e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 06 Issue 1
January 2019

Modeling, Static and Dynamic Analysis of Marine Propeller Blade by Using Composite Material

K.Sai Surya Teja[1] (M.Tech Scholar) & Dr.K.Lalit Narayana[2] (Professor)
Department of Machine Design
[1]sir C.R.REDDY college of engineering & technology, vatluru, Andhra pradesh, 521201, INDIA
surya.krosuru338@gmail.com[1] klalitnarayan@gmail.com[2]

ABSTRACT

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 such that it can with stand the static load distribution and finding the stresses and deflections for STAINLESS STEEL ,CFRP and GFRP materials. CFRP and GFRP 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 composite materials are 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 composite propeller. The present work carries out the structural analysis and dynamic to STAINLESS STEEL, CFRP and GFRP propeller blade which proposed to replace the propeller blade to find the better results.

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 composite 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 STAINLESS STEEL, CFRP and GFRP (composite material).

Key words: catia, cfrp, gfrp, stainless steel, ansys.

INTRODUCTION TO PROPELLER

Marine propeller is a component which forms the principal part of ships since it gives the required propulsion. These materials are 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 CRPF & GFRP 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.

II. LITERATURE REVIEW

[1] M. A Ishak, Sulaiman S., Baharudin B. T. H. T., and Syajaratunnur Y "RESEARCH ON THE SHIPP ROPELLER BLADE TO DETERMINECHANGES IN THE MECHANICAL PROPERTIES BASED ON THE FORCES PROJECTION", [2017]

Research that the existing ship propeller and the effects of casted specimen on the changes of mechanical properties of the propeller structure. The specimen prepared is referred to ASTM E8 2008 standard and including two projections is Longitude and Latitude projected, according to the forces analysis exerted on blade structure.

[2] PALLE PRASAD, LANKA BOSU BABU ,"DESIGN AND ANALYSIS OF THE PROPELLER BLADE",.[2017] They work on the structural analysis of a CFRP (carbon fiber reinforced plastic) propeller blade which proposed to replace the Aluminium propeller blade. Also finding the stresses and deflections for both aluminium and carbon fiber reinforced plastic materials. After the study they conclude the stresses and deflections for both aluminium and carbon fiber reinforced plastic materials and also finding its strength.

[3] A. Satya Dinesh, G. V. Naga Mani, "Modelling and Analysis of a Shaft Blade for its Strength", [2016] They examine the structural analysis of CFRP propeller blades which in future replaces the aluminium propeller blade. And this study basically deals with modelling and design analysis for propeller blade for torpedoes application.

[4] G.Rajesh ,"Modelling and Analysis of Propeller Blade with Different Materials Using FEA", [2016] They studied the structural analysis of a propeller blade which proposed to replace the Aluminium propeller blade for torpedoes application and this work basically deals with the modelling and design analysis of the propeller blade of a torpedo for its strength and they findings the stresses and deflections for both materials.

Types of marine propellers

1. Controllable pitch propeller
2. Skewback propeller
3. Modular propeller

1. Controllable pitch propeller

A controllable pitch propeller One type of marine propeller is the controllable pitch propeller. This propeller has several advantages with ships. These advantages include: the least drag depending on the speed used, the ability to move the sea vessel backwards, and the ability to use the "vane"-stance, which gives the least water resistance when not using the propeller (e.g. when the sails are used instead).

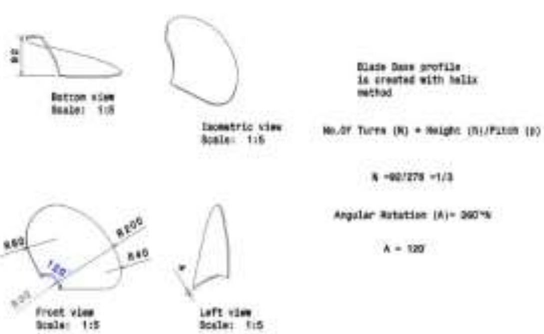
2. Skewback propeller

e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 06 Issue 1
January 2019

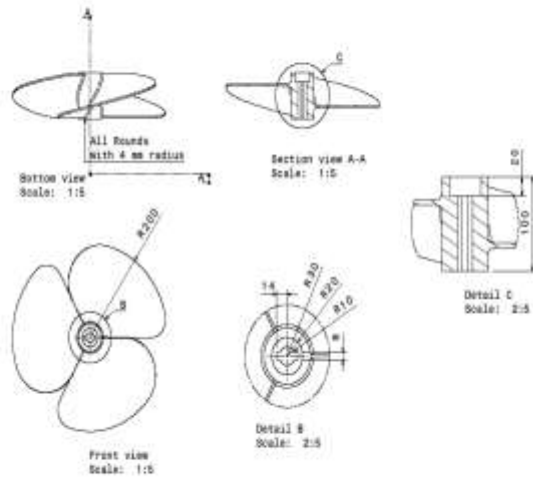
An advanced type of propeller used on German Type 212 submarines is called a skewback propeller. As in the scimitar blades used on some aircraft, the blade tips of a skewback propeller are swept back against the direction of rotation. In addition, the blades are tilted rearward along the longitudinal axis, giving the propeller an overall cup-shaped appearance. This design preserves thrust efficiency while reducing cavitations, and thus makes for a quiet, stealthy design.

3. Modular propeller

A modular propeller provides more control over the boats performance. There is no need to change an entire prop, when there is an opportunity to only change the pitch or the damaged blades. Being able to adjust pitch will allow for boaters to have better performance while in different altitudes, water sports, and/or cruising



Dimensions of blade figure 1



Dimensions of propeller blade figure 2

MODELING OF PROPELLER BLADE BY USING CATIAV5

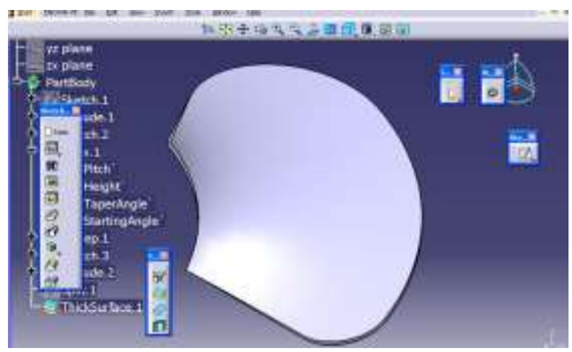
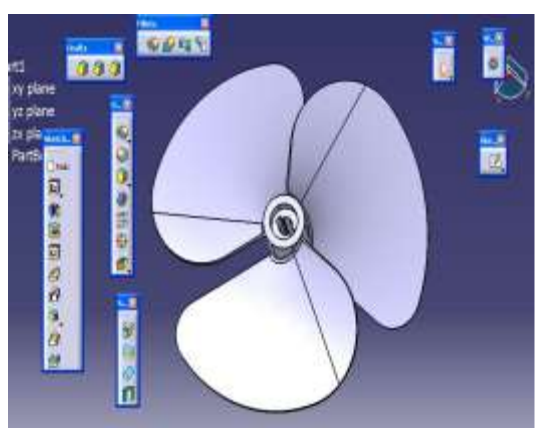


Figure 3 blade wing

MODEL OF A PROPELLER



e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 06 Issue 1
January 2019

Figure 4 propeller blade

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 = 2π r X Tan a

Where: a = pitch angle and r = radius andπ=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,

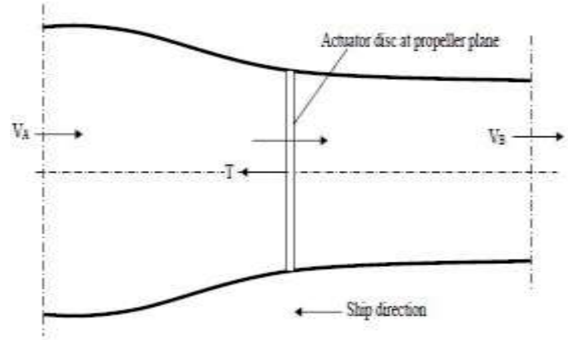
$= 652636X60/10^6$

Gear ratio (G)=1

=39.1581 km/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 x $(V_B - V_A)$

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

$= 2600.74 \times 10^{-6} x39.1581 \times 10^3$

$= 101.840\ m^3/hr$

Thrust (T) = m x $(V_B - V_A)$ = 101.840 x 39.1581 x 10^3

= 3987860.9 N

= 3.98 MN

Steel Alloys

Alloy steels used in marine propeller construction have great strength, more so than other fields of engineering would require. These materials must withstand the forces that occur on today's modern marine propeller. These steels contain small percentages of carbon, nickel, chromium, vanadium, and molybdenum. High-tensile steels will stand stress of 50 to 150 tons per square inch without failing. Such steels are made into tubes, rods, and wires. Another type of steel used extensively is stainless

International Journal of Research
Available at https://pen2print.org/index.php/ijr/
e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 06 Issue 1
January 2019

steel. Stainless steel resists corrosion and is particularly valuable for use in or near water

CFRP

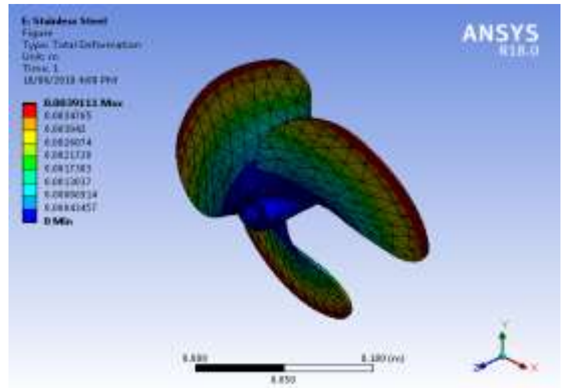
Carbon fiber reinforced polymer, carbon fiber reinforced plastic or carbon fiber reinforced thermoplastic (CFRP, CRP, CFRTP or often simply carbon fiber, carbon composite or even carbon), is an extremely strong and light fiber-reinforced plastic which contains carbon fibers. The alternative spelling 'fiber' is common in British Commonwealth countries. CFRPs can be expensive to produce but are commonly used wherever high strength-to-weight ratio and rigidity are required, such as aerospace, automotive, civil engineering, sports goods and an increasing number of other consumer and technical applications.

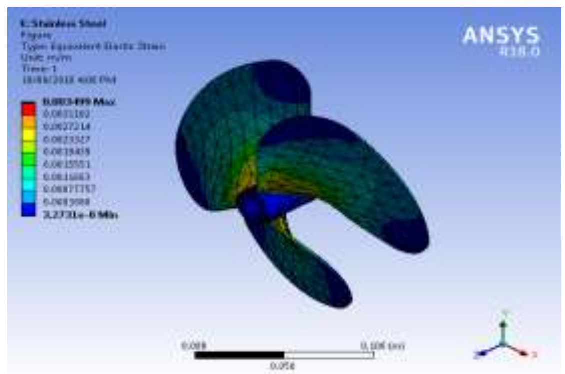
The binding polymer is often a thermo set resin such as epoxy, but other thermo set or thermoplastic polymers, such as polyester, vinyl ester or nylon, are sometimes used. The composite may contain aramid (e.g. Kevlar, Twaron), aluminium, ultra-high-molecular-weight polyethylene (UHMWPE) or glass fibers in addition to carbon fibers. The properties of the final CFRP product can also be affected by the type of additives introduced to the binding matrix (the resin). The most frequent additive is silica, but other additives such as rubber and carbon nano tubes can be used. The material is also referred to as graphite-reinforced polymer or graphite fiber-reinforced polymer (*GFRP* is less common, as it clashes with glass-(fiber)-reinforced polymer).

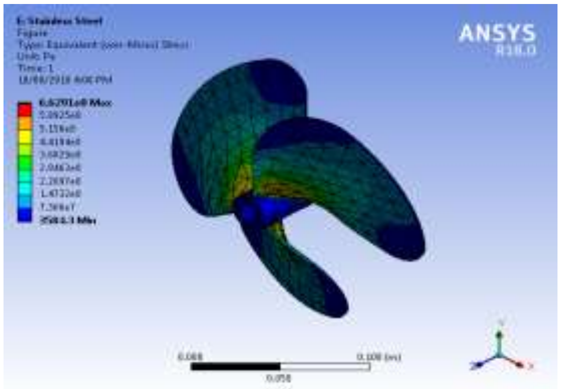
GFRP

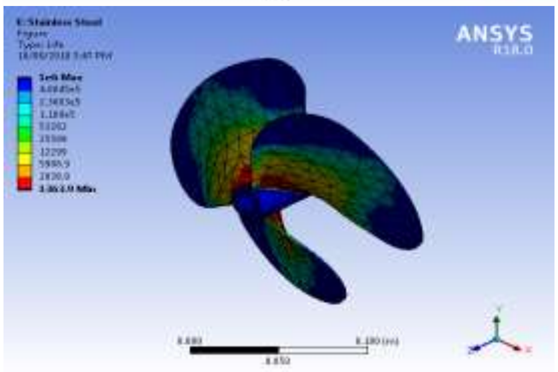
Glass fiber reinforced polymer rebar is a high value-added construction product. The mega infrastructure providers, such as governments, now have acknowledged the fact that GFRP is a cost-effective construction material that has the full potential to extend the life of public structures where corrosion can have a huge economic and environmental impact. With the rise of corrosion due to global warming, **fiberglass reinforcement** material has gained considerable popularity. In future, these advanced composite materials would demonstrate their strengths and properties more evidently

Modal & Static Structural Analysis Of Propeller Blade (STAINLESS STEEL). Figures 5 to 9

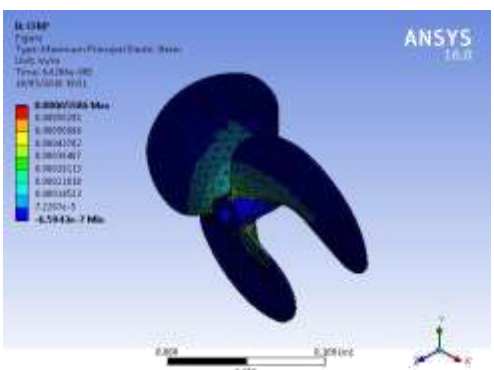


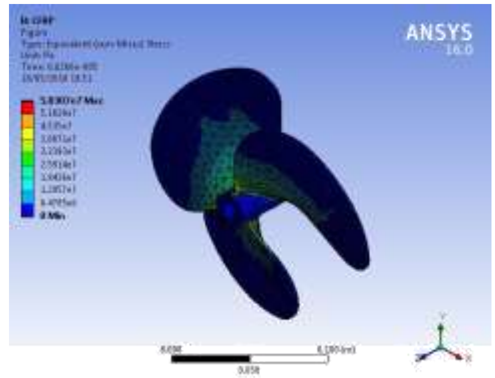


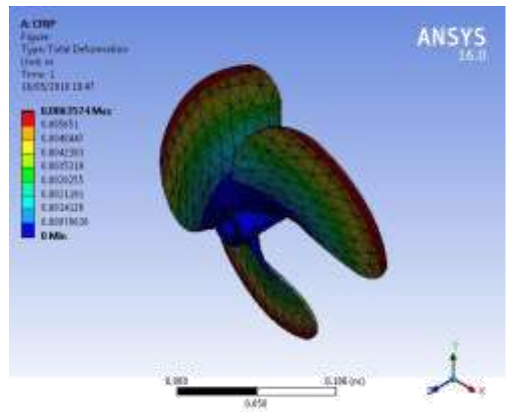


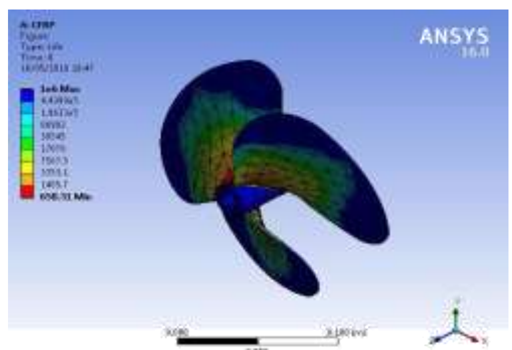


Modal & Static Structural Analysis Of Propeller Blade (CFRP) figure 10 to 13



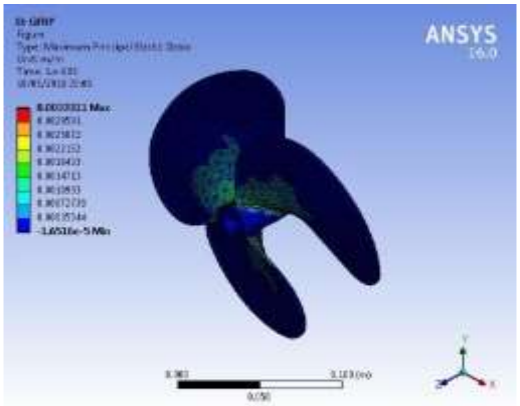


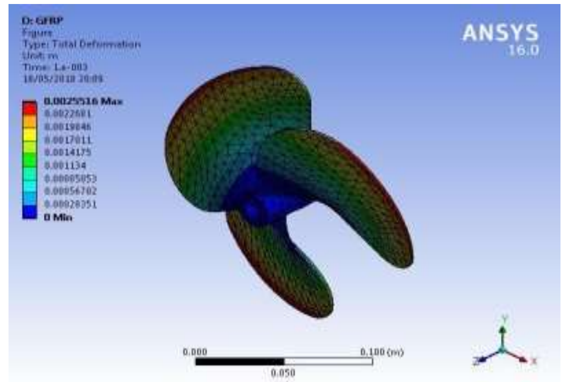


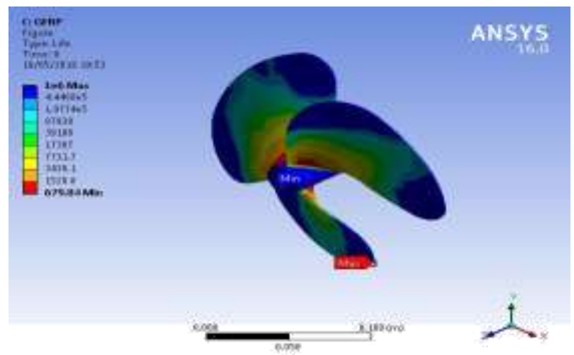


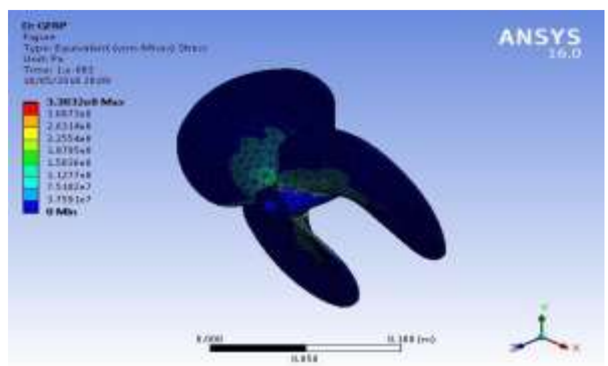
e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 06 Issue 1
January 2019

Modal & Static Structural Analysis Of Propeller Blade (GFRP) v figure 14 to 17









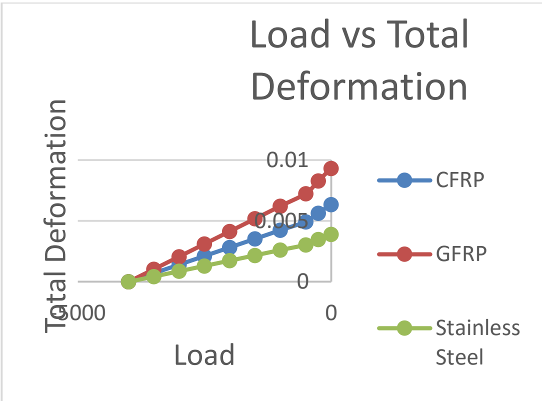
	Stainless Steel	CFRP	GFRP
Von Misses Stress (Pa)	$6.6291\ x10^{-6}$MPa	$6.6988x10^{-6}$MPa	$7.0377x10^{-6}$MPa
Maximum Principle Elastic Strain	$3.499x10^{-3}$	$6.6868x10^{-3}$	$8.306x10^{-3}$
Total Deformation (m)	$3.9111x10^{-3}$	$6.3454x10^{-3}$	$9.3358x10^{-3}$
Life (s)	$1\ x10^{6}$	$1x10^{6}$	$1x10^{6}$
fatigue (s)	$7.3317x10^{5}$	$1.4829x10^{6}$	$1.4432x10^{6}$

Comparison of all materials

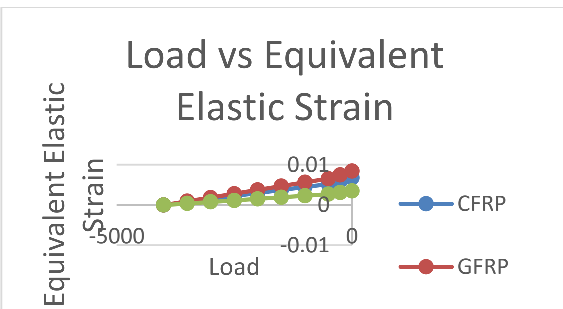
TABLE 1

RESULT GRAPHS:

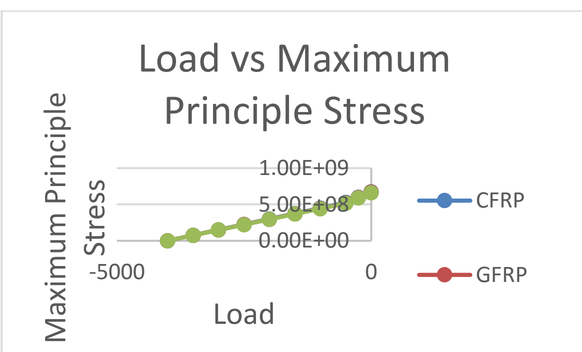
International Journal of Research
Available at https://pen2print.org/index.php/ijr/
e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 06 Issue 1
January 2019



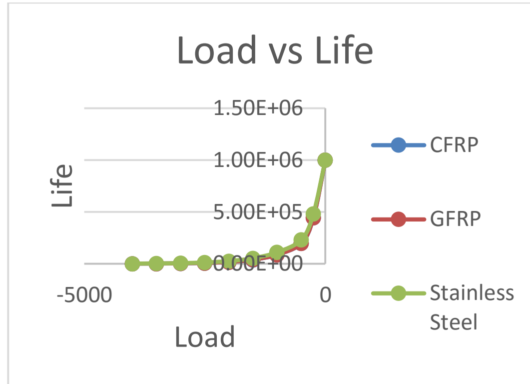
All loads of materials deformation showed in these graph



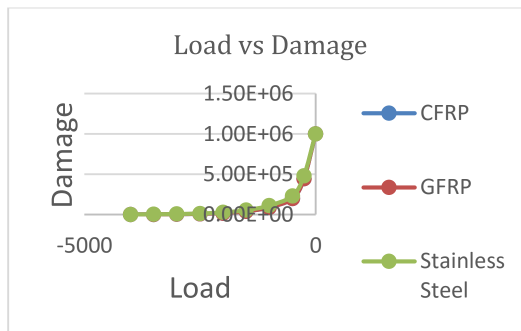
Materials load comparing with the strain



Materials load comparing with stress



Materials load comparing to the life of the materials



Materials load comparing to the fatigue damage of the all materials .

Conclusion

The static analysis and dynamic analysis are carried out for the different type of materials; those are Carbon Fibre Reinforced Plastic (CFRP) Glass Fibre Reinforced Plastic (GFRP) and Stainless Steel. MPa

- The vonmises stress acting on the propeller produced from CFRP is 6.6988x10^{-6}MPa, and the total deformation is 6.3454x10^{-3}m.
- The vonmises stress acting on the propeller produced from GFRP is 7.0377x10^{-6} MPa, and the total deformation is 9.3358x10^{-3}m.
- The vonmises stress acting on the propeller produced from Stainless Steel is 6.6291

$x10^{-6}$ MPa, and the total deformation is $3.9111x10^{-3}$m.

- From the above result the life and the damage of the propeller blade depends on the type of the material, in the above case the life of the material remain same and whereas the damage of the GFRP is less when compared with the other materials.

Finally it is concluded that Glass Fibre Reinforced Plastic (GFRP) material can give a better performance with respect to static and dynamic analysis.

REFERENCES

[1]. Properties of engineering materials by RA Higgin

[2]. Engineering material properties and selection by Kenneth G.Budinski

[3]. Mechanics of composite materials by Robert M.Johnes

[4]. An Accurate Four-Quadrant Nonlinear Dynamical Model for Marine...Ralf

[5]. Nonlinear Output Feedback Control of Underwater Vehicle Propellers...Thor I Fossen, Mogens Blanke – 2000 - IEEE JOURNAL OF OCEANIC ENGINEERING

[6]. A.P. Mouritz, E.Gilbert, P. Burchill, K.Challis., " Review of advanced composites for naval ships and submarines", Composite structures, 53, pp. 21-41, 2001.

[7]. Abdul M.Khan, Daniel O.Adams, Vinay dayal, Jerald M.Vogel., "Effects of Bend-Twist Coupling on Composite propeller performance", Mechanics of composite materials and structures, Vol.7, pp.383-401, 2000.

[8]. Ansys 11.0 Documentation guide 4. Ansys 11.0 documentation. 5. Anthony F. Molland , Stephen R. Turnock, Dominic A. Hudson., " Ship Resistance and Propulsion" , Cambridge university press, 2011.

[9]. Anthony F. Molland , Stephen R. Turnock,. "The Design and Construction of model ship propeller blades in hybrid composite materials", "Composites Manufacturing" Vol.2, No.1, March 1991.

[10]. Atkinson, P., Glover, E.J., "Propeller hydro-elastic effects", SNAME Propeller' 1988, paper 21.