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Modal Analysis on Unconstrained Layer Damping Treated Marine Propeller Blade

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Abstract

Marine propellers with conventional isotropic materials create more vibration and noise by blades during running. It is undesirable in strength point of view. This paper focuses on Modal analysis of free layer damping treated propeller blade of underwater vehicle using different polymers as layers and to analyze their natural frequencies by FE Solver software ANSYS Workbench 18.1 and modeling is carried with SOLIDWORKS 2013 and CATIA V5 Software. The Nitrile rubber with different hardness 60 shore A, 70 shore A and 80 shore A are as layers applied on the surface of propeller blade. The comparison of natural frequencies of untreated and treated or coated propeller blades using hexahedral elements has been made and the corresponding mode shapes are plotted.

Keywords: Free Layer Damping, Marine Propeller Blade, Modal Analysis.

1. INTRODUCTION

A propeller is a rotating fan like structure used to propel the ship by using power generated and transmitted. The transmitted power is converted from rotational motion to generate a thrust which imparts momentum to the water, resulting in a force that acts on the ship and pushes it forward[l]. Marine propellers are made from corrosion resistant materials such as alloy of aluminum and stainless steel. The vibrations are generated in a marine propeller is very common because of water is forced on to the rotating propeller blades [2]. The vibrations are generated in two ways, torsional and longitudinal vibrations. So these vibrations are transferred to the ship hull, there by discomfort of crew/passengers. Vibrations can be suppressed by using damping treatments like free layer damping and constrained layer damping [3]. In the present investigation free layer dumping treatment is considered and Nitrile rubber is used as layer. Here the material is applied on the propeller blade made up of AA6061. If a damping material is applied over the vibrating structure is called as free layer damping. It is also called as unconstrained layer damping [4]. The applied damping material is often thicker than the structure itself.

2. METHODOLOGY

Modeling of the untreated propeller blade is done using SOLID WORKS 2013 and treated propeller blades with CATIA V5. The models of three different layered free layer damping (FLD) propeller blades were then imported to ANSYS Workbench 18.1 for performing modal analysis [5].

2.1 Material Properties

The material properties of blade and layer are as shown in the Tables 1and 2.

Table 1: Material properties for Aluminum Alloy AA6061

Property	Va1ue	Unit
Density	2710	Kg/m^3
Young’s Modulus	70	GPa
Poisson’s ratio	0.33	

Table 2: Material properties for Nitrile Rubber

Material	Property	Value	Unit
Nitrile 60A	Density	0.52	Kg/m^3
	Young’s Modulus	2.64	GPa
	Poisson’s ratio	0.5	
Nitrile 70A	Density	0.64	Kg/m^3
	Young’s Modulus	5.42	GPa
	Poisson’s ratio	0.5	
Nitrile 80A	Density	0.76	Kg/m^3
	Young’s Modulus	9.86	GPa
	Poisson’s ratio	0.5	

2.2 Geometric Modeling

The first step in the analysis part is to prepare the 3-D model of the propeller blade [6]. The structure of the untreated propeller blade is made into 3-D as shown in the Fig. l and treated propeller blade is shown in Fig.2.

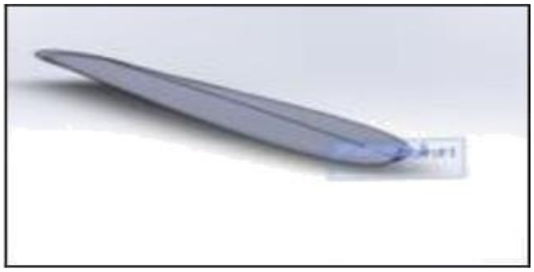

Fig.1 Untreated propeller blade by SOLIDWORKS

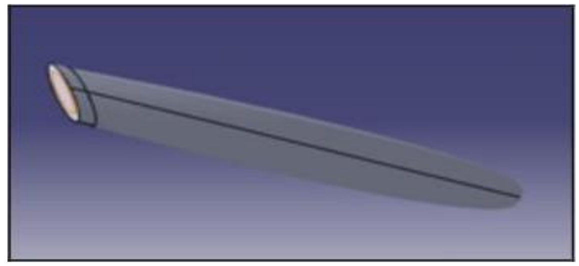

Fig.2 Treated propeller blade by CATIA V5

2.3 Importing and Meshing the Model

Import the model into analysis software ANSYS Workbench 18.1. After importing, it is the necessary step to mesh it. The meshed component is shown Fig.3.

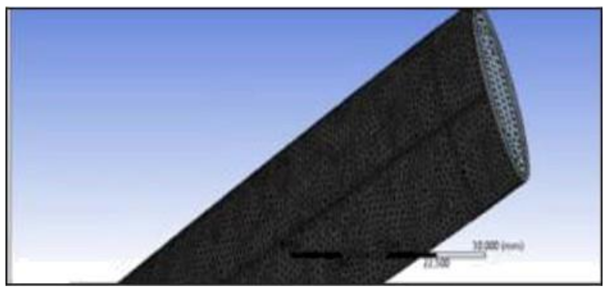

Fig.3.Mesh Generation

3. MODAL ANALYSIS

Modal analysis of Propeller Blades and comparison for mode 2 as shown from the figures 4 to7 [7].

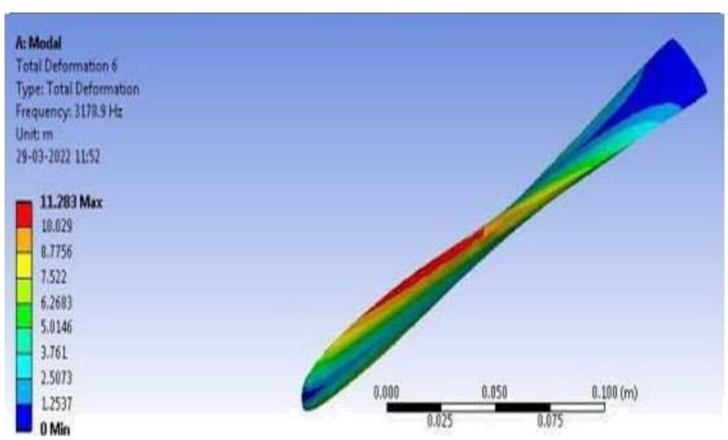

Fig.4 AA6061 for Mode 2:489.72 Hz

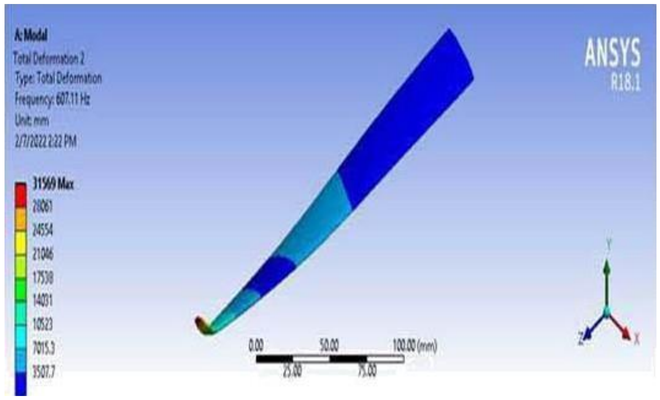

Fig.5 Nitrile 60 shore A rubber treated blade for Mode 2: 607.11 Hz

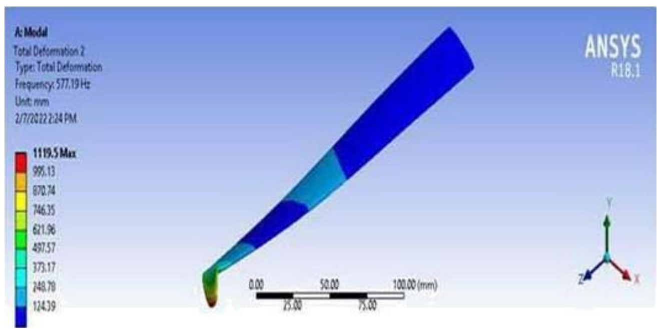

Fig.6 Nitrile 70 shore A rubber treated blade for Mode 2:577.19 Hz

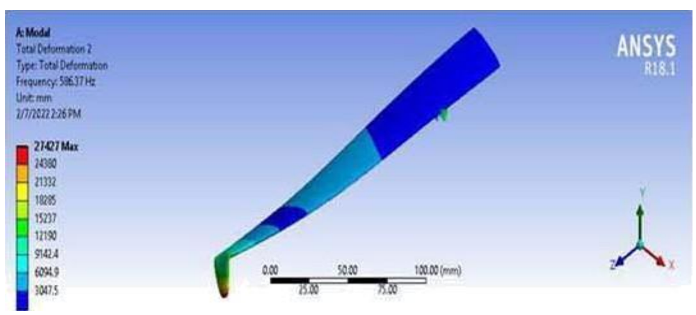

Fig.7 Nitrile 80 shore A rubber treated blade for Mode 2: 586.37 Hz

Table 3 Comparison of results

Mode	Frequency (Hz)			
	AA6061	**Nitrile 60A**	**Nitrile 70A**	**Nitrile 80A**
1	148.54	357.41	287.15	337.22
2	489.72	607.11	577.19	586.37
3	910.96	971.88	971.06	963.34
4	1760.7	1941.2	1963.2	1975.6
5	3169.6	3406.fi	3456.5	3553.2
6	3178.9	3501.2	3561.2	3621.6

4. CONCLUSIONS

The Modal analysis was carried on treated and untreated Marine propeller blades successfully and conclusions are drawn as follows:

- From the analysis it is observed that maximum deformation obtained with the untreated propeller blade made of Aluminium alloy compared with treated blades.
- Modal analysis results showed that the natural frequencies of treated propeller blade were more than aluminum propeller blade, which indicates that the operation range of frequency is higher for FLD propeller blade.
- It is observed that the natural frequencies of Nitrile 70 shore A treated propeller blade were found 18.86% more than the untreated propeller blade.

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