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# A Review on Optimization of Centrifugal Pump Impeller

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## ABSTRACT

**A centrifugal pump is a rotodynamic 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 (an 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.**

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## I. INTRODUCTION

[Centrifugal pump is one of the basic and a superb piece of equipment possessing numerous benefits over its contemporaries. The main advantages of a centrifugal pump includes its higher discharging capacity higher operating speeds lifting highly viscous liquids such as oils muddy and sewage water paper pulp sugar molasses chemicals etc. against the reciprocating pumps which can handle relatively small quantity of liquid operating at comparative slower range of speeds that is limited to pure water or less viscous liquids free from impurities limited from the considerations of separation cavitation and frequent choking troubles. The overall maintenance cost of a centrifugal pump is also comparatively lesser due to less wear and tear. While major disadvantage includes vulnerability to a complexities of eddies formations noise and vibrations and inability to generate higher pressures as executed by the reciprocating pumps. Centrifugal pumps are used to transport fluids by the conversion of rotational kinetic energy to the hydrodynamic energy of the fluid flow.A centrifugal pump is one of the simplest pieces of equipment in any process plant. Its purpose is to convert energy of a prime mover (an electric motor or turbine) first into velocity or kinetic energy and then into pressure energy of a fluid that is being pumped. The energy changes occur by virtue of two main parts of the pump, the impeller and the volute or diffuser. The impeller is the rotating part that converts driver energy into the kinetic energy. The volute or diffuser is the stationary part that converts the kinetic energy into pressure energy.

## II. LITERATURE SURVEY:

[1]. A Syam Prasad, BVVV Lakshmipathi Rao, A Babji, Dr. P Kumar Babu , “Static and Dynamic Analysis of a Centrifugal Pump Impeller” 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 reducing by 12%.

[2] Karthik Matta, Kode Srividya, Inturi Prakash, "Static and Dynamic Response of an Impeller at Varying Effects"

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, analyse 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 Aluminum 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. Total analysis result compares and found that composite materials are having less deformation and stresses.

[3]. G. Kalyan, K.L.N. Murty. "Design and Optimization of Centrifugal Pump Guide Vanes" In this paper an impeller of a centrifugal pump is designed and modeled in 3D modelling 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.

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 thereby the vibrations are reduced. But the frequencies are slightly increasing by increasing the angle of blade. But for aluminium material by increasing the number of blades the frequencies are increasing.

[4] Pramod J. Bachche1, R.M.Tayade "Finite Element Analysis of Shaft of Centrifugal Pump" 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. Maximum dynamic deflection is obtained 11% less than allowable deflection and Maximum stresses for dynamic is obtained 18% less than allowable tensile strength.

[5] S.Rajendran and Dr. K Purushothaman "Analysis of centrifugal pump impeller using ANSYS-CFX"

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 predict 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.

[6] Static Analysis of Centrifugal Blower Using Composite Material Mr M. Sampathkumar, Mr Dsvsra Varaprasad, Mr Vijaykumar

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 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 glass blower is reducing by 16.6% to 27.7% because of high stiffness.The weight of the E-Glass blower is 15 kg which is less than the Aluminium blower with a weight of 19 kg. From the results of harmonic analysis, damping effect is more in E-Glass blower which controls the vibration levels. From the above results we can conclude that E-Glass blower is preferable than Aluminium blower and based up on frequency values can be reduced.

[7]E.C. Bacharoudis, A.E. Filios, M.D. Mentzos and D.P. Margaris, "Parametric Study of a Centrifugal Pump Impeller by Varying the Outlet Blade Angle".

The pump design is facilitated by the development of computational fluid dynamics and the complex internal flows in water pump impellers can be well predicted. Various parameters affect the pump performance and energy consumption. The impeller outlet diameter, the blade angle and the blade number are the most critical. In this study, the performance of impellers with the same outlet diameter having different outlet blade angles is thoroughly evaluated. The one-dimensional approach along with empirical equations is adopted for the design of each impeller. The predicted performance curves result through the calculation of the internal flow field and a successful correlation of local and global parameters. The numerical solution of the discretised three-dimensional, incompressible Navier-Stokes equations over an unstructured grid is accomplished with a commercial CFD finite-volume code. For each impeller, the flow pattern and the pressure distribution in the blade passages are calculated and finally the head-capacity curves are compared.

 

[8]Ajith M S and Dr. Jeoju M Issac, "Design And Analysis of Centrifugal Pump Impeller Using Ansys Fluent"

Impeller is designed for the head (H) 70 m; discharge (Q) 80 L/sec; and speed (N) 1400 rpm. Impeller vane profile was generated by circular arc method and point by point method and CFD analysis was performed for the impeller vane profile. Further the impeller was analyzed for both forward and backward curved vane. The simulation on vane profile was solved by Nevier-Stokes equations with modified k - ω turbulence model. The impeller-Velocity and pressure distribution were analyzed for these Impellers.

[9]Raghavendra S Muttalli and Shweta Agrawal, "CFD Simulation of Centrifugal Pump Impeller Using ANSYS-CFX"

Centrifugal pumps are a most commonly used in different fields like industries, agriculture and domestic applications. Computational Fluid Dynamics is most commonly used tool for simulation and analysis. 3-D numerical CFD tool is used for simulation of the flow field characteristics inside the turbo machinery. CFD simulation makes it possible to visualize the flow condition inside centrifugal pump. The present paper describes the head, power, efficiency and to evaluate the pump performance using the ANSYS CFX-14, a computational fluid dynamics simulation tool. These simulations of centrifugal pumps are strongly related to cavitation flow phenomena, which may occur in either the rotating runner-impeller or the stationary parts of the centrifugal pumps.

[10]Mr V. Jose Ananth Vino, "ANALYSIS OF IMPELLER OF CENTRIFUGAL PUMP".

In this paper we will assemble 5 parts of an impeller of Centrifugal pump. Our primary goal is to apply preload of 100 N in the belt. And to check that impeller is not getting deflected to maximum of 0.0075 mm. We will apply the material to pump whose elastic limit must not exceed than the elastic limit. The variation of von-misses stress, von-misses strain, and deformation factor for different materials can be taken into consideration. The CATIA is used for modelling the impeller and analysis is done in ANSYS .ANSYS is dedicated finite element package used for determining the variation of stresses, strains and deformation across profile of the impeller. An attempt has been made to investigate the effect of temperature, pressure and induced stresses on the impeller. By identifying the true design feature, the extended service life and long term stability is assured .A structural analysis has been carried out to investigate the stresses, strains and displacements of the impeller.

[11]Mr Aniket Patil and Dr. R. J. Patil "STATIC AND MODAL ANALYSIS OF IMPELLER"

Existing blower is made up of the Mild steel material. With this material sponsorer is facing the problem on corrosion resistance of Impeller. The Air which was inlet to the blower is moist one having the temperature of 14o c which leads to the corrosion of impeller at rapid rate. Due to corrosion, some minute particle of MS is getting carried away with the air and got mixed with the pulp which leads to contamination of pulp. As the corrosion resistance of MS is very poor, company need to change the impeller quite frequently which was leading to high operating cost of overall unit. Provide an alternative to Impeller in exiting setup which should have characteristic like Good corrosion resistance, It should have deflection at jamming condition, within the permission limit, Equivalent stress should be within limit, Weight of New impeller should be nearly same or less than exiting one, Natural frequency of impeller should not match with operating frequency, The output pressure and velocity of air should not be less than exiting value.

[12] C. Kundera, "Static and Dynamic Analysis of a Pump Impeller with a Balancing Device Part I: Static Analysis"

The impeller is directly connected with a balancing device. The impeller needs to have a properly designed system of longitudinal and lateral clearances on both sides. With the simplifying assumptions concerning the flow and distribution of pressure in the longitudinal and lateral clearances, the static analysis involved deriving relationships between the impeller geometry and the basic performance parameters of the pump.

[13] V.A. Martsinkovsky and A. Zhulyov, "Static and Dynamics of a Pump Impeller with a Balancing Device Part II: Dynamic Analysis"

In this paper study the system comprising an impeller and a balancing device. It deals with the dynamic analysis of the system, i.e., the axial vibrations of the impeller, and the system stability. The dynamic analysis took into account linearized hydrodynamic forces and moments generated in the longitudinal clearances of the seals of the impeller. The theoretical analysis was supplemented with a numerical example with characteristics determined for a real single-stage centrifugal pump.

[14]Mr Andrzej Wilk, "The Analysis of a Hydraulic Efficiency of an Open Impeller with Radial Blades Obtained in Laboratory Tests of High Speed Impeller Pump"

The laboratory measurements carried out on the high-speed pump and their results. Based on the results of pressure measurements in space around the open-flow impeller with radial blades hydraulic efficiency was calculated. Key Increasing the rotational speed of centrifugal pumps causes increasing the delivery head obtained from one stage of the pump and thus make possible to reduce overall dimensions and weight of the pump. The effect of increasing the rotational speed is increased pressure in the space around the impeller and an increase axial thrust acting on the pump impeller. For this reason, it is preferable to use of open-flow impeller, instead of closed one. In the case of open-flow impeller with curvilinear blades, grows problems associated with large tensile stress on the blade. Therefore in the high-speed pumps with open-flow impellers is preferable to the use of radial (rectilinear) blades. Geometry of flow (velocity field) and pressure field in the case of such an impeller are different than in the impeller of traditional geometry. Therefore it was decided to analyze the hydraulic efficiency of the open-flow impeller with radial blades. For this purpose, the theoretical analysis of flow carried out for such an impeller. Using the results of laboratory measurements of the pump working at high speed, hydraulic efficiency of impeller was calculated. The paper contents the results of the analyses.

[15] Kotakar Sandeep Gulabrao and D.S. Khedekar, "Optimization of Centrifugal Pump Impeller Outlet Vane Angle by using Modal Analysis"

In this paper we have tried to emphasize the static load condition and vibrations in centrifugal pumps, its causes / sources and the diagnosis methods. It is shown how total deformation and vibration in centrifugal pump could be diagnosed and its remedies can be worked out on the basis of diagnosis.

 

## III. CONCLUSION

Pump impeller has high weight as use of existing material as compare to different alloy and composite material. Strength of pump impeller is less due to less stiffness of existing material as compare to different alloy and composite material. The material is selected based on the product application and manufacturing feasibility. FEA is conducted in order to verify the material behaviour under static loading condition.

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