Design Modification of Semi Open Centrifugal Pump Impeller

L. J. Rathi[1] A.V.Bhatt[2]
[1]Research Scholar [2]Assistant Professor
[2]Department of Mechanical Engineering
[1,2]Arham Veeraytan Institute of Engineering. Technology and Research

Abstract— Centrifugal pumps are extensively used to transfer the fluid by converting the rotational kinetic energy to the hydrodynamic energy of the fluid flow. The impeller is the rotating component of the centrifugal pump which accelerates the fluid outwards from the center of the rotation and transfers the velocity achieved by the fluid into pressure when the outward movement of the fluid is confined by the pump casing. In the past years a number of modifications have been done on the pump impeller to improve the pump efficiency like varying the number of blades, inlet/outlet vane angles, blade thickness, trimming of impeller diameter individually or with the combination of maximum of any three of these. In this thesis a CAD 2D and 3D model of a given semi open impeller have been prepared using software.

Key words: Centrifugal pump, Impeller, Volute casing, nos. of blades, impeller inlet angle, impeller outlet angle, blade thickness, impeller diameter, AUTO CAD 2D/3D, CFD

I. INTRODUCTION

A pump is a hydraulic machine which converts mechanical energy into hydraulic energy or pressure energy. A centrifugal pump is also known as a Rotodynamic pump or dynamic pressure pump. It works on the principle of centrifugal force. In this type of pump the liquid is subjected to whirling motion by the rotating impeller which is made of a number of backward curved vanes. The liquid enters this impeller at its center or the eye and gets discharged into the casing enclosing the outer edge of the impeller. The rise in the pressure head at any point/outlet of the impeller is Proportional to the square of the tangential velocity of the liquid at that point. Hence at the outlet of the impeller where the radius is more the rise in pressure head will be more and the liquid will be discharged at the outlet with a high pressure head. Due to this high pressure head, the liquid can be lifted to a higher level. Generally centrifugal pumps are made of the radial flow type only. But there are also axial flow or propeller pumps which are particularly adopted for low heads. Centrifugal pumps are the most preferred hydraulic pumps in domestic and industrial world. Any centrifugal pump comprises of a volute casing, an impeller, a back plate, a mechanical seal/ gland, a shaft, bearing block, a locating flange, coupling and a drive motor. Among these the impeller is the most important component. It has a series of curved vanes fitted inside the shroud plates. The impeller is always immersed in the water. When the impeller is made to rotate, it makes the fluid surrounding it also rotate. This imparts centrifugal force to the water particles, and water moves radially out.

II. LITERATURE SURVEY

P.ArunKumar[1] (Aug 2014, ISSN: 2250-3498) has worked on the investigation of centrifugal pump impeller by varying the number of impeller blades and the blade curves and analysing the results for various speeds considering the head and the discharge using CFD. He concluded that Volumetric and pump gross efficiency for the pump with 4 nos of twisted vanes are more than those for the pump with 3 and 4 nos of vanes without twist.

M.G.Patel, A.V.Doshi[2] (January 2013, ISSN 2250-2459) have examined the effect of blade exit angle on the head and efficiency of the pump by comparing various head-flow and efficiency-flow curves for different blade exit angles with the manufacturer's curves. It is concluded that the head and the efficiency of the pump are significantly increased with the increase in the blade exit angle.

S.Chakroborty and K.M.Pandey[3] have studied the static pressure distribution, total pressure distribution, changes in head as well as efficiencies of the centrifugal pump with impellers having 4,5,6,7,8,9,10 & 12 nos of blades using CFD. The numerical studies on the characteristics of the centrifugal pump were carried out using the ANSYS FLUENT software. The head of the centrifugal pump grows all the time with the increase of blade number and pressure too but the change in hydraulic efficiency with the variation in the blade number is little bit complex.

Nengah Suarnadwipa and Wayan B. Adnyana[4] (November 2006) have determined performance of a small centrifugal volute-pump as turbine at the maximum head of the pump before and after modification of impeller tips of the pump at various capacities. This experiment performed by grinding the inlet ends of the impeller tips of the pump to a bullet-nose shape to preclude excessive turbulence for efficiency consideration. Then, testing is carried out by operating the pump as turbine at the maximum head of the pump, 13 meter, and at various capacities. Efficiency of the volute-pump operating as turbine after modification its impeller tips is slightly better than without modification.

Krishna Kumar Yadav & V.K.Gahlot[5] (ISSN 2321-7308) dealed with the performance analysis of a mixed flow type centrifugal pump designed centrifugal pump to deliver 0.25 m3/s water at a head of 20 m running at 1450 rpm using ANSYS CFX 14.0 software. Modeling of the pump unit has been done using PTC Creo 2.0 software. The performance of the pump was first determined using the initially obtained vane angles. The inlet vane angle and outlet vane angle are then varied to analyses the improvement in pump performance .The results shows that for an initial inlet angle 20.08˚ and outlet angle 16.28˚, the efficiency of the pump is 83 %.however, for an optimized angles at inlet and outlet as 20.16˚ and 16.62˚ respectively, the efficiency of pump raised to 88 % thus showing an improvement in the performance of mixed flow pump. Improvement of the performance for mixed flow pump is simulated by decreasing the inlet blade angle and increasing the outlet blade angle. It was found that overall efficiency of mixed flow pump is increased by 5.68%.

Pranit M. Patil, Shrikant B. Gawas, Priyanka P. Pawaskar, Dr. R. G. Todkar[6] (May-2015, ISSN 2395-0056, ISSN 2395-0072) have studied the techniques for improving the performance of the centrifugal pump like impeller trimming, change in blade inlet & outlet angle, use of diffuser, change in tip clearance and splitter blade. Impeller trimming affects the strength of the impeller, suitable change in blade inlet and outlet angle gives better performance, use of diffuser also improves the performance but increases the weight, change in tip clearance gives better performance but in case of centrifugal fans and splitter blades reduces the pressure fluctuations, noise & vibration and also clogging of fluid at impeller inlet.

Dr. K. Ragu, V.M.Mohmmad Ashif, K.NavinKumar[7] (April-2015, ISSN: 2278-0181) have experimented the change in the head developed, efficiency and torque by varying the no of blades, inlet & outlet blade angle. The existing impeller and volute casing are modelled using NX CAD software and the CAD model is imported and analized using SOLID WORKS Flow Simulation software. The impeller with optimum design parameters (no of blades-5, 16° outlet blade angle and 38.8 ° outlet blade angle) is modeled and CFD analysis is carried out for three different volume flow rates 0.5 LPS, 1 LPS and 1.3 LPS and the performance is obtained .For the optimized impeller design, the torque requirement is decreased by 3.4%. The head developed is increased by 3.22% and the efficiency is increased by 8.28% at the best efficiency point.

PRASHANT KAUSHIK[8] (July-2014) has conducted the simulation study of centrifugal pump performance with variation of number of blades using CFD FLUENT software. He studied the pump performance with the change in blade numbers at 1450rpm and 1750rpm. The results obtained show that head of the pump increases with increase the number of blade and rotational speed. There is a low pressure area at the suction side of the blade inlet of the impeller and it grows continuously with increase in number of blade.

III. Literature Review

From the above literature survey we can conclude the following points:

1) The parameters to be varied for modifying the design of the semi open pump impeller can be its no. of blades, blade inlet & blade outlet vane angle, impeller diameter, vane profile and impeller passage width.
2) Maximum emphasis for the modification and improvement of centrifugal pump impeller had been given on the number of impeller vanes and vane exit angle.
3) Not more than three parameters is combinely varied to modify the design.
4) Any of the above mentioned parameters is varied for different speeds to evaluate and compare the head, discharge and efficiency of the results obtained.

Summary of Literature Review

Research paper no.	Research Paper name	Objectives Parameters taken
1	Analysis and investigation of Centrifugal pump Impeller using CFD	Nos. of blades
2	Effect of Impeller blade exit angle on the performance of Centrifugal pump	Blade exit angle
3	Numerical studies on effects of blade number variations	Nos of blades
4	Experimental work on modification of impeller tips of a centrifugal pump as a turbine	Impeller tip
5	Performance improvement of a mixed flow pump impeller using CFD analysis.	Inlet and outlet vane angle
6	Effect of geometrical changes of impeller on centrifugal pump performance	Impeller trimming, inlet and outlet angle, use of diffuser, change in tip clearance and use of splitter blades
7	Simulation study of centrifugal pump performance with variation of nos of blades	Nos. of blades
8	Design optimization of monoblock centrifugal pump impeller using computational fluid dynamics	Nos of blades, inlet and outlet blade angle

IV. Conclusion

As per the literature survey no research has been done on the semi open impeller of any centrifugal pump. So based on the literature review to increase the efficiency and/or discharge the parameters of the impeller viz. no of blades, inlet/outlet blade angle, blade depth and impeller diameter can be modified individually or together.

Reference

[1] P. ArunKumar, K. Saravanakumar, P.Dhachinamoorthi, S.Venkatesh, “Analysis and Investigation of centrifugal pump impellers using CFD” in international journal of Engineering Science and Technology, Volume-4, Issue 4, August 2014, ISSN 2250-3498.

[2] M. G. Patel, A. V. Doshi, “Effect of Impeller Blade Exit Angle on the performance of Centrifugal Pump” in international journal of Engineering Technology and Advanced Engineering, Volume-3, Issue 1, January 2013, ISSN 2250-2459.

[3] S. Chakraboty, K. M. Pandey, “Numerical studies on effects of blade number variations on performance of Centrifugal pumps at 4000 rpm” in international journal of Engineering and Technology, Volume-3, Issue 4, August 2011.

[4] Made Suarda, Nengaj Suarnadwipa, Wayan B. Adnyana, “ Experimental work on modification of impeller tips of a centrifugal pump as a turbine” November 2006.

[5] Krishna Kumar Yadav, V. K. Gahlot, "Performance improvement of mixed flow pump impeller through CFD analysis" in international journal of Research in Engineering and Technology, Volume-4, Issue 7, July 2015, ISSN 2319-1163.
[6] Pranit M. Patil, Shrikant B. Gawas, Priyanka P. Pawaskar, Dr. R. G. Todkar, "Effect of geometrical changes of impeller on centrifugal pump performance" in international research journal of Engineering and Technology, Volume-2, Issue 2, May 2015, ISSN 2395-0056.
[7] Dr. K. Ragu, V. M. Mohmed Ashif, K. Naveen Kumar, "Design optimization of monoblock centrifugal pump impeller using Computational Fluid Dynamics" in international journal of Engineering Research and Technology, Volume-4, Issue 4, April 2015, ISSN 2278-0181.
[8] Prashant Kaushik, "Simulation study of centrifugal pump performance with variation of number of blades" in Thapar University, July-2014.
[9] www.booksc.org
[10] www.googleimages.co.in
[11] www.sciencedirect.com