HARMONIC ANALYSIS OF MARINE PROPELLER BY USING NAB & GFRP

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Abstract : Current work intends on harmonic analysis to design a propeller of underwater vehicle with a composite material and to analyze its displacements and natural frequencies using Ansys software. Harmonic analysis is performed to evaluate the suitability of composite material for underwater vehicle propeller over NAB propeller. A propeller is a complex geometry which requires high end modelling software. The solid model of propeller is developed in CATIAV5. A solid mesh is generated for the model. Static analysis and Modal analysis are carried on both NAB and composite propeller in ANSYS software. A comparison analysis is done on metallic and composite propeller and the response graphs for the displacements and frequency were plotted.

Keywords: Propeller, Glass fibre reinforced plastic, NAB, CATIAV5, ANSYS, Harmonic Analysis.

Introduction

Ships and UWV's as submarines, torpedoes and submersibles etc., uses propeller as propulsion. The Propeller blade geometry and its design is more complex involving many controlling parameters. The strength analysis of such complex 3D blades with conventional formulas will give less accurate values. In such cases numerical analysis (Finite Element Analysis) gives comparable results with experimental values. The conventional UWV Propellers are made up of Nickel Aluminium Bronze (NAB) present the work aims to replace the propeller blade material from Nickel Aluminium Bronze (NAB) metal to a fiber reinforced composite material (FRP). This complex analysis can be solved easily by finite element method techniques. The Harmonic analysis is done for the three bladed solid NAB as well as Composite propeller. The Harmonic analysis includes the evaluation of Displacement and frequency analysis for the propeller blades. The goal of this work is to design and evaluate the performance of the composite Propeller with that of the NAB propeller.

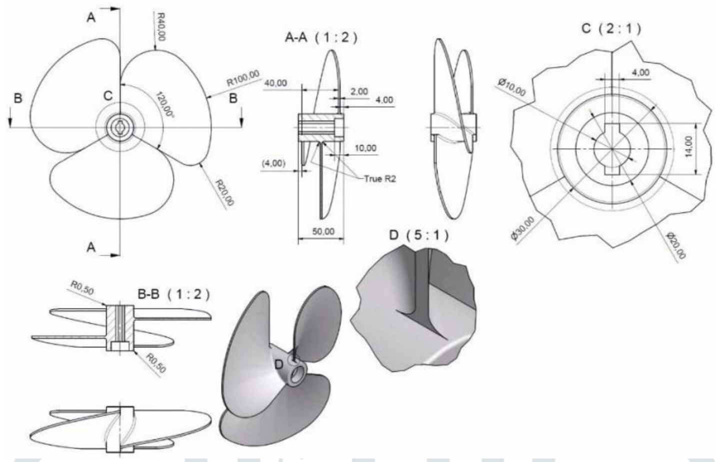
Literature review

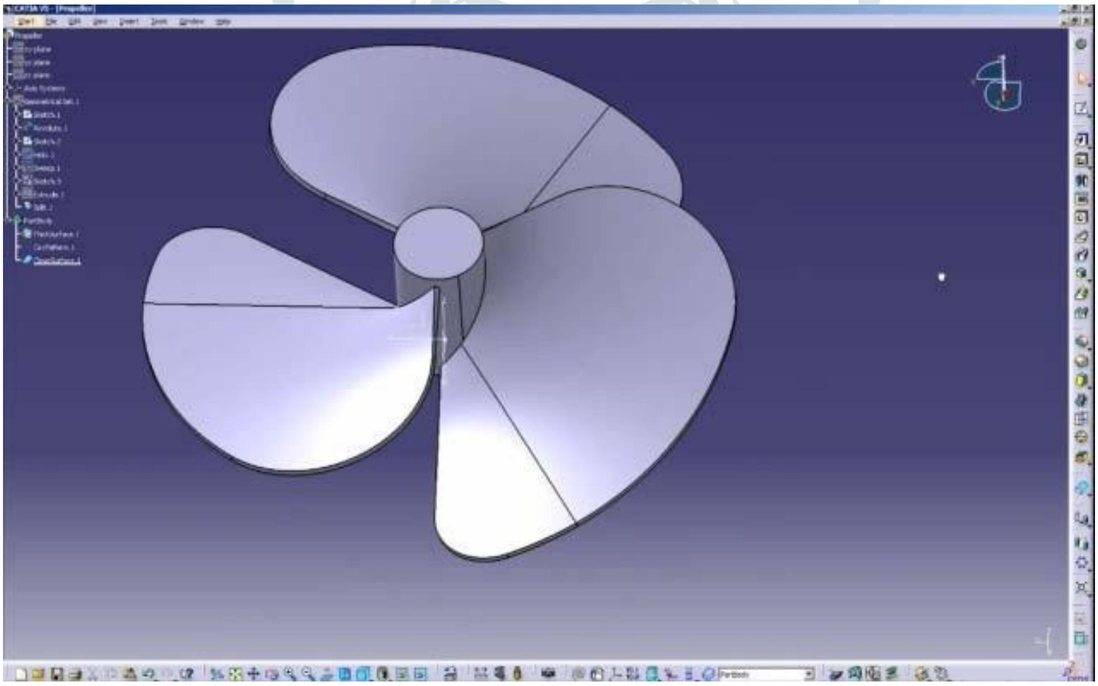
Propeller blades are designed for moderate and deeper depths require minimization of structural weight for increasing payload, performance/speed and operating range for that purpose Aluminum alloy casting is used for the fabrication of propeller blades[1]. In current years the increased need for the light weight structural element with acoustic insulation, has led to use of fiber reinforced multi-layer composite propeller[2]. one's attention is restricted to air propellers operating at low Mach numbers (where compressibility effects are negligible) and to water propellers operating without cavitations[3]. The objective of this study is to evaluate the strength and vibration characteristics of the Propeller blade design for metal and composite material. Also compare the performance under different operating loading conditions[4].This paper effort is made to reduce frequency of composite propeller so advantage of weight reduction can be obtained[5]. The application of composite materials technology to marine architecture has increased with particular benefits of its light weight, less noise and pressure fluctuation and less fuel consumption[6]. Gau Fenglin[7] carried out stress calculations for fibre reinforced composite thrust blade. Changes to the tensile and flexure properties of marine-grade glass –reinforced polyster, vinylster and resole phenolic composites after exposure to radiant heat are investigated[8].When using the Genetic Algorithm approach, some techniques for parameter setting to provide quick and correct results were discussed along with the influence of these parameters[9].The numerical results are in aggrement with experimental data and the general characteristics of the propeller flow seem to be quite well predicted[10]. The metal propellers generally used cause vibration during its operation. In order to avoid it, conventional isotropic materials are replaced with composite materials. Glass fibre reinforced plastics (GFRP) materials are woven with fibre orientation angles 45, –45. Strength analysis is carried out for composite propeller by using different number of layers for composite materials and inter laminar shear stresses are found out[11].

Modelling of propeller:

To model a propeller blade of particular series type is needed. In present work standard airfoil points are chosen for the modelling. The outline airfoil points and propeller blade are modelled in CATIA V5. As the propeller blade consisting of various radii are located through corresponding pitch angles, all rotated sections are projected onto a right circular cylinder of respective radii as shown in fig below. Then by using multi section surface option, the blade is modelled. The solid model of the propeller blade along with hub is imported and solid mesh is generated for the model.

Design parameters:

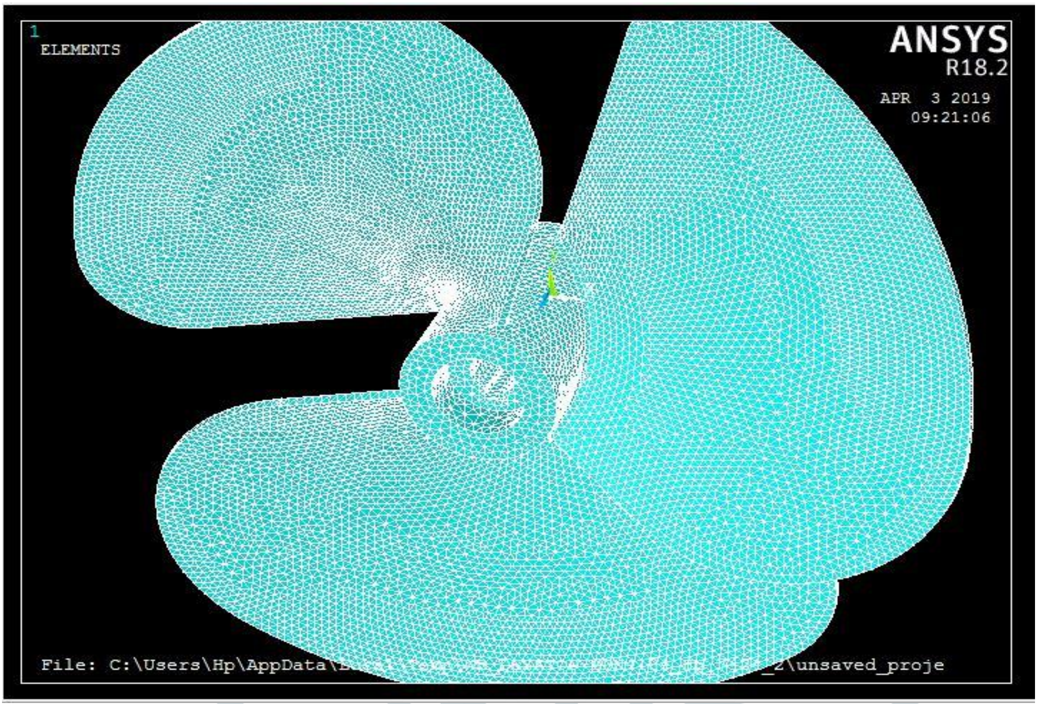




Propeller Model

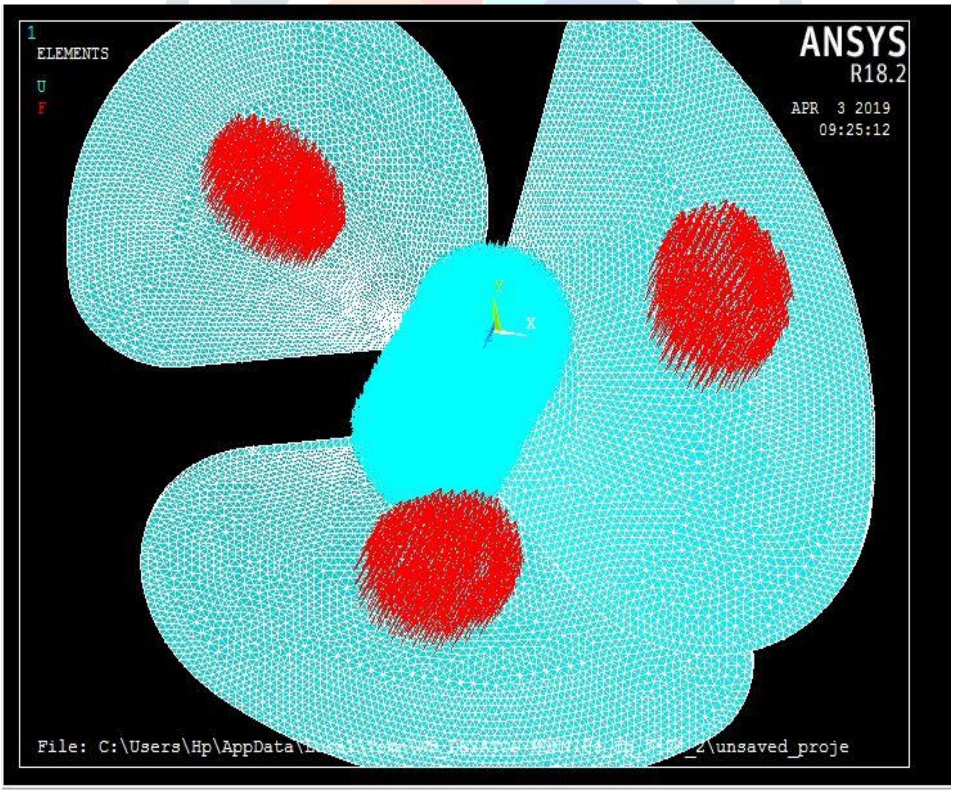
Mesh generation:

The solid model of the propeller blade along with hub is imported and solid mesh is generated for the model and the meshed model is shown in figure below.



Boundary conditions and loads:

Boundary conditions are applied to meshed model i.e., The contact surface between hub and shaft is fixed in all degrees of freedom and a Thrust of 609.1 N is applied.



Harmonic Analysis:

This analysis gives the ability to predict the sustained dynamic behaviour of structures, thus enabling to verify the designs will successfully overcome resonance, fatigue and other harmful effects of forced vibrations. Harmonic response analysis is a technique used to determine the steady state response of a linear structure to loads that vary sinesoidally with time. It calculates the propellers response at several frequencies and obtain the graphs of displacement versus frequencies. In this analysis all loads as well as the structure's response vary sinusoidally at the same frequency. A typical harmonic analysis will calculate the response of the structure to cyclic loads over a frequency range (a sine sweep) and obtain a graph of some response quantity (usually displacements) versus frequency. "Peak" responses are then identified from graphs of response vs. frequency and stresses are then reviewed at those peak frequencies.

RESULTS AND DISCUSSIONS:

Harmonic Analysis Of NAB Propeller:

From the harmonic analysis, the displacements of various nodes over the entire frequency range of 0 to 3000Hz were obtained. The natural frequencies of the propeller lies in the same above frequency range. The observed peaks in the frequency response graphs were plotted. Fig 1, Fig 2 and Fig 3 shows the variation of displacement in X, Y and Z directions. The maximum displacement of component in X ,Y and Z directions obtained in harmonic analysis for NAB are shown

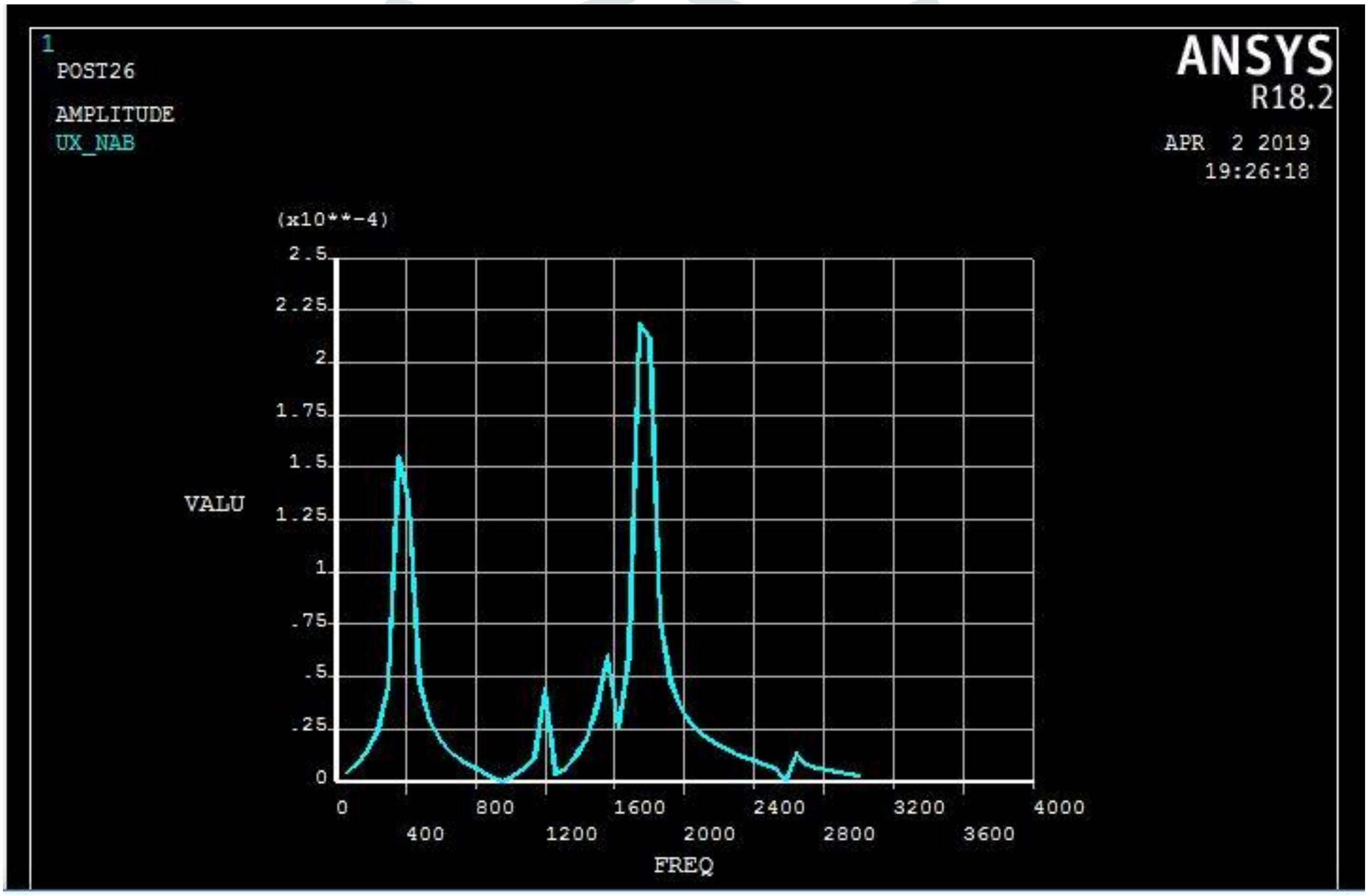


fig1. x-Component of displacement versus frequency response graph of nab propeller.

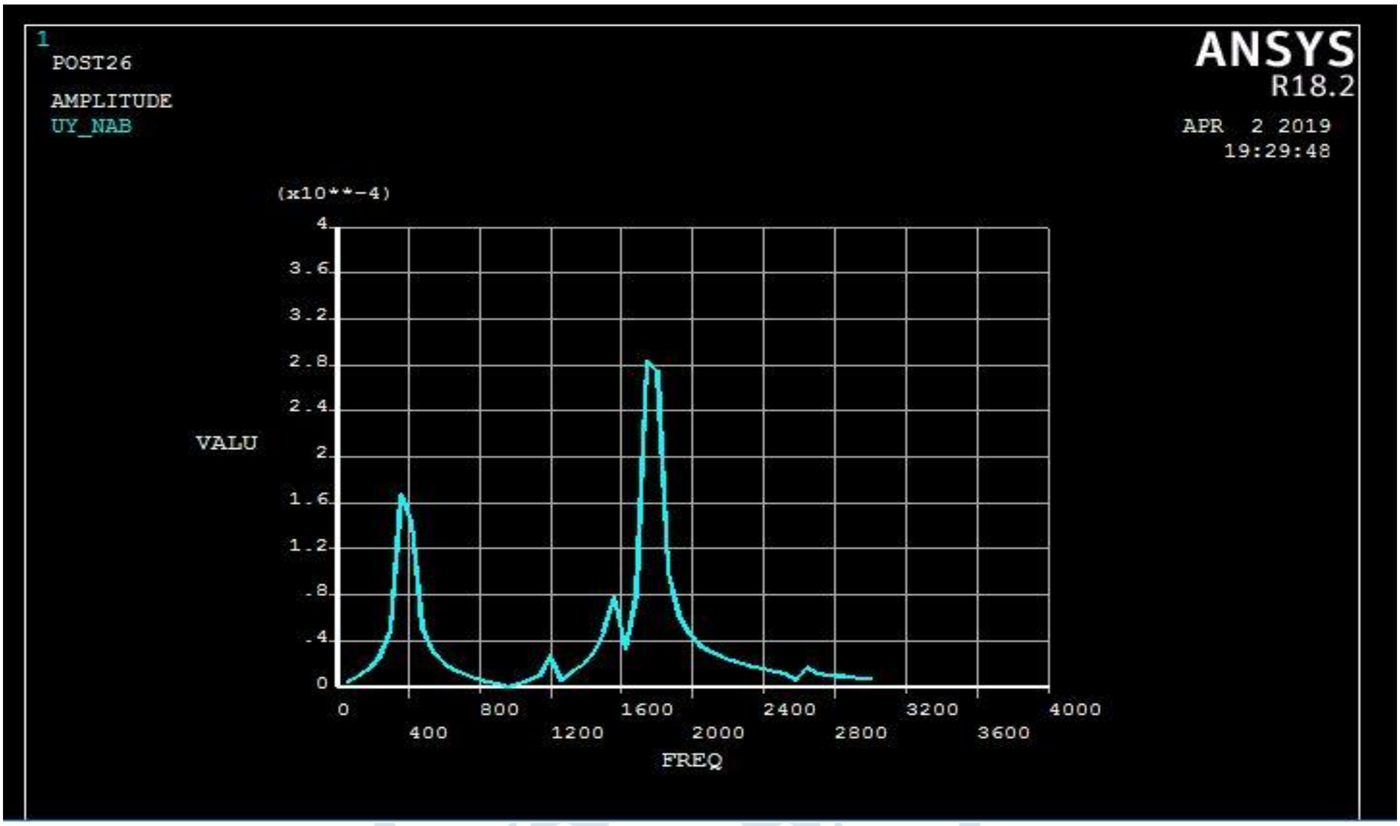


fig 2.y-component of displacement versus frequency response graph of nab Propeller

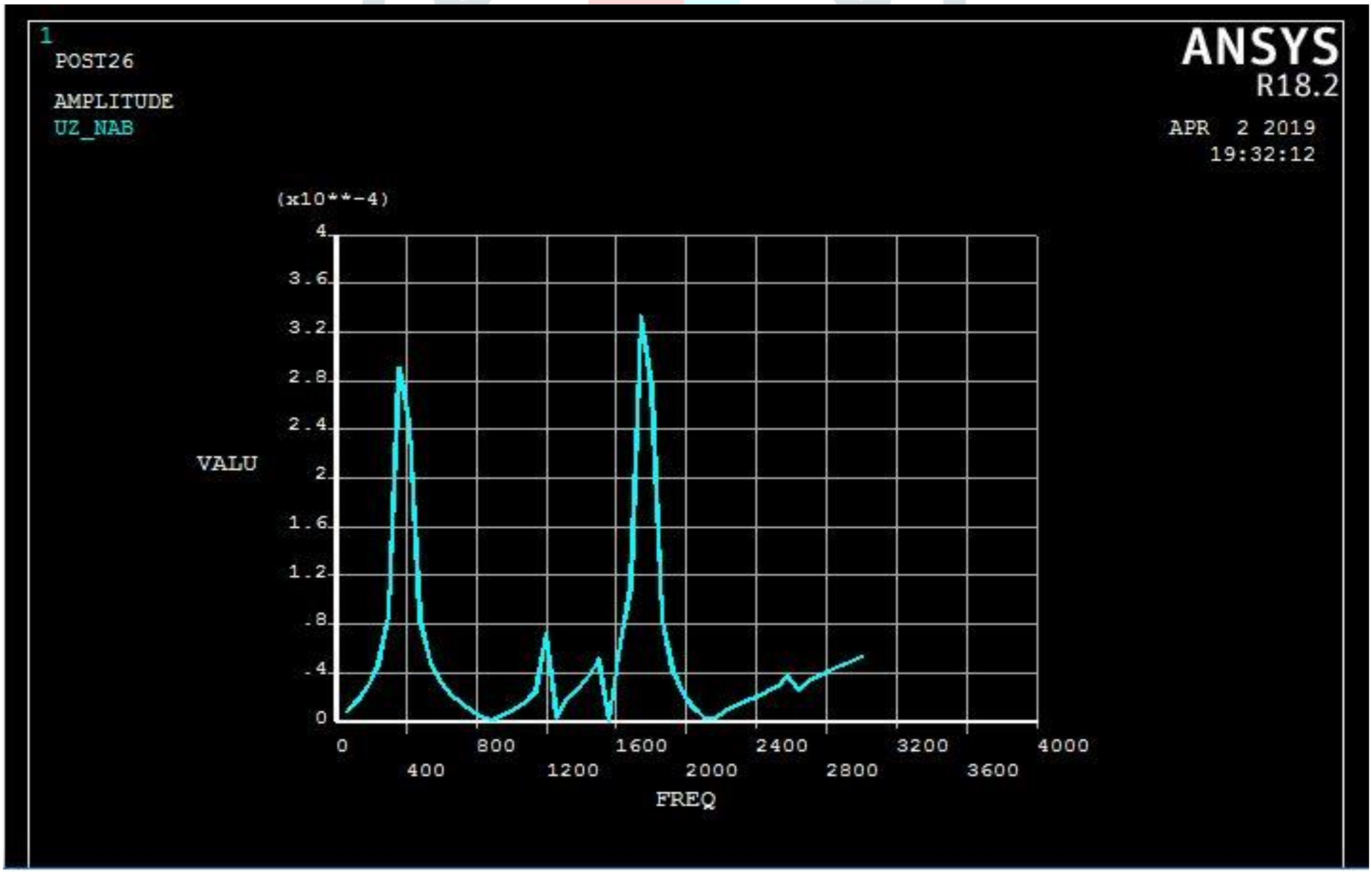


fig3. z-component of displacement versus frequency response graph of nab propeller

maximum displacement of nab propeller:

Displacements of NAB Propeller	Maximum
X-Component	0.22mm
Y-Component	0.285mm
Z-Component	0.34mm

Harmonic analysis of composite Propeller:

From the harmonic analysis, the displacements of various nodes over the entire frequency range of 0 to 3000 Hz were obtained. The natural frequencies of the propeller lies in the same above frequency range. The observed peaks in the frequency response graphs were plotted. Fig 4, Fig 5, and Fig6 shows the variation of displacement in X, Y and Z directions. The maximum displacement of component in X ,Y and Z directions obtained in harmonic analysis for composite material were plotted below.

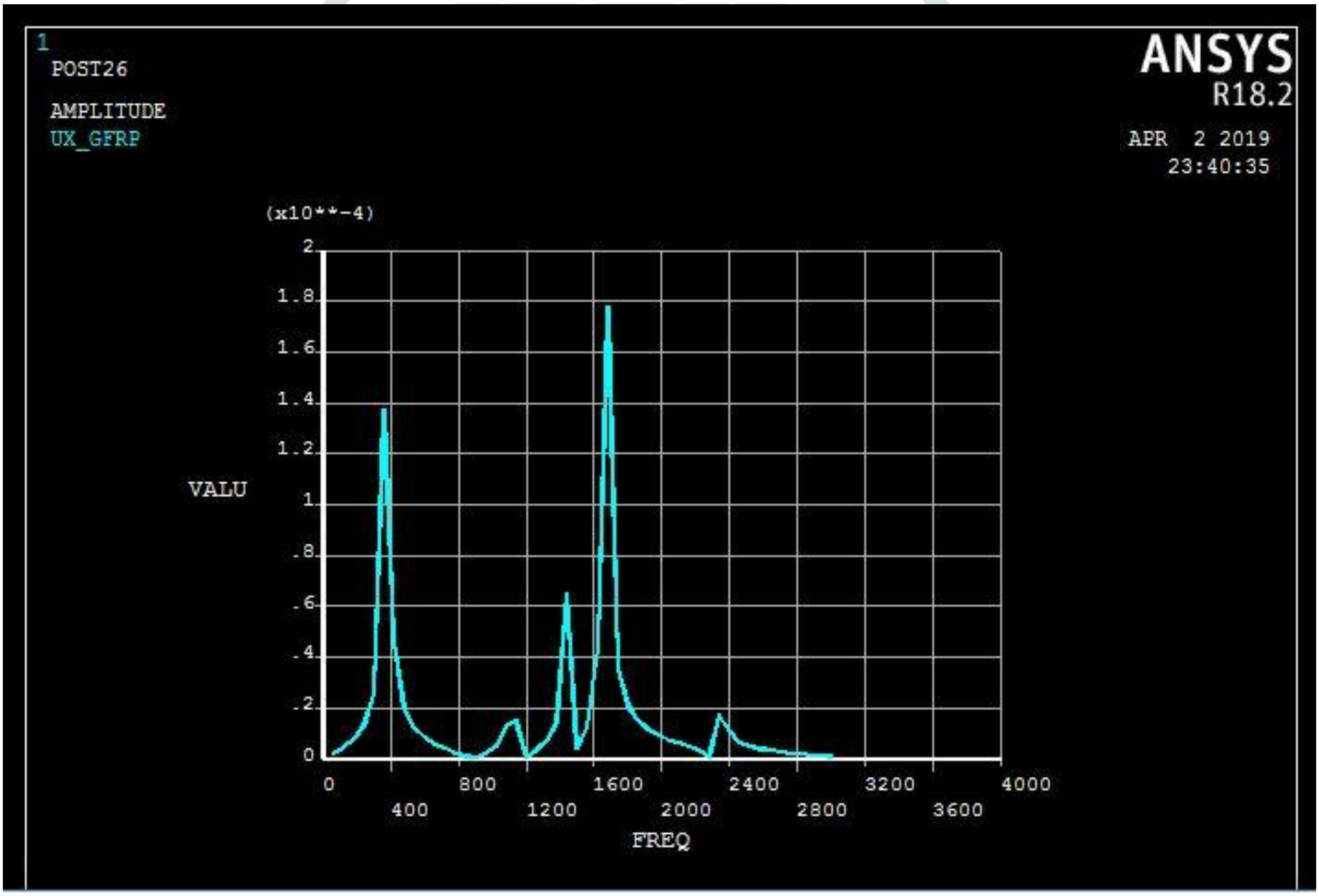


Fig4. x-component of displacement versus frequency response graph of nab propeller

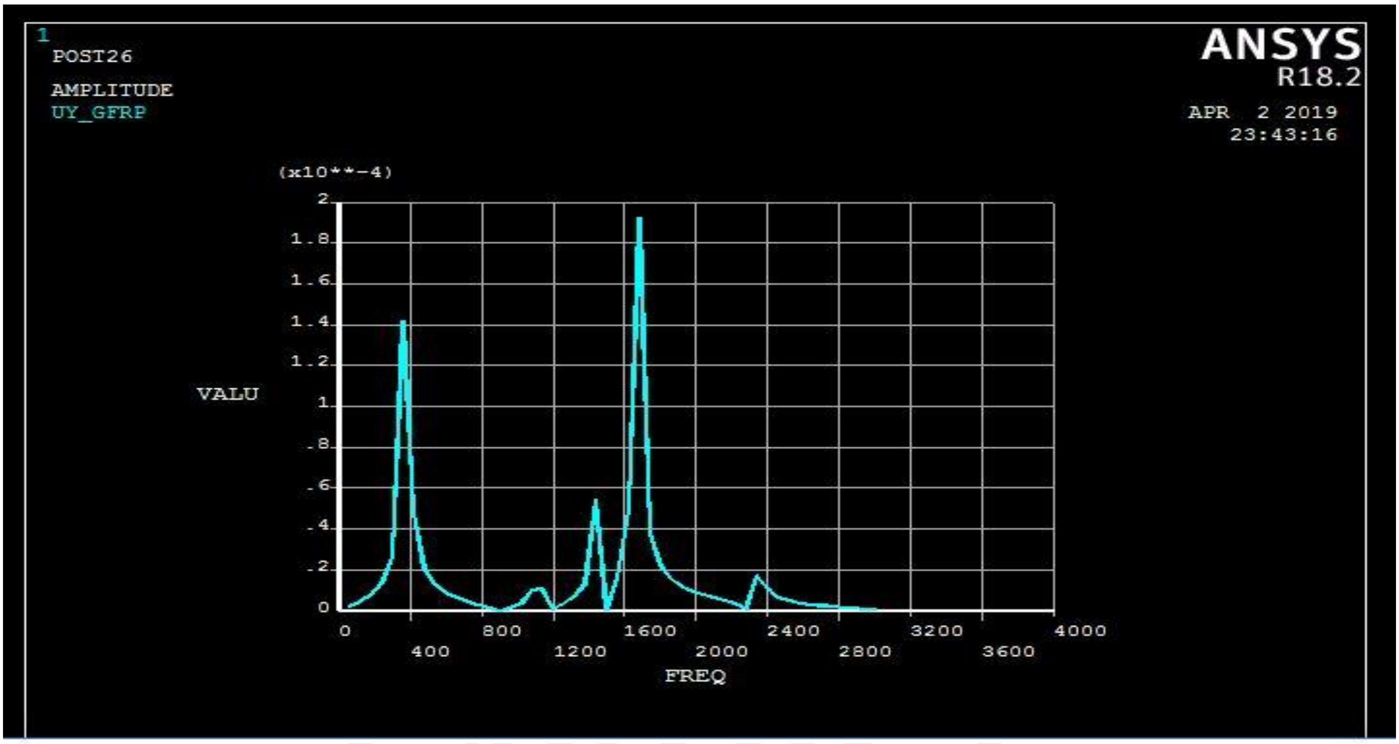


fig 5. y-component of displacement versus frequency response graph of nab propeller

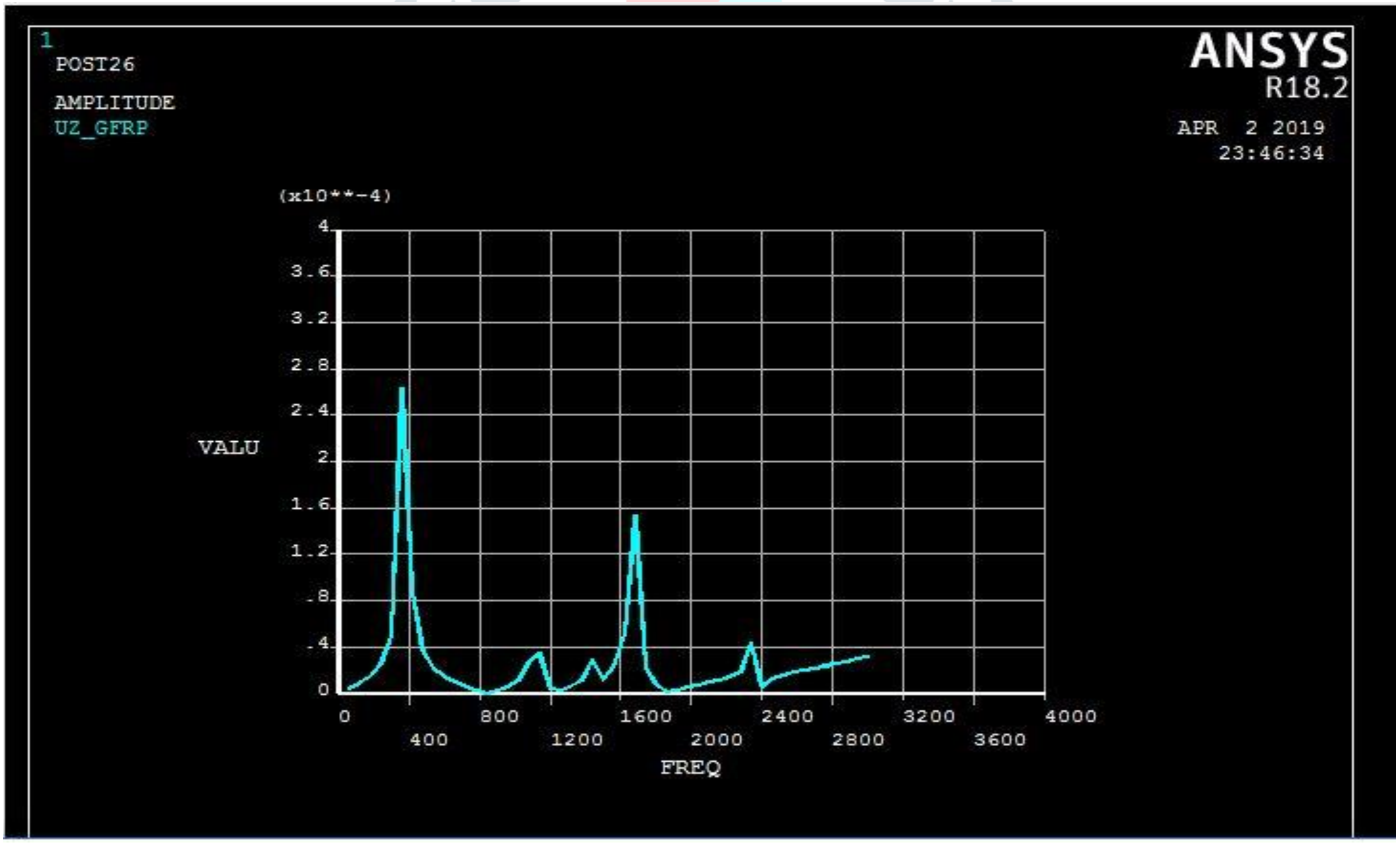


fig 6. z-component of displacement versus frequency response graph of nab Propeller

Maximum displacement of composite propeller:

Displacements of Composite Propeller	Maximum value
X-Component	0.178mm
Y-Component	0.192mm
Z-Component	0.265mm

CONCLUSIONS:

1. From the results of harmonic analysis, composite propeller is safe against resonance phenomena because the obtained frequency comes in the range of given input i.e 0 to 3000Hz.
2. Harmonic analysis is carried out on both NAB and composite propellers, it was observed that maximum displacement for composite propeller is less than the NAB propeller.
3. Due to addition of Aramid fiber layer on the glass fiber cavitation performance of composite propeller is improved.
4. Here by we conclude that weight of the composite propeller is less than that of NAB propeller so that reaction forces can reduce to some extent due to that durability of propeller increases.
5. As weight gets reduced, composite propellers areused to drive high speed under water vehicles.

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