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Finite Element Analysis of M.S. Impeller of centrifugal Pump

Prof. Pranav R.Mane[1], Prof. Pankaj L. Firake[2], Prof. Vijay L. Firake[3]

[1, 2]*Department of Mechanical Engineering, JSPM'S Rajarshi Shahu College of Engineering Tathwade, Pune*
[3]*Department of Mechanical Engineering, J. T. Mahajan College of Engineering Faizpur*

Abstract- *Centrifugal pump is a device mainly used for transporting liquid from lower level to higher level. Centrifugal pumps are widely used for irrigation, water supply plants, steam power plants, sewage, oil refineries, chemical plants, hydraulic power service, food processing factories and mines, because of their suitability in practically any service. In pumps the mechanical energy is converted into hydraulic energy. The two main components of centrifugal pump are impeller and casing therefore, they must be carefully designed for better performance of pump. Impellers impart a radial and rotary motion to the liquid, which results in increase in both the pressure and the kinetic energy and forcing it to the volute. The main function of pump casing is to guide the liquid from the suction nozzle to the center of the impeller. The centrifugal pump terms are firstly introduced by H. Addison.*

Keywords - *Static and Modal Analysis of pump impeller, weight optimization of impeller.*

I-INTRODUCTION

In order to carry out a finite element analysis, the model we are using must be divided into a number of small pieces known as finite elements. Since the model is divided into a number of discrete parts, FEA can be described as a discretization technique. In simple terms, a mathematical net or "mesh" is required to carry out a finite element analysis. If the system under investigation is 1D in nature, we may use line elements to represent our geometry and to carry out our analysis. If the problem can be described in two dimensions, then a 2D mesh is required. Correspondingly, if the problem is complex and a 3D representation of the continuum is required, then we use a 3D mesh. Area elements can be triangular or quadrilateral in shape. The selection of the element shape and order is based on considerations relating to the complexity of the geometry and the nature of the problem being modelled. Membrane elements don't have any thickness. As a consequence they have no bending stiffness; loads can only be carried in the element plane. Plate & shell elements are used to model thin walled regions in 3D space. The plate element is formulated around plate theory, which assumes that the load is carried via bending. Shell elements are used to model shells, where there is combination of flexure and membrane action.

LITERATURE SURVEY

[1] "Static and Dynamic Analysis of a Centrifugal Pump Impeller" A Syam Prasad, BVVV Lakshmipathi Rao, A Babji, Dr P Kumar Babu , Alloys are playing major role in many engineering applications. They offer outstanding mechanical properties, flexibility in design capabilities, and ease of fabrication. Additional advantages include light weight and corrosion resistance, impact resistance, and excellent fatigue strength. In this paper study of static and modal analysis of a centrifugal pump impeller which is made of three different alloy materials. (viz., Inconel alloy 740, Incoloy alloy 803, Warpaloy) .

The best material for design of impeller is Inconel 740. Specific modulus of Inconel 740 obtained in static analysis is 10 % higher than other material. The natural frequency in modal analysis is 6% higher than other material. The deformation of Inconel 740 in static analysis is reduce by 12%.

[2] "Static and Dynamic Response of an Impeller at Varying Effects" Karthik Matta, Kode Srividya, Inturi Prakash , An impeller is a rotating component of a centrifugal pump, usually made of iron, steel, bronze, brass, aluminum or plastic. The modeling of the impeller was done by using solid modeling software, CATIA V5

R18. It is proposed to design a blower with composite material, analyze its strength and deformation using FEM software. In order to evaluate the effectiveness of composites and metal blower and impeller using FEA packaged (ANSYS). Modal analysis is performed on both Aluminium and composite centrifugal blower impeller to find out first 5 natural frequencies. If number of blade and outer diameter increases stresses and deformation also increases all are allowable limit.

[3] "Design and Optimization of Centrifugal Pump Guide Vanes" G. Kalyan, K.L.N. Murty. They observe CFD analysis results the velocity is decreasing by increasing the number of blades and angle the pressure is increasing and the temperature is decreasing For 500 angle the results are reverses so using angle 500 is not proposed. So it can be concluded that using Aluminum for impeller is better since the stresses are less. They examine that by considering stresses using number of blades 5 and angle 200 is better but by considering frequencies using number of blades 6 and angle 200 is better.

[4] Finite Element Analysis of Shaft of Centrifugal Pump" Pramod J. Bachche1, R.M.Tayade .They have conducted centrifugal pump is world one of the oldest water pumping devises. In this paper study Shaft of centrifugal pump for static and dynamic analysis. The shaft is analyzed by using finite element analysis technique for stresses and deflections. The total work is carried out in two stages first stage is static analysis. In this stage pump shaft is analyzed for stresses and deflection and same results are verified using graphical integration method. And second for dynamic analysis, in this stage result obtained by static analysis are used to calculate dynamic forces coming in pump shaft. Again shaft is analyzed in dynamic input condition and results are verified by using graphical integration method. Maximum deflection and stress are generated to minimum flow condition.

[5] "Analysis of centrifugal pump impeller using ANSYS-CFX" S.Rajendran and Dr. K Purushothaman .
They have studied analysis of centrifugal pump impeller design is carried out using ANSYS-CFX. It is most common pump used in industries and domestic application. The complex internal flow in centrifugal pump impeller can predicted by ANSYS-CFX. A centrifugal pump is kinetic device.
Liquid entering the pump receives kinetic energy from the rotating impeller. The centrifugal action of impeller accelerates the liquid to high velocity, transferring mechanical (rotational) energy to the liquid. The flow pattern, pressure distribution in blade passage and blade loading of centrifugal pump impeller are discussed in this paper. Centrifugal pump impeller without volute casing is solved at designed mass flow rate is high. Total efficiency of pump is 30% increases.

GEOMETRY

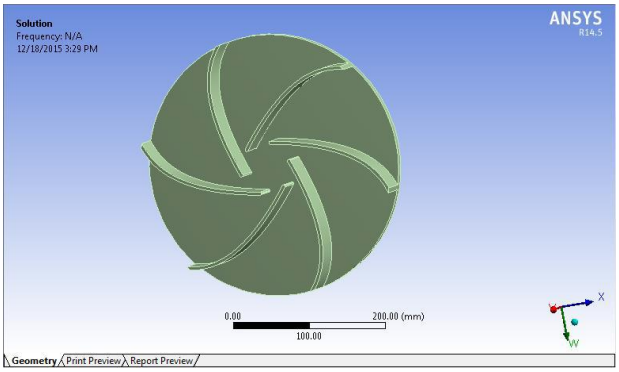

Fig.1.1 - Geometry of centrifugal pump impeller

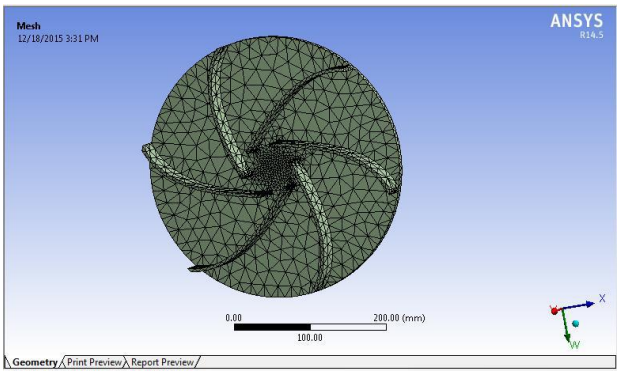

Fig.1.2 -Meshing of impeller model

Nodes	Elements
14775	7636

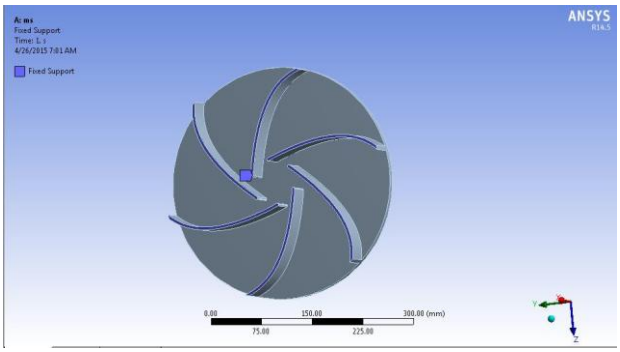

Fig.1.3- Fixed support of centrifugal pump impeller

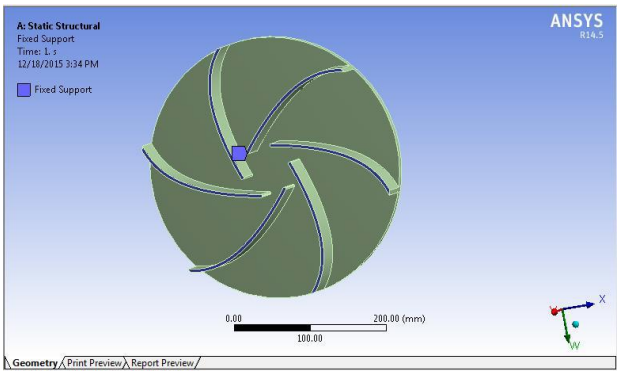

Fig.1.4-Moment applied on pump impeller

MODAL ANALYSIS

Modal Analysis of MS Pump impeller:

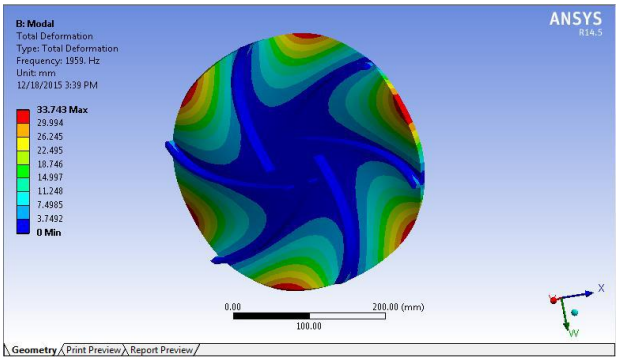

Fig. 2.1 First Mode Shape of MS Pump Impeller

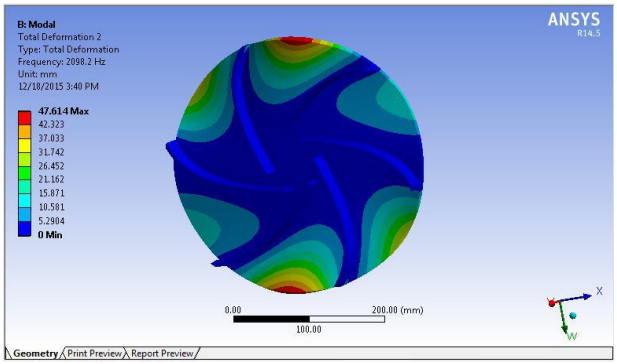

Fig. 2.2 Second Mode Shape of MS Pump Impeller

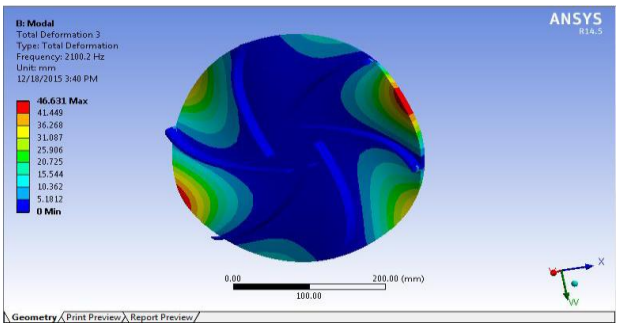

Fig. 2.3 Third Mode Shape of MS Pump Impell

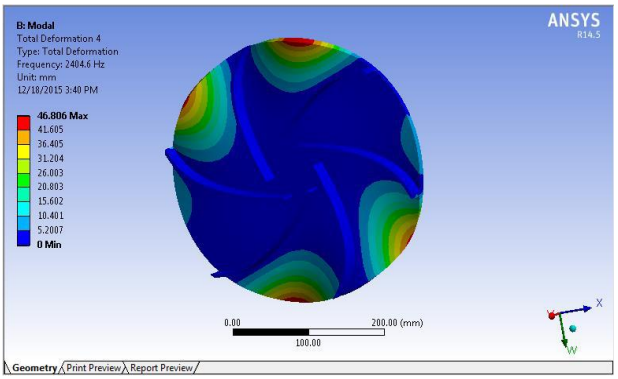

Fig. 2.4 Fourth Mode Shape of MS Pump Impeller

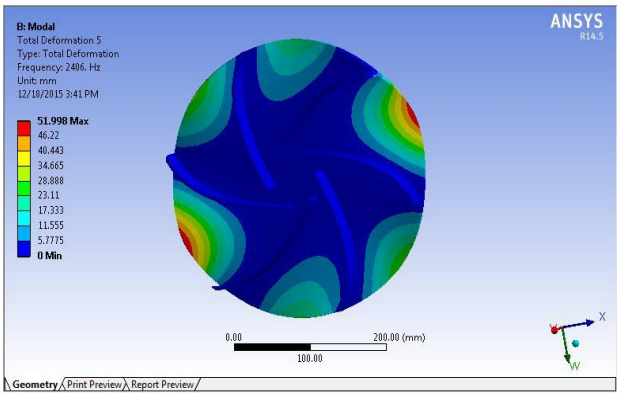

Fig. 2.5 Fifth Mode Shape of MS Pump Impeller

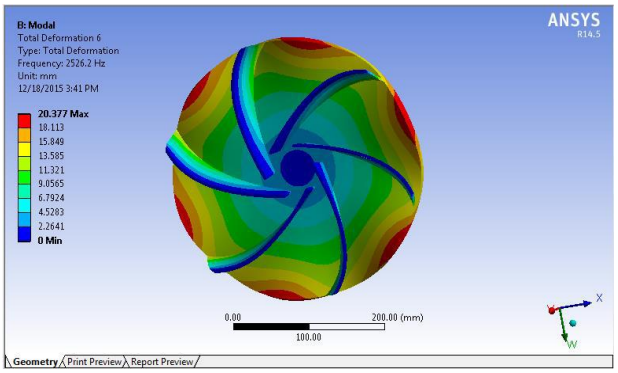

Fig. 2.6 Sixth Mode Shape of MS Pump Impeller

MODAL PRESTRESSED

Mode	Frequency(Hz)
1	543.42
2	543.86
3	564.45
4	675.86
5	675.99
6	1094.1

RESULT AND DISCUSSION

For sake of convince and to get optimum result we have taken six mode, each mode wise natural frequency are shown in above table. From the mode shapes diagrams the mode shapes represent the bending mode in the blade of impeller and deformation of impeller. It is clear that the blade of impeller stiffness needs to be increase. On the other hand, to avoid the resonance at the operating speed, the difference between first natural frequency and operating frequency must be high.

CONCLUSION

The modal analysis of the semi-open impeller was done by the finite element analysis. The natural frequencies and the mode shapes of the impeller were extracted. It was found that the vector displacement of the impeller increased by increasing natural frequencies. At operating speed deformation in blade and resonance phenomena will not occur. In the modal analysis it is observed operating speed frequency of the impeller due to number of RPM doesn't match with the natural frequency of the impeller at every mode.

Future Scope of the Work

- Dynamic analysis can be performed for pump impeller using incnel 625.
- We can check the lifetime of the impeller with changing various material.
- Further development of this designed impeller can be done by CFD analysis of the impeller.
- Another way of development is by increasing the number of vanes. In this design as the numbers of vanes on diffuser

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