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Numerical Study and Analysis of Ship Propeller

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ABSTRACT: This research deal with the propeller which is the main and most important part for propelling in submarine , ships etc. The blades of propeller modeled and simulated by using solidwork 2015 software and analysis them by using Ansys 16.1. The blades contained bump on the their surfaces . Two materials used for propeller Aluminum and Titanium to study the effect of materials difference on the deformation and stress when the propeller subjected to water flow at specific speed . The results showed that the Titanium is better than Aluminum to withstand the deformation.

KEYWORDS: Ship Propeller; Bump; Aluminum; Titanium; Ansys.

INTRODUCTION

The propeller, whose name came from the Latin word (propellare) which mean (to drive forward) is very old concept . A propeller is kind of fan that transmits power by changing the rotation motion to the thrust. The pressure difference is produced between forward and backward surface of airfoil-shaped and a fluid (like air or water) is accelerated behind the blades [1].

The propeller is design by using both Bernoulli law and Newton third law. The propeller is very significant part of the propulsion plant. The propeller must be designed carefully in conjunction with each specific vessel to get not the high efficiency only but also the perfect level of comfort.

To design the propeller the main particles must be determined (diameter , mean pitch and blade area) . The propeller is determined by the number of blades, its pitch, and its diameter and off course the rotation direction (left or right) as shown in figures (1, 2) below. The number of blades is different according to the use of propeller . There are two blades propeller, three blades propeller which is the most often used , four blades propeller and multi blades propeller [2].

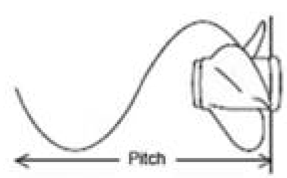

Figure 1. Pitch of the propeller.

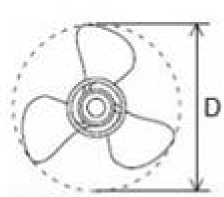

Figure 2. Diameter of the propeller.

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LITUREATURE REVIWE

T. CHITTARANJAN KUMAR REDDY, K.NAGARAJA RAO. The work is directed towards the study of marine propeller working and its terminology, simulation and flow simulation of marine propeller has been performed. The von misses stresses ,resultant deformation ,strain and areas below factor of safety has been displayed. The velocity and pressure with which the propeller blades pushes the water has been displayed in the results [1].

P. DurgaNeeharika, etal. The present work deals with modeling and analyzing the aluminum propeller blade of an underwater vehicle for its strength. A propeller is a complex geometry which requires high end modeling software. The solid model of propeller is developed in CATIA-V5 R20 and a tetrahedral mesh is generated for this model using HYPER MESH and static analysis is carried out using ANSYS [2].

D. W. Taylor studied the velocity and power of ships for the designing parameters of the propeller like Pitch, Diameter, No of blades etc [3].

Ab Volvo Pentacarried down the propellers from inboard propellers and theory for introduction like History and designing of propeller [4].

Y.SEETHARAMA RAO, etal, investigated the design of propeller with metal and composite materials and analyze it strength and deformation with ANSYS software. The mean deflection, normal stress and shear stress were found for both metallic and composite propeller by using ANSYS [5].

M. Suneetha , etal. research basically deals with the modeling and Analysis of the propeller using composite material of a marine vehicle having low draft. A propeller is complex 3D model geometry. CATIA modeling software is used for generating the blade model and tool path on the computer. Sectional data, pitch angle of the propeller are the inputs for the development of propeller model. Finite element analysis was carried out using ABAQUS [6] .

MOHAMMED AHMED KHAN, etal. work is to carry out the dynamic analysis of aluminum, composite propeller which is a combination of GFRP (Glass Fiber Reinforced Plastics) and CFRP (Carbon Fiber Reinforced Plastics) materials [7].

PROPELLER AND ITS MATERIALS

For ships and submarines the main property in choosing the material of propeller depends on its stiffness, weight , strength , corrosion resistant to seawater and thermal expansion. The material used for the producing of propeller depends upon the strength , ease of manufacturing, production methods, environment, weight etc.

The material used for propellers must be ductile , light, strong , easy to cast and machine and high resistance for corrosion and erosion [2].

Two materials used in this research, Aluminum alloy and titanium alloy to investigate the effect of difference materials on the life of propeller and its efficiency. The blades contain the bump on their surfaces to study the vortices effect on the propeller. The composition of Aluminum alloy and Titanium alloy are listed in tables (1 ,2 ,3) below.

Table 1. Chemical composition of Aluminum.

Metal	Chemical composition: (in %)
Copper	0.1
Magnesium	0.2 to 0.65
Silicon	6.5 to 7.5
Iron	0.5 max
Manganese	0.3 max
Nickel	0.1 max
Zinc	0.1 max
Lead	0.1 max
Tin	0.05 max
Titanium	0.2 max
Aluminum	90.4

Table 2. Mechanical properties of Aluminum.

Density	2770 kg/m^3
Coefficient of thermal expansion	2.3x10^{-5}
Young modulus	7.1 x 10^{10} pa
Poisson ratio	0.33
Tensile yield Strength	2.8x10^8
Tensile ultimate Strength	3.1x10^8

Table 3. Mechanical properties of Titanium.

Density	4620 kg/m^3
Coefficient of thermal expansion	9.4x10^{-6}
Young modulus	9.6x 10^{10} pa
Poisson ratio	0.36
Tensile yield Strength	9.3x10^8
Tensile ultimate Strength	1.07x10^9

MODELLING OF PROPELLER

Modeling of propeller is done by using Solidwork 2015 simulation software. To simulate the blade , it is necessary to have sections of propeller with various radius. These sections are drawn and rotated through their respective pitch angles with bump . The propeller has four blades , every blade has three bumps on its surface as shown in Figure 3.

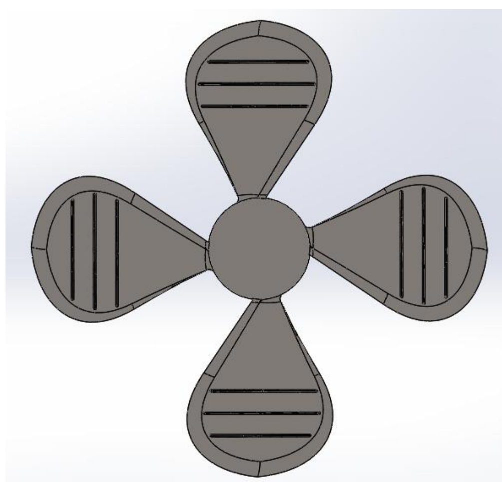

Figure 3. The propeller with bumps.

The dimensions of propeller are listed in table 4 below .

Table 4. The dimensions of Propeller.

Radius of hub	80 mm
Length of blade	280 mm
Max. width of blade	228 mm
Twist angle of blade	55^o
No. of blades	4
Thickness of bump	3 mm

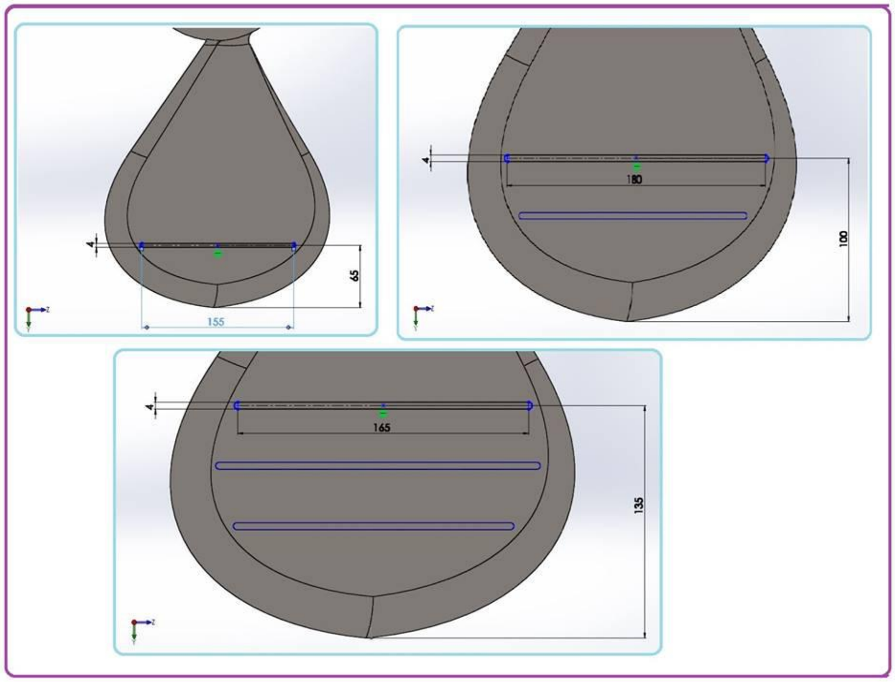

Figure 4. Illustrated the dimensions of blade and tips.

MESH GENERATION

The solidwork model is imprted to ANSYS 16.1 and tetrahedron mesh is generated with (121712) elemnets as shown in Figure 5.

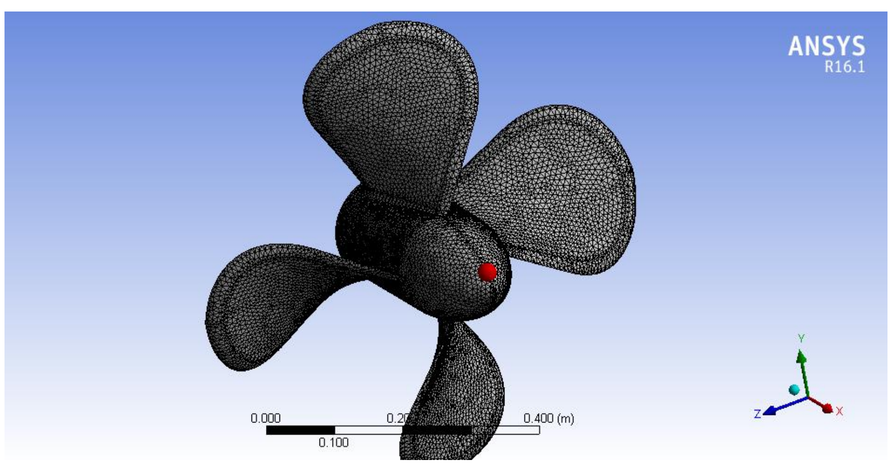

Figure 5. The mesh generation for propeller.

FINITE ELEMENTS ANALYSIS OF PROPELLER

The analysis of propeller was done by using ANSYS 16.1 finite elemnet analyizer . The boundary conditions were applied , the hub is fixed in all degrees of freedom . Number of element number is 121712 , number of nodes is 184580 , the velocity of water hit the blade is 15 m/s and the thrust is 232700 N. The thrust is produced because the pressure difference on the face and back sides of blades. The maximum deformation for titunaum blades with bump is 18 mm as shown in figure 6.

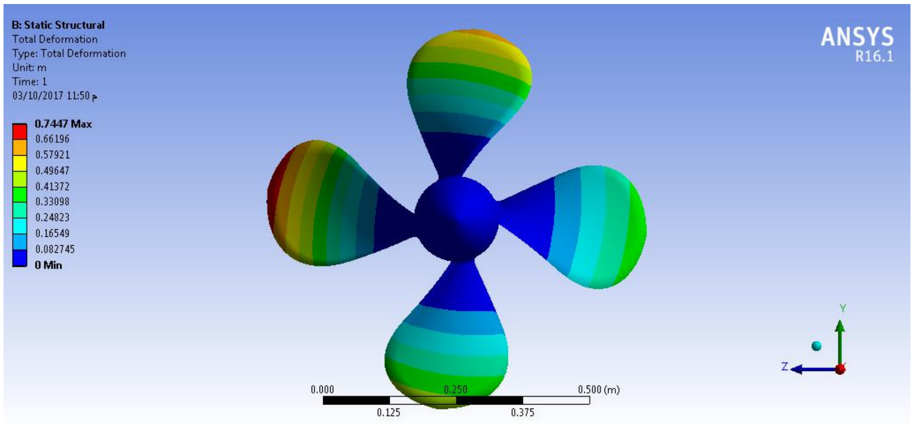

Figure 6. The deformation of titanium blade with bump.

While the maximum stress according to von mises theory is $3.2x10^8$ pa as shown in figure 7 and the maximum principle stress is 3.4 $x10^8$ pa as shown in Figure 8.

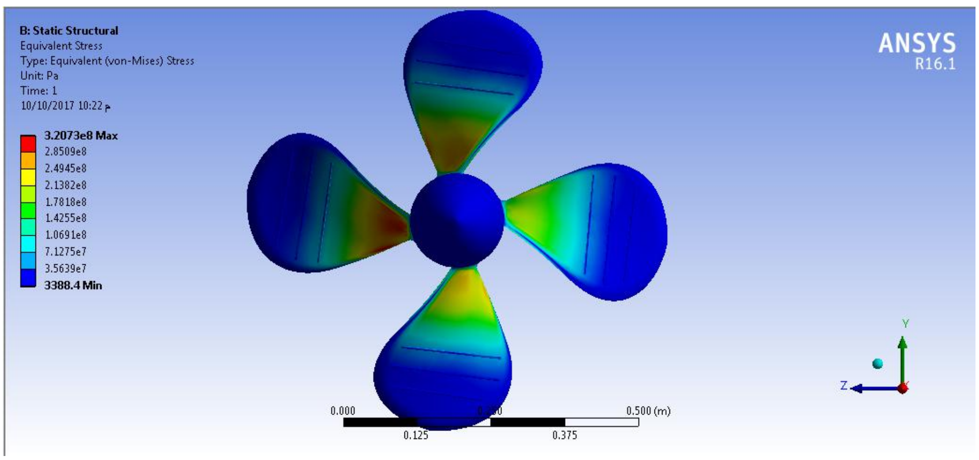

Figure 7. The von mises stress for titanium blade with bump.

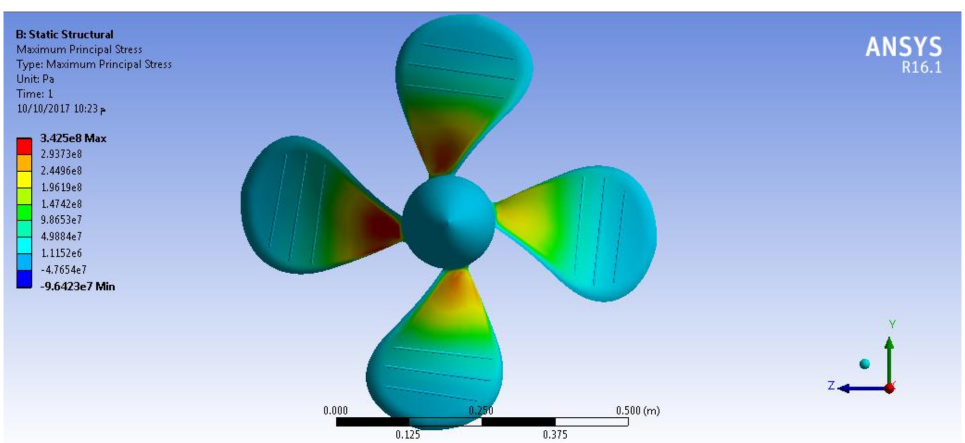

Figure 8. The maximum principle stress for titanium blade with bump.

The maximum deformation for Aluminum blade with bump is 25 mm as shown in Figure 9.

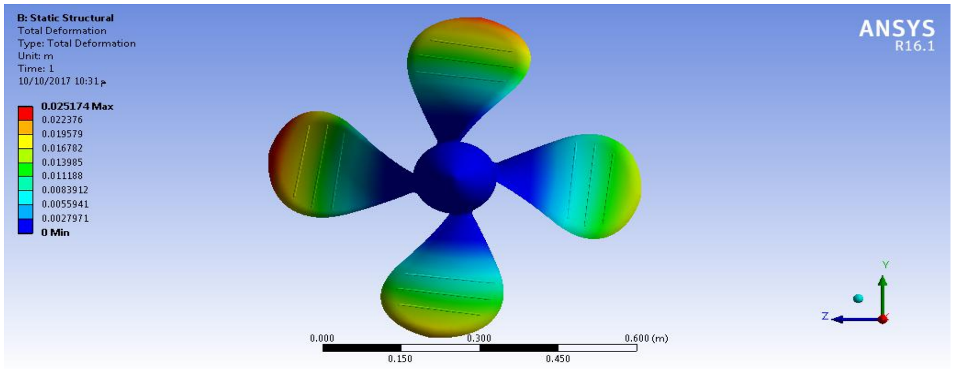

Figure 9. The deformation of Aluminum blades with bump.

While the maximum stress according to von mises theory is $3.2x10^8$ pa as shown in Figure 10 and the maximum principle stress is 3.9 $x10^8$ pa as shown in Figure 11.

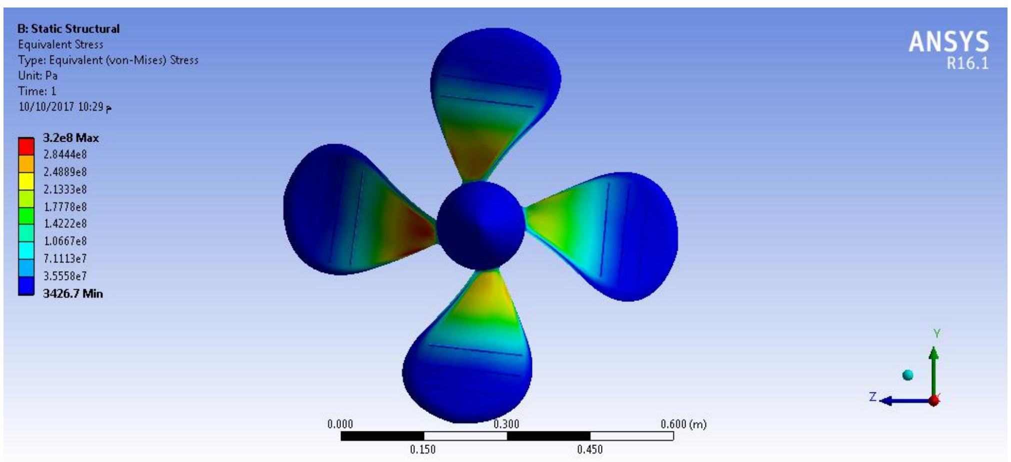

Figure 10. The von mises stress for Aluminum blade with bump.

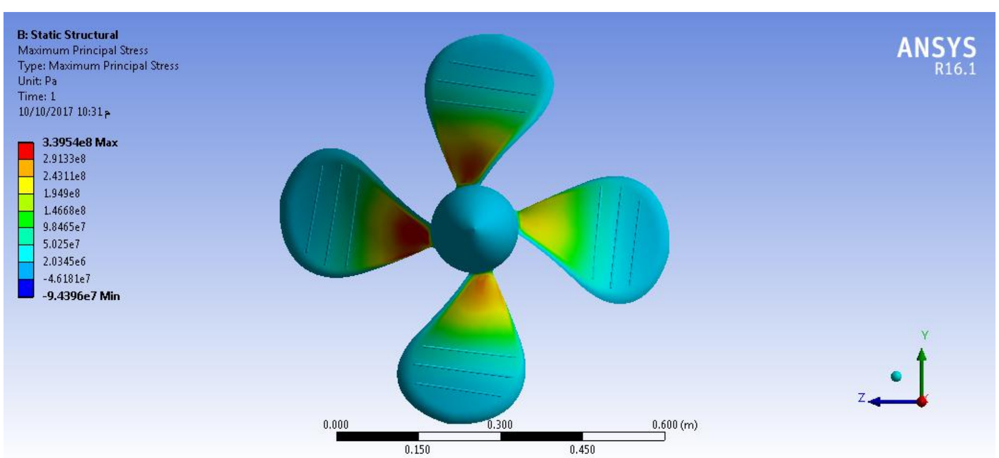

Figure 11. The maximum principle stress for Aluminum blades with bump.

CONCLUSIONS

The propeller of ship was designed , simulated and analyzed in this was work with four blades and with presence of bump on the blades surface. The results showed that Titanium is better than Aluminum for manufacturing the propeller. the maximum deformation in Titanium was 18 mm while the maximum deformation in Aluminum was 25 mm that means the Titanium can withstand fluid flow (water flow) with speed about 15 m/s more than Aluminum and it suitable for producing the ship or submarine propeller**.**

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