A REVIEW PAPER ON DESIGN, VIBRATION AND FATIGUE LIFE ANALYSIS OF IMPELLER OF SUBMERSIBLE PUMP

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Abstract- *A pump is a device that moves fluids (liquids or gases) or sometimes slurries, by mechanical action. Pumps operate via many energy sources, including manual operation, electricity, engines, or wind power, dynamic pump that uses a rotating impeller to increase the pressure of a fluid. Centrifugal pumps are commonly used to move liquids through a piping system. The fluid enters the pump impeller along or near to the rotating axis and is accelerated by the impeller, flowing radially outward into a diffuser or volute chamber (casing), from where it exits into the downstream piping system. Its purpose is to convert energy of a prime mover (a electric motor or turbine) first into velocity or kinetic energy and then into pressure energy of a fluid that is being pumped. Centrifugal pumps are used for large discharge through smaller heads. centrifugal pumps converts mechanical energy from a motor to energy of a moving fluid; some of the energy goes into kinetic energy of fluid motion, and some into potential energy, represented by a fluid pressure or by lifting the fluid against gravity to a higher level. The transfer of energy from the mechanical rotation of the impeller to the motion and pressure of the fluid is usually described in terms of centrifugal force, especially in older sources written before the modern concept of centrifugal force as a fictitious force in a rotating reference frame was well articulated. The concept of centrifugal force is not actually required to describe the action of the centrifugal pump. In this work analysis on MS & SS pump impeller is done in order to optimize strength of centrifugal pump. This work gives the static & Modal analysis of SS structural steel, Aluminium alloy and composite material CFRP Pump Impeller to check strength of Pump, weight & vibrations produced by pump.*

Keywords- Analysis, Pump Impeller, Optimization

I. INTRODUCTION

A pump is a device that moves fluids (liquids or gases), or sometimes slurries, by mechanical action. Pump is device it may be mechanical energy into hydraulic energy is a pump. Pumps can be classified into three major groups according to the method they use to move the fluid: direct lift, displacement, and gravity pumps .Pumps operate by some mechanism (typically reciprocating or rotary), and consume energy to perform mechanical work by moving the water. Pumps operate via many energy sources, including manual operation, electricity, engines, or wind power. Other word pump may be hydraulic energy into mechanical energy or mechanical energy into hydraulic energy. It assists to increase the pressure energy or kinetic energy, or both of the fluid by converting the mechanical energy.

The basic difference between a turbine and pump, from hydrodynamic point of view, is that in the former flow takes place from the high pressure side to the low pressure side, whereas in pump flow takes place from the low pressure towards the higher pressure. Thus in a turbine there is accelerated flow, while in a pump, the flow is decelerated. The Submersible Pump main application is agriculture, wind power , industries and water tank etc. Single or multi-stage centrifugal pumps in Radial or Mixed Flow hydraulic systems. Stage casings of radial pumps are connected by metal straps; those of mixed flow pumps by stud bolts. A suction casing is fitted between the pump & motor. Suction casing is fitted with strainer to protect the pump from coarse particles/ sand in the fluid. Pumps with check valve (non-return valve) in option are supplied. Threaded or flanged end is an option. Additional bearings are fitted depending on the number of stages. Stainless Steel inserts are fitted to the impeller. The impeller hub is protected by stainless steel inserts. This design improves the starting torque & has the effect that solid particles such as sand are propelled outside.

Common problems faced by a pump are Cavitations, excess vibration, excess noise and heat, leakage, mechanical seal failure, components failure, and many more. Symptoms of Cavitations are rattling noise and high level of vibration occurring in the pump.

Sources of the problems can be seen from the characteristics of flow inside the pump. When fluid moves through the impeller, the pressure drop will affect the boiling temperature of the fluid . Therefore, the lower the pressure of fluid, the lower the boiling point of the fluid . Cavitations occurs

if the pressure of fluid falls below the vapour pressure . This will cause the vibration and noise of the pump.

Indirectly, the problems will disintegrate the impeller and create small holes. The head pressure output of the pump will also decrease. The pressure drop can be caused by the loss of energy in the fluid which moves from the pump suction line to the rotating impeller. Other considerations that contribute to pressure drop include impeller angles, impeller vanes, and entrance angle which are related to the velocity of the fluid .

Air entrainment is another problem faced by the centrifugal pump. It happens when vapour bubble is already present before the fluid enters the pump. The presence of turbulent flow at the suction line is the cause of air entrainment. Turbulent flow exists due to inappropriate piping condition at the suction line .

Other than pump mechanism problems, a simple problem such as mechanical seal failure can massively contribute to pump shutdown . It fails due to wear and tear and inadequate operations such as poor selection and installation error. A pump failure can be identified by knowing when it happens, whether during start-up of the pump, after 2-3 weeks of operation or 3-4 months of operation. These symptoms are caused by the operation and design of pump that failed to meet the requirements, parts failure due to wear and tear, or the pump is damaged from the fluid being transported through the pump. The only way to solve these problems is by doing maintenance work in order to keep up with the operation schedule. The maintenance repair could take weeks depending on the level of damage of that particular centrifugal pump.

Another proposition to overcome these problems is to design a new pump impeller. With the new impeller design prior to the given pump specification, the pump can operate at high efficiency and can operate as the operation phase, thus reducing the cost of maintenance. Hence, the objective of this study is to provide an impeller design with better flow and pressure distribution by studying the effect of RPM on efficiency and static head. The design is done by performing analysis on the impeller with various rotating speeds.

Objectives of the study :

1. To check strength of pump by static analysis using various material like steel, aluminium and alloys.
2. To reduce weight of pump by using different material.
3. To determine natural frequency by modal analysis of steel, aluminium and alloys .

II. LITERATURE REVIEW

A Syam Prasad, BVVV Lakshmipathi Rao, A Babji , Dr P Kumar Babu [1], "Static and Dynamic Analysis of a Centrifugal Pump Impeller". In this paper author shows that the static and dynamic analysis of a centrifugal pump impeller which is made of three different alloy materials (viz., Inconel alloy 740, Incoloy alloy 803, Warpaloy) to estimate its performance. The investigation has been done by using CATIA and ANSYS13.0 software. The CATIA is used for modelling the impeller and analysis has been done by using ANSYS. The results show that The best material for design of impeller is Inconel 740. Specific modulus of Inconel740 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 Inconel740 in static analysis is reduce by 12%.

Karthik Matta1, Kode Srividya2, Inturi Prakash3 [2] "Static and Dynamic Response of an Impeller at Varying Effects '' In this paper author shows that 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. The results show that to evaluate the effectiveness of composites and metal blower and impeller using FEA packaged (ANSYS). Modal analysis is performed on both Aluminum and composite centrifugal blower impeller to find out first 5 natural frequencies. If number of blade ,angle of the blade and outer diameter increases stresses and deformation also increases all are allowable limit. Total analysis result compares and found that composite materials are having less deformation and stresses

G. Kalyan*1K. L .N. Murty*2 [3]"Design and Optimization of Centrifugal Pump Guide Vanes" .In this paper author show that an impeller of a centrifugal pump is designed and modeled in 3D modeling software Pro/Engineer. Materials used are steel and aluminum. The optimization of the impeller design is done by observing the results obtained from the analysis performed. The results considered are stress frequency velocity pressure flow rates. Analysis is done in ANSYS. The results show that by observing the structural analysis results the stresses are increasing by increasing the number of blades and increasing the angle of blade. When Aluminium material is used the stresses are less than that of steel By observing modal analysis results the frequencies are reducing by increasing the number of blades there by the vibrations are reduced.

Pramod J. Bachche1, R.M.Tayade² [4] "Finite Element Analysis of Shaft of Centrifugal Pump". In this paper author show that the 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. The results show that to 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. Maximum dynamic deflection is obtained 11% less than allowable deflection and Maximum stresses for dynamic is obtained 18% less than allowable tensile strength.

S.Rajendran1 and Dr. K. Purushothaman2 [5] "Analysis of centrifugal pump impeller using ANSYS-CFX". In this paper author show that In this paper 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 results show that 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.

1Mr M. Sampathkumar, 2Mr.Dsvsra Varaprasad, 3Mr.Vijaykumar [6] "Static Analysis of Centrifugal Blower Using Composite Material" In this paper author show that this paper is static and model analysis of centrifugal blowers using composite materials Centrifugal blowers are used in naval applications and motors which have high noise levels. The noise generated by a rotating component is mainly due to random loading force on the blades and periodic iteration of incoming air with the blades of the rotor. The results show that the Contemporary blades in naval applications are made up of Aluminum or Steel and generate noise that causes disturbance to the people working near the blower. The present work aims at observing the choice of E-Glass as an alternative to metal for better vibration control. E Glass, known for their superior damping characteristics are more promising in vibration reduction compared to metals. The stresses of E-Glass/Epoxy blower obtained in static analysis are within the allowable stress limit. The natural frequency of E glassblower is reducing by 16.6% to 27.7% because of high stiffness.

Mane Pranav Rajanand [7] "Design & Analysis of Centrifugal Pump Impeller by FEA". In this paper author show that the analysis on MS & SS pump impeller is done in order to optimize strength of centrifugal pump. This paper gives the static & Modal analysis of MS & SS Pump Impeller to check strength of Pump & vibrations produced by pump.The results show that tried to overcome weight by using different material with improvement in stress and deformation result. For that purposes he replace mild steel material with stainless steel which resulting improved stress by 3.6685%, reduction in weight by 1.2738%.

Anirudha S. Bhosale & P. N. Gore [8] "Improvement of Impeller Design a Centrifugal Pump using FEM and CFD".In this paper researchers concluded that optimization of design of centrifugal pump impeller by FEA software and weight could be significantly reduced by composite materials. Which may resulting same stress result or may improve stress result based on composite material structure.

Yu Zhang, Sanbao Hu, Yunqing Zhang, and Liping Chen [9] published research article on "Optimization and Analysis of Centrifugal Pump considering Fluid-Structure Interaction". Kriging-based optimization method for the vibrations optimization of centrifugal pumps was used to analyse and optimize design. To conduct experiment prototype has been manufactured according to optimized values of geometrical parameters of the pump. Experimental tests carried out on prototype well agreed with the results of Kriging meta model and fluid-structure interaction (FSI) simulation.

III. CONCLUSIONS

In this paper an impeller of a pump is designed and Modelled in 3D Modelling software Pro/Engineer or SOLIDWORKS. This study is found that the Comparing the results of steel , aluminium and different alloys material of impeller. Alloy material facilitates ease of fabrication so any difficult shape can made by investment casting. Number of blades and outer diameter of impeller plays significant role in designing. Because deformation increases as no. of blades are increases but frequencies are reduces as no. of blades are increases. Centrifugal pump impeller without volute casing having high mass flow rate. Total efficiency of pump is increases. Nowadays composites material also used for manufacturing impeller because of less weight. Natural

frequency of composites less compare to conventional material because of high stiffness of the material. So, the best suggested material for the design of impeller. Structural analysis and frequency analysis are performed. Analysis is done in ANSYS. Hence finite element method is a viable alternative to perform better analysis of engineering structures.

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