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Parametric Analysis of Centrifugal Pump Impeller

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ABSTRACT

The objective of this work is to use CFD technique in analyzing & predicting the performance of micro grooved closed impeller & semi closed impeller of centrifugal pump. Pump performance improvement can be achieved by making geometrical changes in design of an impeller. The idea includes the use of grooves inside the impeller passage performed on disc of impeller. The application of microgrooves should increase ability of impeller to transmit power to the liquid. The characteristic of centrifugal pump with micro grooved closed impeller & micro grooved semi closed impeller were compared.

Keywords— Micro grooves; Centrifugal pump; Impeller

I. INTRODUCTION

The impeller is the key part of centrifugal pump. The performance of pump depends on the impeller diameter & design. In general, there are three possible types of impeller according to their mechanical construction open type, closed type and semi closed type impeller.

1. Open Impeller: Open impellers has free vanes. Open impellers are structurally weak. They are typically used in the small-diameter pumps, inexpensive pumps and suspended solid handling pumps.

2. Semi Closed Impeller: The vanes are free on one side and enclosed on the other side. The shroud adds mechanical strength. They also offer higher efficiencies than open impellers. They can be used in medium-diameter pumps and small amount suspended solid particle handling pumps. For minimization of the recirculation and other losses, it is very important to maintain small clearance between impeller vanes and casing.

3. Closed Impeller: The vanes are located between the two discs, all in a single casting. They are used in large pumps with high efficiencies and low required net Positive Suction Head. The centrifugal pumps with closed impeller are mostly used for the handling of clear liquid. The closed impeller has a more complicated and expensive design not only due to the impeller structure but also due to the additional wear rings.

From the relevant study of closed impeller with grooves it seen that, micro grooved impeller increases the ability of impeller power transmission to the liquid. With the above study it is proposed that implementation of microgrooves on semi closed impeller to analyze the performance parameter of pump.

Comprehensive literature survey would be made by using paper published in the International journals like mechanical science, Aerospace science and technology, chemical engineering & processing: process intensification.etc. Manuals of ANSYS fluent, SOLIDWORKS and books related to mechanical science, Aerospace science and technology was studied. Janusz Skrzypacz et al. [1] they studied comparative

experimental analysis of two impellers. One was smooth and other was equipped with microgrooves. Experimental research of impellers carried out at SLS technology on a test rig. The influence of micro blade on performance of centrifugal pump impeller is verified with CFD simulation. It showed that characteristics of smooth & microgroove impeller are stable. As the flow rates increases beyond 2 m^3/sec, impeller with micro blades obtain bigger head. The efficiency of micro blades impeller is higher than smooth impeller.

Janusz Skrzypaczet al. [2] focuses modelling of flow in pump with multi piped impellers using CFD analysis. Further they verified numerical model using experimental data. A standard k-ε turbulence model was suitable for calculations. They determined the influence of computational grid size on accuracy of result. For calculation purpose tetra type of element was used. The three grid sizes are taken 1720941, 2279318, 3409769. The difference in the results between 1&2 option is 24% for head and 3.5% for momentum value. The difference in the results between 2&3 options is only 3% for head and 0.1% for momentum value. Option 2 was assumed for calculation. The results obtained that a multi piped impeller reaches the head by 30% more than drilled impeller. The performance characteristics for multi piped is much more favorable than for a drilled impeller.

A. Farid Ayad et al. [3] analyzed the performance computationally and experimentally for the validation of numerical modal on a semi open impeller with the same working conditions. To study the performance of centrifugal pump side clearance effect is focused. They represents 3 different side clearance widths (e=1,2,3) & finally compared with closed impeller(e=0).It is found that when the side clearance increases the head and efficiency are decreases. Effect of the side clearance on pressure field is discussed as; increase in side clearance width the pressure at impeller tip decreases. Effect of the side clearance on velocity field is discussed as; whenever side clearance width increases the relative velocity inside the impeller channel increases. Suthep kaewnai et al.[4] performed the CFD technique in analyzing and predicting the performance of radial flow type impeller used in centrifugal pump. The analysis of radial flow type impeller was done with design details such as; speed of pump 1450 rpm, flow rate 528m^3 /hr, head 20m, Specific speed 3033l/min. The analysis starts with mesh generation & refinement. The mesh type was hexahedral. The grid independency test shows that 45000 to 75000 nodes give the similar results. They selected one of the model in above range for analysis. Q-H curves shows instability at low volume rate so that produces friction at surface. The losses in impeller are increases with increase in surface roughness. P.Gurupranesh et al. [5] presented CFD analysis of centrifugal pump for performance enhancement. The characteristic study of the pump is carried out to reduce the losses such as turbulence loss, shock loss, impeller friction loss, volute friction loss, disk friction loss & recirculation losses, also power consumption. Results are obtained such as; fluid pressure = 38446.82, fluid flow rate Q= 0.0417752 m^3 /sec, efficiency = 62.16%. Pranit Patil et al. [6] studied impeller trimming, varying blade angles, addition of the diffuser, tip clearance, splitter blades techniques for improving centrifugal pump performance. Trimming technique results in the efficient operation and reduced operating cost but this affects on strength of impeller. Pump performance curve becomes smoother with increased blade angle. As number of diffusers increases the performance of deep well centrifugal pump increases. Larger blade angle creates the vacuum & smaller blade angle increases the clogging of water inside the impeller. Hiroshi Satoh et al. [7] discuss method for improving efficiency of pump which have specific speeds lesser than 500 rpm. If impeller is designed according to traditional way the width of the impeller would become extra ordinarily small & friction loss becomes large.

Therefore to reduce friction loss the ditches were preferred rather than the blades. Testing of impellers such as circular disk type & partially cut down type impeller were carried out at periphery. The partially cut down type impeller gives better efficiency when specific speed is lower.

II. NUMERICAL ANALYSIS

2.1 Geometry, mesh and boundary conditions

The geometry of the closed impeller with microgrooves is drawn in SOLIDWORKS. The dimensions are used to draw the geometry taken from research paper of Janusz Skrzypacz et al. [1]. Unstructured mesh is generated for the computational domain is shown in Figure 1. Boundary details are as maintained in Table 1.

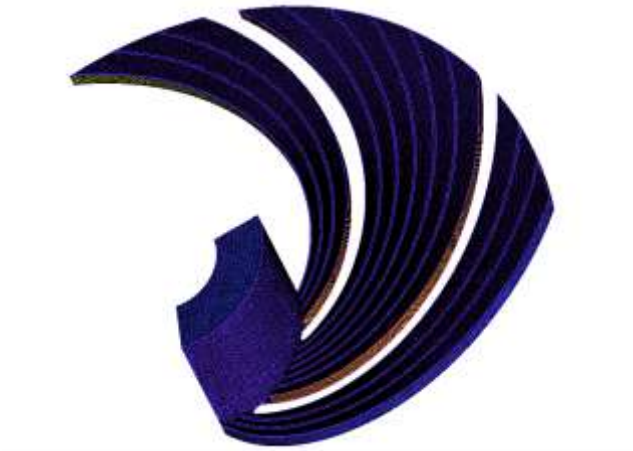

Fig. 1 Mesh Model Closed Impeller

Table 1. Boundary conditions

Sr. No	Boundary	Type of boundary condition	Magnitude
1.	Inlet	Mass flow Inlet	0.21kg/sec
2.	Outlet	Pressure Outlet	330000 Pa (a)
3.	Hub	Wall	-
4.	Impeller Blade	Wall	-
5	Periphery	Periodic	

2.2 Turbulance model

Firstly according to Janusz Skrzypacz et al. [1] k-ω SST viscous turbulence model is selected for the simulation of closed impeller with microgrooves. Moving reference frame used with rotational speed of impeller as 2950rpm.

For further study of semi closed micro grooved impeller, same model was used with same boundary conditions as used to simulate closed micro grooved impeller.

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III. RESULTS AND DISCUSSION

3.1 Numerical Validation of Closed micro grooved Impeller

In order to validate results with Janusz Skrzypacz et al. [1] simulation was run with k-ω SST viscous turbulence model with moving reference frame. Using available boundary conditions at the inlet & outlet the static head observed as 33.6m, also the static head counters shows same values as obtained by Janusz Skrzypacz et al. [1] Static head counters are as shown in Figure 3a, 3b.

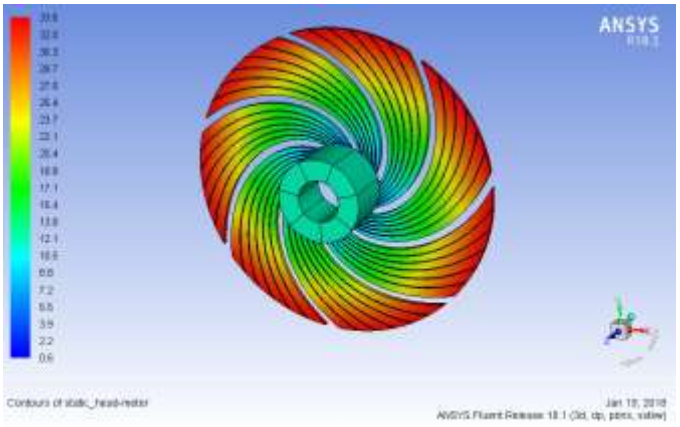

Fig.3a Static Head At Outlet for Closed Impeller

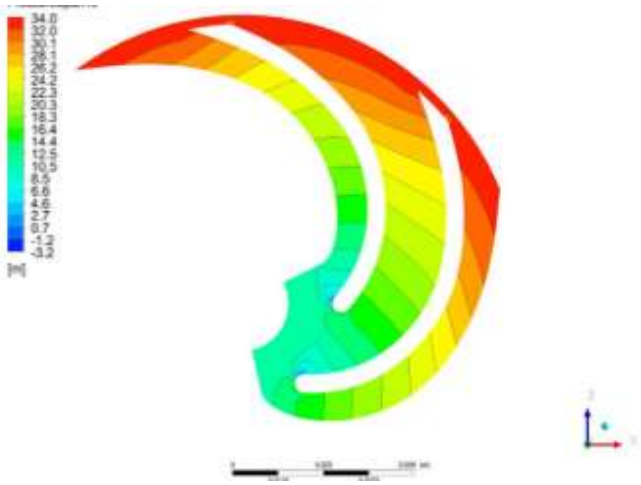

Fig.3b Static head by Janusz Skrzypacz et al. [1]

3.2 Numerical analysis of Semi Closed micro grooved Impeller

After validation of numerical k-ω SST viscous turbulence model for closed micro grooved impeller, similar turbulence model was used to analyse performance of semi closed micro grooved impeller.

For semi closed micro grooved impeller dimensions were selected as similar as the dimensions of micro grooved closed impeller. Unstructured mesh was done using ICEM CFD.

Static head counter for semi closed micro grooved impeller is as shown in figure 4, it shows 32.9m static head at outlet of impeller. From the results obtained it was seen that characteristics of semi closed micro grooved impeller had same nature like the closed micro grooved impeller.

At the outlet of closed micro grooved impeller Area-Weighted Average static pressure was observed as 330000pa whereas 329983pa was observed at semi closed micro grooved impeller.

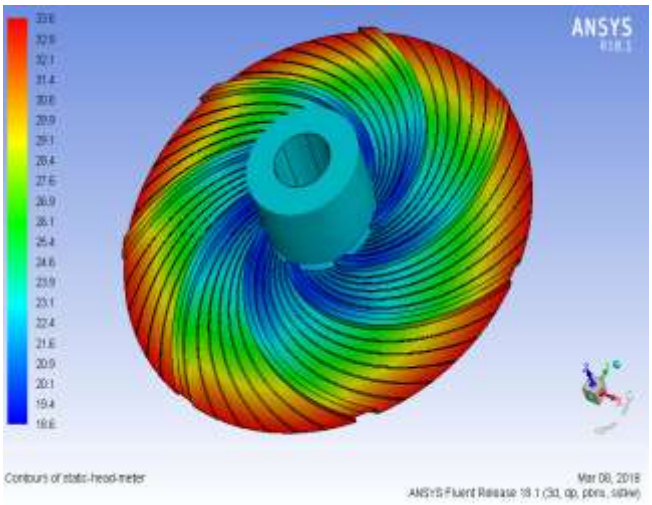

Fig.4a Static Head At Outlet Semi Closed Impeller

IV. CONCLUSIONS

The use of micro grooves in the impellers of centrifugal pumps is an innovative idea. Even though geometric variation done in numerical study, obtained performance had similar nature. Also it can be observed that implementation of micro grooves provides much better velocity distribution.

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