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Review of Design and CFD Analysis of Centrifugal Pump

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ABSTRACT

This review offers a thorough evaluation of centrifugal pump systems, encompassing hydraulic design, material selection, performance metrics, and mechanical considerations. Emphasizing factors like cavitation prevention, structural integrity, and thermal management, it also addresses cost-effectiveness and regulatory compliance. Additionally, it underscores the value of computational analysis techniques. This review provides crucial insights for fluid mechanics professionals and industrial stakeholders.

Keywords: Hydraulic design, Impeller, Volute casing, Head-flow curve, Efficiency, Cavitation, Computational fluid dynamics (CFD).

1. Introduction:

Centrifugal pumps play a pivotal role in countless industrial and commercial applications, facilitating the movement of fluids with efficiency and precision. The optimal performance of these pumps hinges on meticulous design and rigorous analysis, encompassing a spectrum of engineering considerations. From the intricacies of impeller geometry to the selection of materials withstanding corrosive environments, each facet contributes to the overall effectiveness of the system. This review embarks on a comprehensive assessment, delving into the multifaceted realm of centrifugal pump design. By scrutinizing hydraulic dynamics, mechanical robustness, and thermal resilience, this evaluation aims to distill the essence of an effective and reliable pumping solution. Moreover, it underscores the significance of computational tools, such as Computational Fluid Dynamics (CFD) and Finite Element Analysis (FEA), in refining performance metrics. Through this review, we endeavor to provide engineers, designers, and stakeholders a consolidated understanding of the pivotal elements driving centrifugal pump excellence.

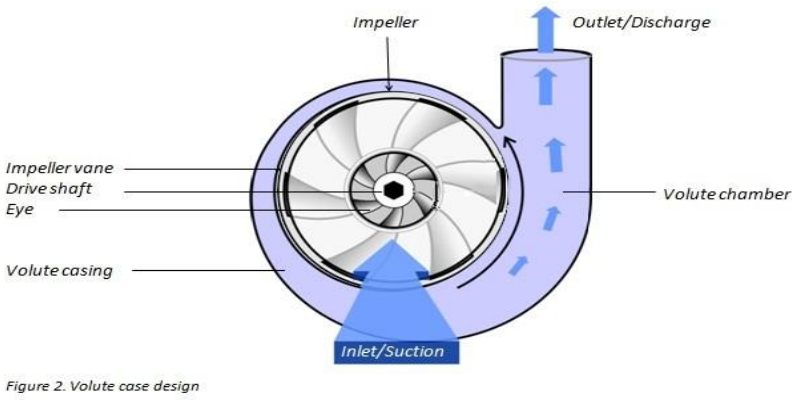

Figure 1: Components of centrifugal Pump

2. Literature Review

Selamat, Farah Elida, et. al, [1] Because of its usefulness and effectiveness, centrifugal pumps have been more popular in the last year. The energy input into the pump propels the liquid from one location to another. The focus of this study is on how to improve centrifugal pump performance within the constraints of the pump's design.

S Muttalli, Raghavendra, et. al, [2] An orthogonal experiment was conducted to optimise the impeller design parameters, which improved the centrifugal pump's hydrodynamic performance. The performance of the pump is determined by using a commercial computational fluid dynamics (CFD) software

to the solution of the NavierStokes equations for steady flow in three dimensions. We compared the results of experimental testing conducted on the original pump's prototype to the results predicted by the numerical simulation, and we found a good agreement in all operating situations.

Zhou, Ling, et. al, [3] To enhance the centrifugal pump's hydrodynamic performance, an orthogonal experiment was conducted to fine-tune the impeller's settings. The performance of the pump is anticipated by solving the Navier-Stokes equations for three-dimensional steady flow using a commercial computational fluid dynamics (CFD) package. Overall, experimental testing findings on the prototype corroborated the numerical simulation's predictions quite well.

Hawas, Malik N., et. al, [4] The flow mechanics and dynamic performances of centrifugal pumps may be greatly affected by modifications to the blades' shape or design arrangement. The standard method for checking these characteristics now is numerical simulation.

Pandya, Kapil, Patel, Chetankumar M, [5] The focus of this study is on the various approaches to CFD analysis of centrifugal pumps, emphasising their strengths and applications in different sectors. The limitations of the conventional method of pump design are overcome by using CFD analysis. These days, it's normal procedure to use CFD analysis to fine-tune every aspect of a pump's design and operation, including things like the pump's Head, Power, Discharge, and Speed.

kokpujie, Imhade P., et. al, [6] Using a water storage wall and a flow-regulating valve, this project describes the design, construction, and testing of a single-stage centrifugal pump driven by an electric motor. Using just 1.5 horsepower, the tested pump was able to achieve a head of 30 metres, a volumetric discharge of 9 cubic metres per hour, and a speed of 2900 revolutions per minute in the laboratory.

Bhosale, Anirudha S, [7] Centrifugal pumps may be used in a wide range of industries and applications, from water treatment to steam power to sewage treatment to oil refineries to chemical plants to hydraulic power service to food processing to mining. The ideal design parameters, operational conditions, and power efficiency must be established. According to studies, CFD analysis is increasingly being employed in the development of centrifugal pumps.

Aung, Kyaw, et. al, [8] An impeller for a centrifugal pump with a single section is calculated and manufactured in this work. The pump is a close-coupled, single-stage centrifugal design. The water flow rate is 0.9 m3/min and the head is 20 m with this impeller. A 97 mm inlet diameter, a 226 mm outlet diameter, a 20 intake vane angle, and a 23 mm outlet vane angle characterise the impeller's design.

Kim, J. H., et. al, [9] In this research, a centrifugal pump's efficiency was enhanced by refining the impeller and volute designs. In order to optimise the impeller design, CFD and the Response Surface Method were used to analyse the influence of various design parameters on pump performance based on vane plane development.

Gurupranesh, P, et. al, [10] When the distance pumped is short to medium and the head and discharge requirements are low, centrifugal pumps are the pump of choice. The goal of this project is to improve centrifugal pump efficiency by making structural changes to the impeller's design. Characteristics of pumps and their theories are examined in depth. The impeller's vane profile is drawn using a point-by-point process.

Kaliappan, S., et. al, [11] An existing Mather and Platt centrifugal pump's impeller was analysed and modified using an integrated, since its shape and performance were already known. The geometry modelling and fluid dynamics components of the design/analysis system were used consistently. To examine the previously developed impeller, let's call it Impeller A, which followed standard industrial hydraulic layout practises.

Matlakala, M. E.., et. al., [12] An impeller, which rotates to provide centrifugal forces to the fluid being pumped, and a diffuser, which remains stationary, are the two major components of centrifugal pumps. The pump's efficiency is affected by the impeller's design. Therefore, the impeller geometric parameters are the critical area of focus in pump design for maximising pump performance. Incorrect pump sizing, installation, and operation all contribute to the pump's excessive energy consumption. Maintenance costs, downtime, lost productivity, and higher operating costs are just some of the negative outcomes that might result from poor pump performance.

Zhang, Yu., et. al., [13] In this study, we show how to optimise the vibrations of a centrifugal pump while taking FSI into account. The FSI method was used to investigate the transient vibration performance of a number of different centrifugal pumps with varying blade shapes. Using the outcomes of FSI simulations, a Kriging model was created to approximatively connect the geometrical parameters of the pump impeller with the root mean square (RMS) values of the displacement response at the pump bearing block.

Kaewnai, Suthep., et. al., [18] The primary goal of this study is to analyse and forecast the performance of a radial flow-type centrifugal pump impeller using the CFD method. The impeller was examined under its design conditions of 528 m3/hr flow rate, 1450 rpm speed, and 20 m head, which is equivalent to a specific speed (Ns) of 3033 1/min in US-Units. In the first step, the impeller's domain mesh is generated and refined.

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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