Study of Effects on Strength and Weight of Centrifugal Pump Impeller with Different Materials by Finite Element Method

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STUDY OF EFFECTS ON STRENGTH AND WEIGHT OF CENTRIFUGAL PUMP IMPELLER WITH DIFFERENT MATERIALS BY FINITE ELEMENT METHOD

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ABSTRACT

In this study we will use centrifugal pump impeller as part . To find out strength of impeller with different materials, we will perform FEA study. We will compare strength of impeller with different materials and from comparison we can find material with good strength which can replace conventional materials which are being used in manufacturing of impeller.FEA simulation technique will be used to compare strength of impeller with different materials like Aluminium, SS316, Carbon fiber and glass fiber. CAD modelling will be done in solidwork,Material will be assigned. For Meshing and post processing FEA simulation module of solidwork will be used. This analysis will give data of strength and weight of impeller with different materials. That data of strength with different material will be compared and on comparison, material which gives more strength can be proposed .
Keywords: Centrifugal pump, Impeller, Weight, Solidwork, FEA

1. INTRODUCTION

Centrifugal pump is widely used in all types of industry such as food processing, beverage, milk product, chemical, Pharmaceutical, Medical, Automobile , water filtration, farming etc. Impeller of centrifugal pump is made by conventional techniques and by using conventional material like SS316, steel casting etc.

As new trend is going on in additive manufacturing and we can replace conventional materials by using additive manufacturing technology so we have scope to propse new materials to replace centrifugal pump impellers.

As material from plastic family and composite fiber have proven capability to alter conventional materials time has come to proposed material from plastic family, fiber reinforced material/composite fibers to make part light in weight . parts from thses material can be manufactured by other techniques like injection moulding ,3D printing etc.

In this study we will check strength of impellerwith different materials with same loading conditions.

In centrifugal pump, Impeller and shaft are rotating members.Casing is stationary member.due to heavy impeller , unbalance forces produce into pump . due to which vibration occurs . this vibration creates noise as well damage to casing. This very important to reduce vibrations. If we use light weight impeller with same strength can reduce vibration and noise.

2. METHODOLOGY

Impeller of centrifugal pump will be CAD modelled into solidwork. Solidwork FEA simulation module will be used to perform stress analysis for von mises stress and deflection.Aluminium, steel , PP, ABS and carbon fiber. CADModel will be redesigned to give best suitable result on strength with respect to each material. Results will compared and Material which gives good strength with reduction in weight will be selected for fabrication and testing.

3. LITERATURE REVIEW

[1] **G. Kalyan, K.L.N. Murty. "Design and Optimization of Centrifugal Pump GuideVanes"** In this paper an impeller of a centrifugal pump is designed and modeled in 3D modeling software Pro/Engineer. steel and aluminium materials are used. The optimization of the design is achieved by getting the results from the analysis which has been performed.Stress frequency velocity pressure flow rates are considered as results. For analysis ANSYS is used . As per result Stresses increase with increase in number of blades and angles. When Stresses are less for Aluminiummaterial..Frequencies are reduced by increasing blades.

[2] **Pramod J. Bachche1, R.M.Tayade "Finite Element Analysis of Shaft of Centrifugal Pump"** In this paper they have performed analysis of shaft of centrifugal pump for static and dynamic analysis . In static FEA analysis for stress and deflection is performed. Results areverified using graphical integration method. In dynamic analysis results of static analysis are used as input and dynamic forces are calculated. Shaft is analysed by using dynamic input conditions and results are verified using graphical integration method. Maximum dynamic deflection is obtained 11% less than allowable deflection and Maximum stresses for dynamic is obtained 18% less than allowable tensile strength.

[3] **Weight Optimization of Centrifugal pump Impeller by FEA Method Dnyaneshwar Lande1 , Prof.A.Z.Patel2 , Prof.A.B.Ghalke3** In this paper they have used 3hp pump impeller. They have prepared CAD modelling of the impeller. Meshing and Post processing is performed. For static conditions results are obtained in terms of strength (Von mises stress) and deflections. Analysis is performed for Aluminium, Steel and glass fiber. From result it found that glass fiber reduces weight of impeller without compromising its strength.

[4] **Static Analysis of Centrifugal Blower Using Composite Material 1Mr M.Sampathkumar, 2Mr.Dsvsra Varaprasad, 3Mr.Vijaykumar** In this paper static and model analysis of centrifugal blowers using composite Materials is done . Centrifugal blowers are used in naval applications and motors.All this areas have high levels ofnoise. The noise generated by a rotating component is mainly because of loading force on the blades and frequent iteration of incoming air with therotor blades. The Blades in naval applications are made up of Aluminum or Steel . Noise creates disturbance for people. E glass can be very good alternative to metal in making impeller by considering strength and stiffness . The natural frequency of E glass blower is reducing by 16.6% to 27.7% . And this is because of high stiffness.

[5] **Static and Dynamic Response of an Impeller at Varying Effects Karthik Matta1 , Kode Srividya2 , Inturi Prakash3** In this paper composite material is used for blower. CAD model is prepared in CATIA V5 and Ansys is used to FEA. Modal analysis is performed on blower with Aluminium and composite material to obtain 5 natural frequencies . Effectiveness of impeller with composite material is analysed.

4. CAD MODLE PREPARATION

CAD refers to Computer aided design . There are different softwares are available for CAD activity. Preparing 3D models, drafting , assembly all these task are performed in CAD modelling. In our case 3D model will be prepared by using Solidwork. And material will be assigned as per requirement.

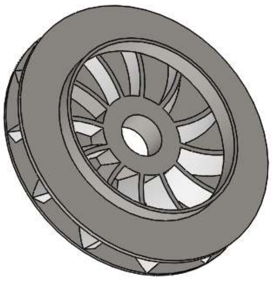

Fig.1 3D model of impeller

5. FEA OF IMPELLER

1. Applying load and boundary conditions
2. Meshing of Mode

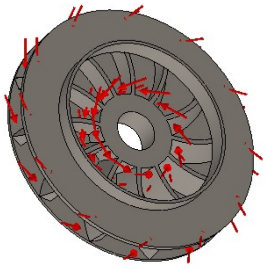

Fig.2 Model after applying load and boundary condition

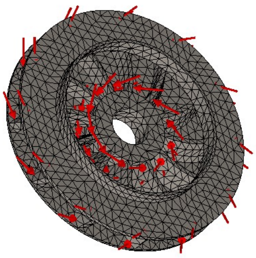

Fig.3 Meshed model

6. RESULTS FOR SS316

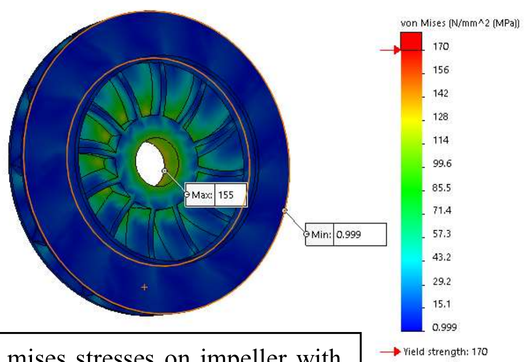

Fig.4 Von mises stresses on impeller with SS316L

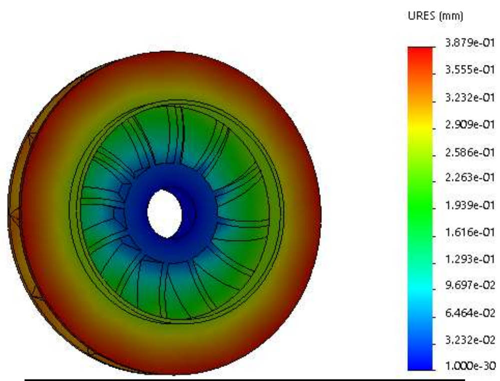

Fig.5 Deflections in impeller with SS316L

7. MECHANICAL PROPERTIES OF DIFFERENT MATERIAL :

Table 1. comparison of result of analysis

Material	Young's Modulus	Poissons Ratio	Density	Yield stress	Ultime tensile Stress
SS316L	200 GPa	0.26	8027 kg/m3	170 MPa	485 MPa
Aluminium	68.9 GPa	0.33	2700 kg/m3	214 MPa	241 MPa
Carbon fibre T300	140 GPa	0.25	1760 Kg/m3	1790Mpa	1820 MPa
Nylon 6/10 With 50% Glass fiber	152 Gpa	0.28	1400 Kg/m3	240 MPa	600 MPa

8. FEA results for different materials

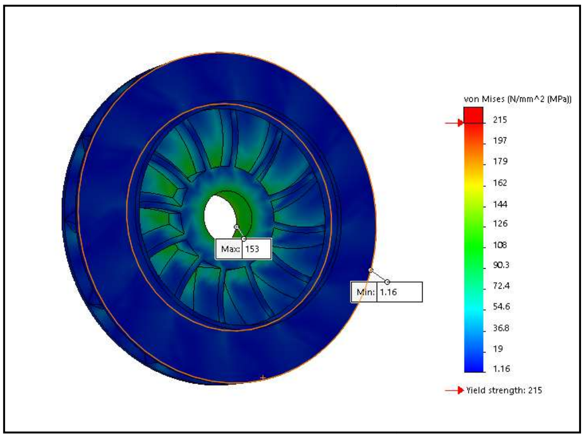

Fig.5 Von mises stresses of impeller with Alumium

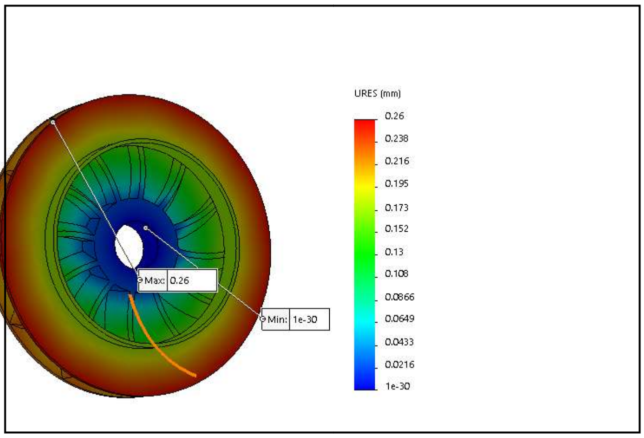

Fig.6 Deflections in impeller with Aluminium

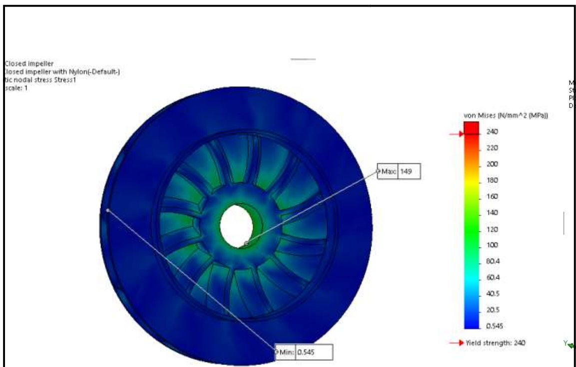

Fig.7 Von mises stresses of impeller with Nylon 6/10 With 50% glass fiber

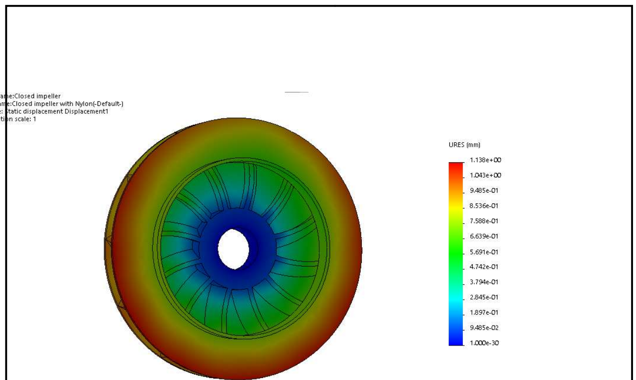

Fig.8 deflection of impeller with Nylon 6/10 With 50% glass fiber

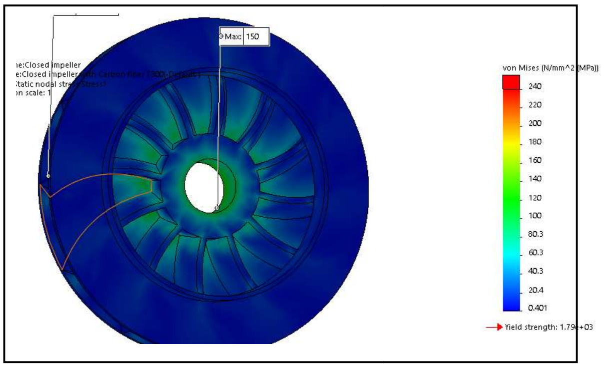

Fig.9 Von mises stresses of impeller with Carbon fiber T300

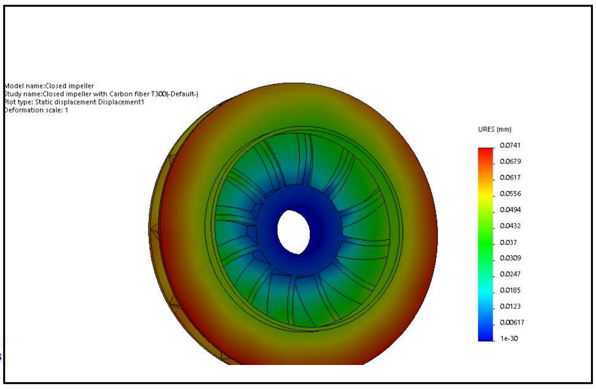

Fig. 10 deflection of of impeller with Carbon fiber T300

9. Comparison of result of analysis

Table 2. comparison of result of analysis

Material	Max. Vonmises stress	Max. Displacement	Weight
SS316L	**155 Mpa**	**0.08 mm**	**1.35 Kg**
Aluminum	**153 Mpa**	**0.26 mm**	**0.45 Kg**
Carbon fiber T300	**150 Mpa**	**0.07 mm**	**0.3 Kg**
Nylon 6/10 With 50% Glass fiber	**149 Mpa**	**1.1 mm**	**0.24g**

10 . Weight reduction of impeller compared to SS 316

9.1 Weight reduction with Aluminum
= (1.35-0.45/1.35)*100
= 66.67%

9.2 Weight reduction withCarbonfiber T300
= (1.35-0.3/1.35)*100
= 77.78%

9.3 Weight reduction with Nylon 6/10 with 50% glass fiber
= (1.35-0.24/1.35)*100
= 82.22%

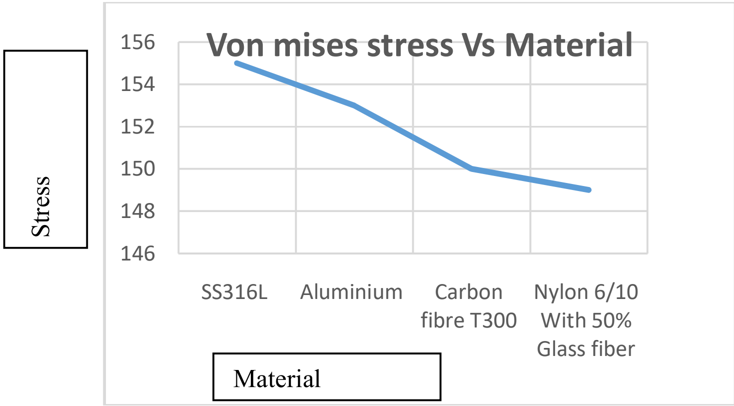

Fig. 11 Graph for Von mises stresses in impeller with different material

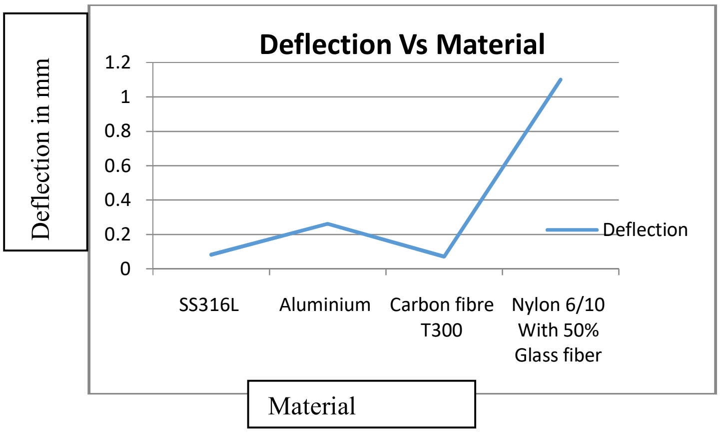

Fig. 12 Graph for deflection in impeller with different material

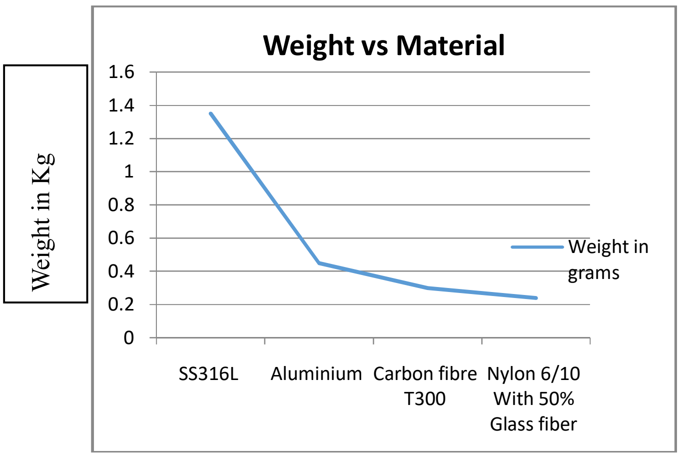

Fig. 13 Graph for Weight of impeller with different material

11. CONCLUSION

82.22 % Weight reduction can be possible by using Carbon fiber T300 material in impeller. And 77.78 % Weight reduction is possible in Nylon 6/10 with 50% glass fiber without compromising strength of parts.

Maximum stresses in T300 carbon fiber 150 Mpa , Maximum stresses in Nylon 6/10with glass fiber 149Mpa.. And displacement is observed 0.07 mm for carbon fiber T300 and 1.1mm forNylon 6/10 with glass fiber.

From comparison it can be found that Carbon fiber T300and Nylon 6/10 with 50% glass fiber both can be good alternative for SS316 and aluminum in impeller. T300 carbon fiber exhibits good performance among all selected material.

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