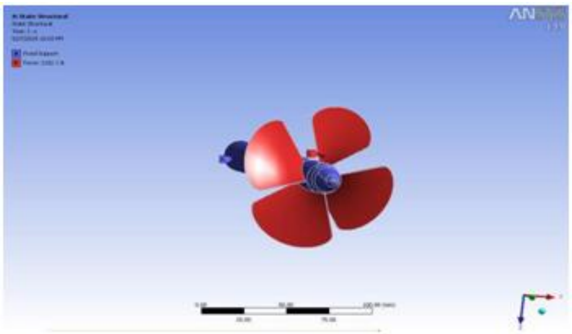


Figure6. Loads are applied to the marine propeller blade in ANSYS.

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Explicit Dynamic Analysis

Explicit Dynamic Analysis in ANSYS-WORKBENCH suits us to capture the physics of short- duration events for products that undergo highly nonlinear, transient dynamic forces. It shares the same graphical user interface (GUI). Serving Mechanical engineers who need to study highly complex problems.

Vonmises-stress (Equivalent stress) is very important stress in design this stress tells us wether the design is safe or not.If the vonmises stress is within the Ultimate strength of the material then the design is safe.

CFRP Material Properties Young's Modulus :1160.64 Mpa Poisson's Ratio :0.28

Density : 1600kg/m^3

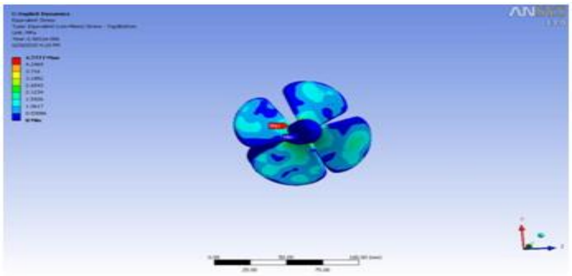

Figure7. Vonmises-Stress distribution of CFRP marine propeller blade in ANSYS.

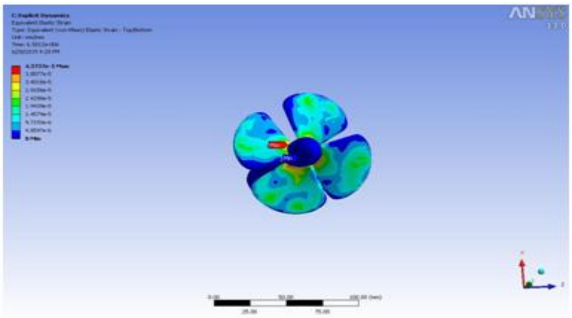

Figure8. Vonmises-Stain distribution of CFRP marine propeller blade in ANSYS.

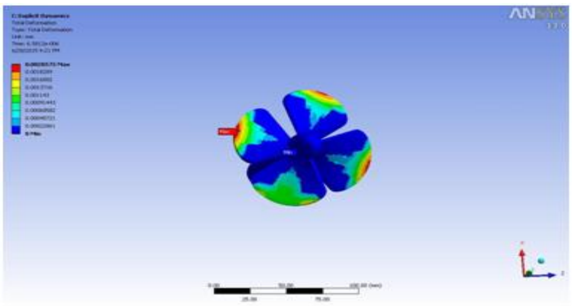

Figure9. Total deformation over CFRP marine propeller blade in ANSYS.

NFRP Material Properties Young's Modulus :7300 Mpa Poisson's Ratio :0.28

Density : 1800kg/m^3

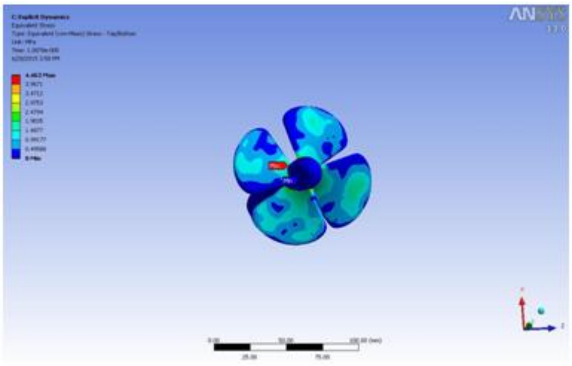

Figure10. Vonmises-Stress distribution of NFRP marine propeller blade in ANSYS.

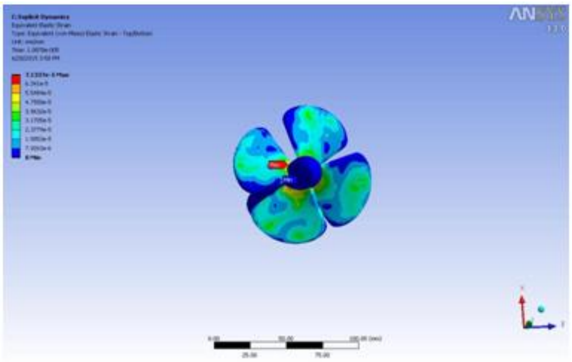

Figure11. Vonmises-Strain distribution of NFRP marine propeller blade in ANSYS.

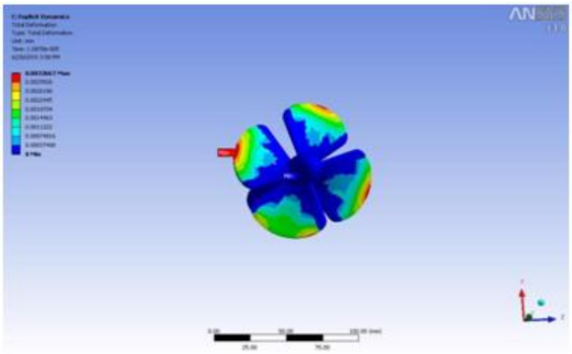

Figure12. Total deformation over NFRP marine propeller blade in ANSYS.

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RESULTS & DISCUSSIONS

Table1. Result for Dynamic Analysis

S.NO	Material	Vonmises-Stress (MPA)	Vonmises-Strain	Total Deformation (mm)
1	CFRP	4.777	4.3737e-5	0.002857
2	NFRP	4.463	7.8337e-5	0.003366
3	%Difference	31.4%	0.00346%	0.059%

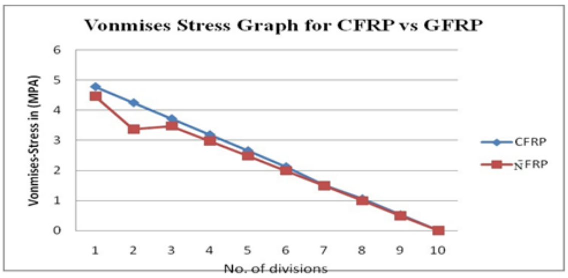

Figure13. Vonmisses stresses over CFRP and NFRP marine propeller buckets.

CONCLUSION

From the output of the static analysis and dynamic analysis of the marine propeller, it can be concluded that (i) the propeller is assumed as a cantilever beam i.e., when the load applies on it then the deformation will be formed at the free end and no deformation at the fixed end.(ii) Dynamic Analysis is carried out on turbine blade by varying the material for propeller blade from CFRP to GFRP Vonmises stress is reduced to a percentage of 31.4%.

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