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A Review On Performance Analysis of Centrifugal Pump Impeller

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***Abstract*: The main objective of this review is to investigate the centrifugal pump and to increase the efficiency of the pump. The average efficiency of centrifugal pump is about 65–70 percent. The significance of efficiency in pump is selecting a proper pumping system will conserve fuel or electricity and decrease the annual pumping costs. Inefficient and poorly chosen pumping systems can increase annual costs dramatically. Obtained efficiency of centrifugal pumps with low specific speed is not high. The scope of the work is to reduce hydraulic losses. In this paper a literature review is identified by providing a modified impeller channel with design changes that are capable of improving the efficiency of the centrifugal pump.**

***Keywords*: impeller, pump, groove, CFD.**

1. Introduction

Centrifugal pump is used to convert kinetic energy to hydrodynamic energy. The type of kinetic energy is rotational kinetic energy and the rotational energy typically comes from engine to electric motor. Already obtained efficiency is not too high so the efficiency of the pump should be increased. So, the different loses should be reduced. So, the impeller should be modified with micro grooves. The characteristics of smooth impeller and the grooved impeller should be identified and compared. To evaluate this CFD calculations should be done and the application of micro geometry in centrifugal pump impeller is done and calculations are made. The main objective is to increase the efficiency of the pump.

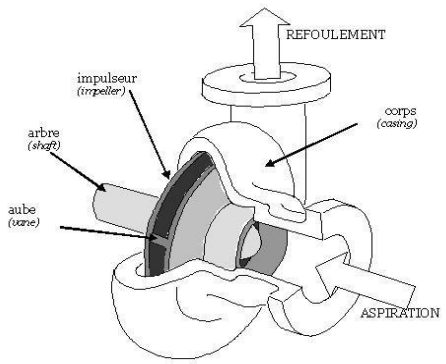

Fig. 1. Components of centrifugal pump

2. Literature Survey

Dave, S. Shukla, S, Jain, S, [1] A comprehensive overview of fluid dynamic models and experimental results that can help solve problems in centrifugal compressors and modern techniques for a more efficient aerodynamic design.

Abo Elyamin, Gamal R.H., et. al, [2] A numerical investigation is carried out on a centrifugal pump to show the effect of the impeller blades number on the pump performance. Three different impellers with 5, 7, and 9 blades are tested numerically to determine the optimum blades number at rotational speed of 2800 rpm.

Li, Jidong, et. al, [3] The three-dimensional flow field of the whole flow passage of a mixed-flow pump was numerically simulated by using CFD software on the basis of Spalart-Allmaras turbulent model according to the original design of the plant. Through analyzing the calculation results, the reason why the flow rate of this pump cannot reach to the design requirements was found out. After replacing the impeller, a new pump impeller was optimally designed.

Selamat, Farah Elida, et. al, [4] Centrifugal pump usage has increased over the past year due to its importance and efficiency. Its function is to transport liquid from one place to another using energy applied to the pump. This paper revolves around the idea of design and analysis of centrifugal pump for performance enhancement within the pump specifications.

S Muttalli, Raghavendra, et. al, [5] In order to improve the hydrodynamic performance of the centrifugal pump, an orthogonal experiment was carried out to optimize the impeller design parameters. This study employs the commercial computational fluid dynamics (CFD) code to solve the Navier-Stokes equations for three-dimensional steady flow and predict the pump performance. The prototype experimental test results of the original pump were acquired and compared with the data predicted from the numerical simulation, which presents a good agreement under all operating conditions.

Zhou, Ling, et. al, [6] In order to improve the hydrodynamic performance of the centrifugal pump, an orthogonal experiment was carried out to optimize the impeller design parameters. This study employs the commercial computational fluid dynamics (CFD) code to solve the Navier-Stokes equations for three-dimensional steady flow and predict the pump performance. The prototype experimental test results of the original pump

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Hawas, Malik N., et. al, [7] In centrifugal pumps, the flow physics and dynamic performances are generally affected by any modification in blades shape and design layout. At the present time, the dominant verification method used for investigation these characteristics are numerical simulation.

Pandya, Kapil, Patel, Chetankumar M, [8] The main objective of this work is to go through various approaches used in CFD analysis of centrifugal pump and highlight the advantages and application of CFD analysis in turbo industries. The CFD analysis is the advanced tool to overcome the limitation of conventional method to design the pump. Now a days CFD analysis is very familiar approach to improve the design of centrifugal pump and optimize it's operational parameters like Head, Power, Discharge and Speed.

Okokpujie, Imhade P., et. al, [9] The design, construction and testing of a single stage centrifugal pump is presented in this project work, electric motor drives the centrifugal pump, which draws fluid (water) from a water storage wall and delivers same through a flow control valve to a tank. The experimental results obtained shows that the tested pump can develop a head, (H) of 30m, volumetric discharge, (Q) of $9m^3$/hr and the speed of 2900 rpm for an input power of 1.5HP.

Bhosale, Anirudha S, [10] Centrifugal pumps are widely used for 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. Therefore, it is necessary to find out the design parameter, working conditions and maximum efficiency with lowest power consumption. Study indicates that Computational fluid dynamics (CFD) analysis is being increasingly applied in the design of centrifugal pumps.

Aung, Kyaw, et. al, [11] This paper presents the calculation and production procedure of impeller for single section centrifugal pump. The pump type is single stage centrifugal pump with close impeller type. This impeller develops a head of 20 m and delivers 0.9 m^3 /min of water. The designed impeller has 97 mm inlet diameter, 226 mm outlet diameter, 20˚ inlet vane angle and 23˚ outlet vane angle.

Kim, J. H., et. al, [12] In this study, optimization of the impeller and design of volute were carried out in order to improve the performance of a centrifugal pump. Design parameters from vane plane development for impeller design were selected and effect of the design parameters on the performance of the pump was analyzed using CFD and Response Surface Method to optimized impeller.

Gurupranesh, P, et. al, [13] Centrifugal pumps are used extensively for pumping water over short to medium distance through pipeline where the requirements of head and discharge are moderate. This project is devoted to enhance the performance of the centrifugal pump through design modification of impeller. Theories on pump characteristics are studied in detail. Vane profile of the impeller is generated using point by point method.

Kaliappan, S., et. al, [14] The impeller of an existing Mather and Platt centrifugal pump with both geometry and performance known was analyzed and redesigned using an integrated. Fluid dynamics and geometry modeling parts of the design /analysis system were systematically applied. To analyze the existing impeller say impeller A, which was designed using conventional (routine in industry) hydraulic layout procedures.

Matlakala, M. E.., et. al., [15] Centrifugal pumps contain two main parts: an impeller that imparts Centrifugal forces to the production fluid and diffuser which is the fixed part that guides the flow to the discharge. The shape of the impeller influences the performance of the pump. Thus, the area of the significance to the pump design is the impeller geometric parameters to achieve pump performance. The consumption of energy by the pump is caused by the failure to choose the right pump size for the system, improper installation, and pump operation. Poor pump performance may affect the plant operation such as maintenance cost, downtime, loss of production, increase in operating cost.

Zhang, Yu., et. al., [16], This paper presents the optimization of vibrations of centrifugal pump considering fluid-structure interaction (FSI). A set of centrifugal pumps with various blade shapes were studied using FSI method, in order to investigate the transient vibration performance. The Kriging model, based on the results of the FSI simulations, was established to approximate the relationship between the geometrical parameters of pump impeller and the root mean square (RMS) values of the displacement response at the pump bearing block.

Korakianitis, Theodosios., et. al., [17] Mechanical pumps as heart assist devices impose power and size limitations on the pumping mechanism, and therefore requires careful optimization of pump characteristics. Typically, new pumps are designed by relying on the performance of other previously designed pumps of known performance using concepts of fluid dynamic similarity. Such data are readily available for industrial pumps, which operate in Reynolds numbers region.

Kaewnai, Suthep., et. al., [18] The main objective of this work is to use the computational fluid dynamics (CFD) technique in analysing and predicting the performance of a radial flow-type impeller of centrifugal pump. The impeller analysed is at the following design condition: flow rate of 528 m^3/hr; speed of 1450 rpm; and head of 20 m or specific speed (Ns) of 3033 1/min in US-Units. The first stage involves the mesh generation and refinement on domain of the designed impeller.

Protopopov A, et. al., [19] In various industries where centrifugal pumps are used, a common problem is the starting overheating of electric motors. Such overheating can lead to motor failure, especially in the case of starting-up the centrifugal pump on the open valve. It happens due to the fact that the starting current is many times greater than the rated current, and the rated current with an open valve usually makes is much more. In this case, complex methods of centrifugal pumps analysis and manuals do not contain any methods of evaluation the magnitude of the starting overheating of centrifugal pump electric motors.

Vigovskij V, et. al., [20] The article deals with the problems

associated with the analysis of high-speed low-flow centrifugal pumps. The existing methods for analysis of such pumps and their disadvantages were reviewed. A method of multi-criteria optimization of high-speed centrifugal pumps has been proposed. The method is based on the search for a compromise between the cavitation characteristics and the hydraulic head of the centrifugal pump by plotting a compromise curve. The LP-tau searching method was used for finding the points of this curve in the article.

Wang C. Y, et. al., [21] For three-dimensional inverse design of water pump, both blade-loading distribution and stacking condition of high-pressure side are important factors affecting the quality of design. For example, inclined trailing edge of blade can suppress the pressure fluctuation and reduce the sound pressure level and sound power of noise for single-suction centrifugal pump. And the lean mode of blade trailing edge can influence hydraulic performance of pump-turbine in pump mode. However, there is no clear view on the effect of lean mode of blade trailing edge on hydraulic performance for double-suction centrifugal pump.

Yan X. F, et. al., [22] The current investigation is aimed to simulate the unsteady internal flows in a centrifugal pump impeller with seven twisted blades by using a three-dimensional Navier-Stokes equation with Scale-adaptive simulation (SAS) turbulence model. A detailed analysis of the results at design flow rate Q 0 and low flow rate 0.5Q 0 and 0.3Q 0, is presented. Unsteady flow analyses in centrifugal pump are focused mainly on the volute. The calculation results of pump head and efficiency at different flow rate conditions is in good agreement with the experimental data.

Yuan J. P, et. al., [23] In order to study the characteristics of radiated noise of multistage centrifugal pump, radiated noise test system of multistage centrifugal pump was built. Radiated noise experiments were carried out for a medium specific speed multistage centrifugal pump and its modification, which was devised with a new hydraulic design method in the field of sound optimization. The experiment validation on the sound field was performed in a semi-anechoic room and the acoustic parameters of the multistage pump at the different flow rates were gathered with the LMS system (a complete set of solutions for vibration and noise test

Zhang J. F, et. al., [24] The experimental investigation in impellers was conducted at different conditions and phases by means of PIV (Particle Image Velocimetry) to study the internal flow. Meanwhile, the absolute and relative velocity distributions in impellers were obtained. Experimental results show that the head value is higher in the impeller with splitter blades and both two head curves appear hump phenomena at small flow rate. The absolute velocity value increases with radius and from pressure side to suction side at the same radius gradually. The splitter blades can scour the wake, making outlet velocity distribution more uniform and improving the internal flow. The velocity distribution becomes less even in the process of closing to tongue due to reinforced interference of tongue on internal flow.

3. Conclusion

Thus, the literature review shows a detailed study on performance improvement in centrifugal pump with by a changing the suitable design parameters, such as blade angle, number of blades, micro grooved impeller, grove thickness. This review predicts that, with the change of design parameters a considerable amount of increase in efficiency will be achieved.

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