

EVALUTION OF EROSION WEAR OF CENTRIFUGAL PUMP USING CFD

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ABSTRACT

Centrifugal pumps are extensively used for transportation of water, slurries, oil etc. through pipelines over short/medium distances. Major problems associated with centrifugal pumps handling slurries are the estimation of hydraulic performance and wear of the pump components. Wear is one of the most common problems encountered in industrial applications. CFD simulation makes it possible to visualize the erosion wear with different flow condition inside a centrifugal pump, and provides the valuable hydraulic design information of the centrifugal pump. Present work is to analyze the erosion wear in the pump passage at different speed conditions with different particle size distribution and concentration using the ANSYS-CFX computational fluid dynamics simulation tool.

Keywords: *Erosion wear, Centrifugal pump impeller, CFD simulation, ANSYS-CFX.*

1.INTRODUCTION

Slurry pumps are used for the transportation of solids like coal, copper, iron ore, phosphate and in other mining operations. They are also used on dredges cleaning waterways, in environmental cleanup and in reclaiming land throughout the world. Slurries by their very nature are very abrasive requiring the impeller, casing and suction liner wet end component parts be replaced at regular intervals. In order to establish the life of pump and period of replacement of its parts, wear studies in the impeller and casing have to be carried out. Some of the earlier studies have simulated the flow in the impeller and casing and developed empirical correlations to predict wear in the pump. Rayan et al. [7] have conducted experiments to calculate the erosion wear rate on the impeller of the centrifugal slurry pump. They observed that erosion wear rate depends on the solid concentration and flow velocity. Pagalthivarthi et al. [5] have studied erosion wear in the casing of the centrifugal slurry pump using finite element method. Computation result has shown that erosion wear in an arbitrary radial cross-section of centrifugal slurry pump casing depends on particulate phase motion and concentration of the slurry. Gandhi et al. [4] evaluated experimentally erosion wear at various locations inside the volute casing of a centrifugal slurry pump for the zinc tailing slurries. They observed that wear along the casing is the function of solid concentration, flow rate and variation of impact angles of the solid particles around the casing. Adde et al.[1] have developed a numerical model to study the influence of different design parameters on the impeller nose wear of the centrifugal slurry pump. Sellgeren et al. [9] have developed numerical simulation model to estimate the centrifugal slurry component wear rates (suction liners, casings and impellers) at different heads,

particle sizes, volumetric solid concentrations and specific speed designs for white iron pumps for handling silica sand slurry. They have studied the effect of various slurry pump operating parameters and design geometries on the component wear. Wang et al.[10] have designed an experimental system to the study of centrifugal slurry pump wear condition monitoring. They studied that the wear patterns of impeller, suction liner and volute casing using data acquisition system at different operating speeds and flow rates. Roudnev et al. [8] studied the casing erosion wear of centrifugal slurry pump by using finite volume computational fluid dynamics code. Three different CFD approaches were used to analyze the wear in the centrifugal slurry pump casing with different inlet boundary condition. Engin [3] presented a numerical method for calculating the distribution of solid particles concentration in centrifugal pump impeller. They used finite element technique to solve the convection-diffusion differential equation between blades. By using this method they predicted best optimum impeller design. Computational fluid dynamics (CFD) is being increasingly applied in the design of the centrifugal pumps. 3-D numerical computational fluid dynamics tool can be used for simulation of the flow field characteristics inside the turbo machinery. Numerical simulation makes it possible to visualize the flow condition inside a centrifugal pump, and provides the valuable hydraulic design information of the centrifugal pumps. Present work is to analyze the erosion wear in the pump passage at different speed conditions with different particle size distribution and concentration using the ANSYS-CFX computational fluid dynamics simulation tool.

II.DESIGN OF CENTRIFUGAL PUMP

Present work is carried out under the following assumptions, the flow comes in through the inlet without any pre-swirl, the flow in the van less space is of a free-vortex type, and the volute casing is constructed of gradually increasing circular cross-sections with a constant average velocity. For design of the centrifugal pump input data are design specifications, geometrical and hydraulic variables, given below. Geometrical and hydraulic parameters are calculated with the help of conventional design method.

2.1Design Specification

Design of the pump input data: volume flow rate, total pressure head, specific speed, density of liquid, operating fluid viscosity.

2.2Geometric and Hydraulic Parameter

Vane angle, number of vanes, impeller discharge width, hub/tip ratio, inclination of the mean stream line to axial direction, Flow coefficient, head coefficient, blade velocity, relative velocity and other hydraulic parameter needed to describe the flow direction and magnitudes become direct function of geometry.

III.SIMULATION OF EROSION WEAR OF CENTRIFUGAL PUMP IMPELLER

A 3-D flow simulation is carried out on an impeller of a radial flow centrifugal pump using ANSYS-CFX computational code. Modelling and grid of the impeller has been generated using ANSYS–Blade modeller and turbo grid module of ANSYS workbench which is shown in figures1.1 and 1.2.

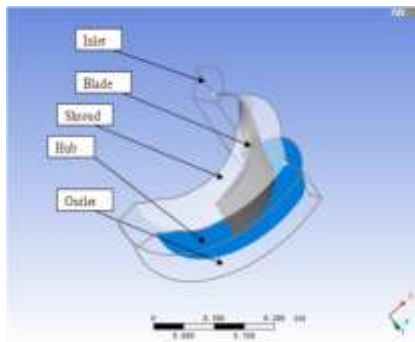


Figure 1.1 Impeller geometry of one blade

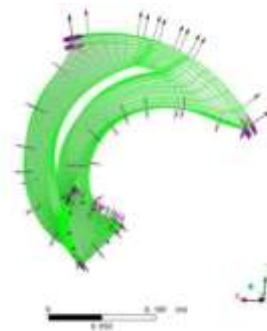


Figure 1.2 Meshing of single blade

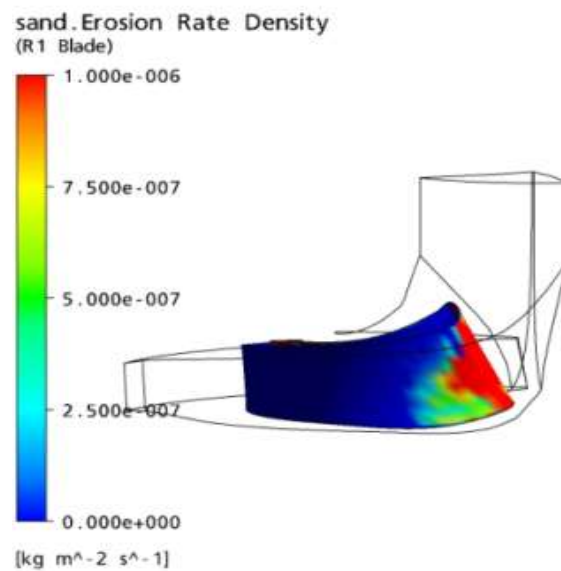
3.1 Boundary Conditions

The Shear-Stress-Transport (SST) turbulence model is used for the flow and erosion wear simulation of the rotating impeller of the centrifugal pump and the boundary conditions used for the flow simulation are summarized in the table 1.1.

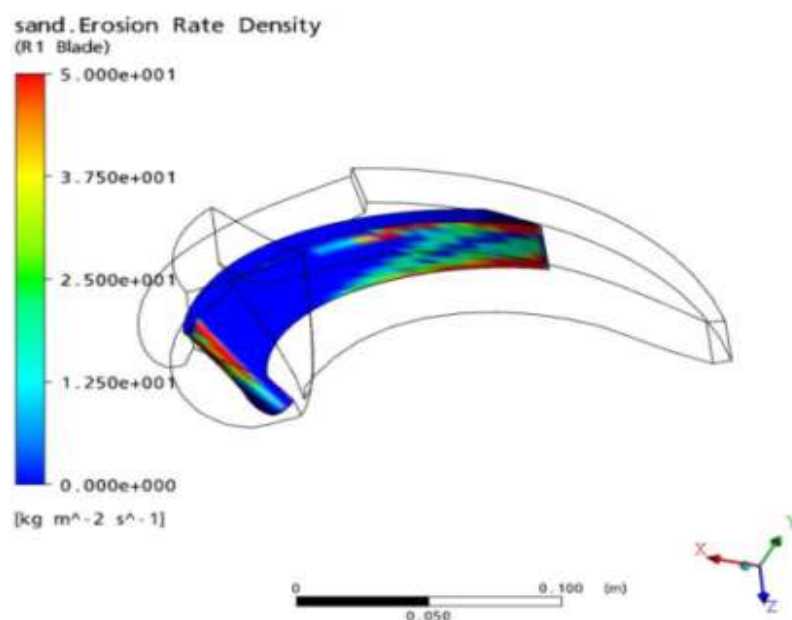
Table 1.1. Boundary condition.

Parameters	Boundary Conditions
Flow simulation domain	Single impeller flow channel
Grid	Structured
Fluid	Water at standard conditions
Inlet	Pressure along rotation axis
Outlet	Imposed mass flow rate
Periodic	Two symmetry surfaces positioned in the middle of the blade passage
Wall	No Slip
Turbulence model	SST model

IV.RESULTS AND DISCUSSIONS



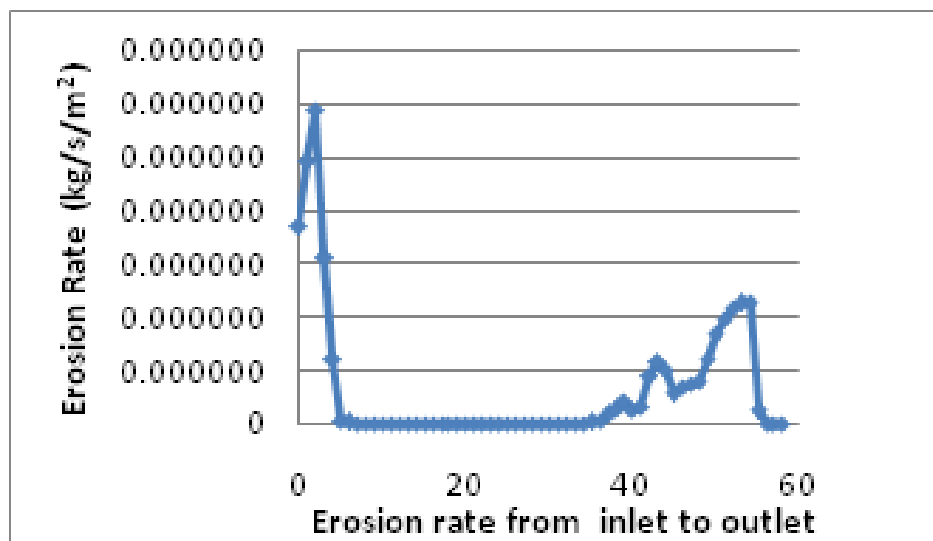
(a)



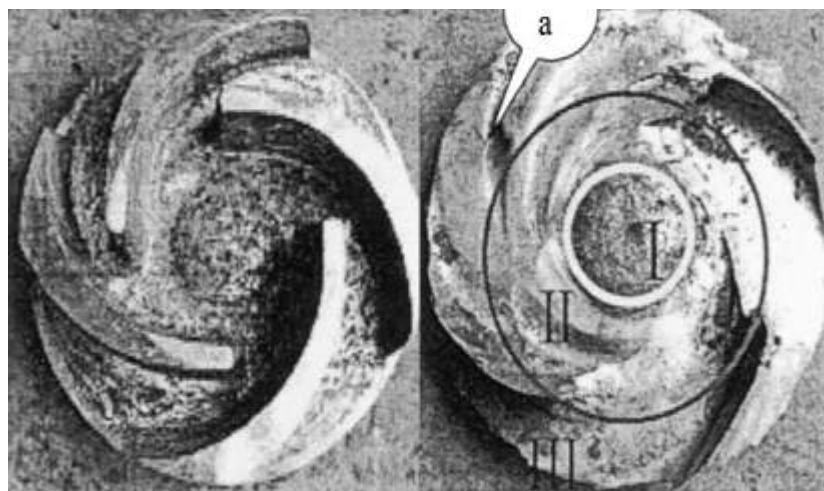
(b)

Figure 1.3(a) Wear of blade on pressure side (b) Wear of blade on suction side

Computational fluid dynamics erosion wear simulation has been carried out for radial flow impeller of centrifugal slurry pump at different speed for transporting of sand –water mixture with sand particle size distribution range 50-600 micron and concentration range 0.02-0.2% by weight. Figure 1.3(a) clearly indicates that the erosion rate is higher nearer to the pressure side. The sand particles strikes directly with the blades rotating at high speeds at inlet causing high wear as comparison to other parts of the impeller. Figure 1.3(b) shows that the erosion rate at suction side of the blade. Erosion rate is higher nearer to the root of the blade than compared central portion of blade.



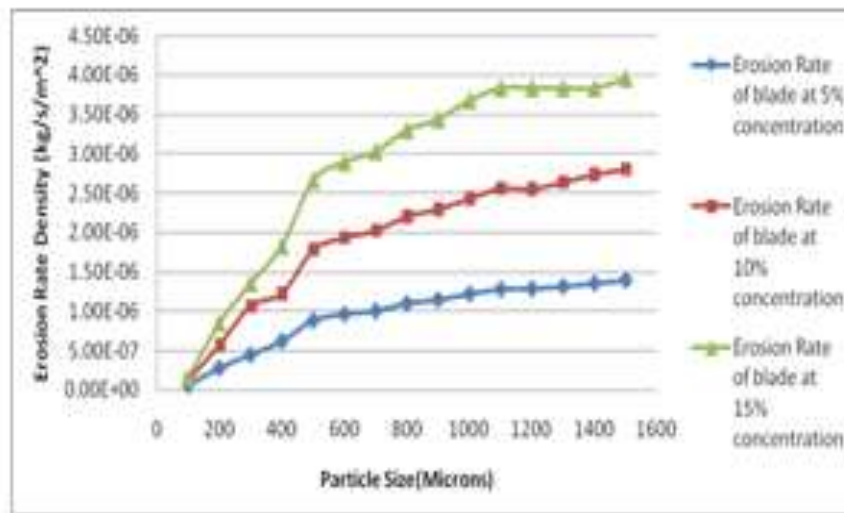
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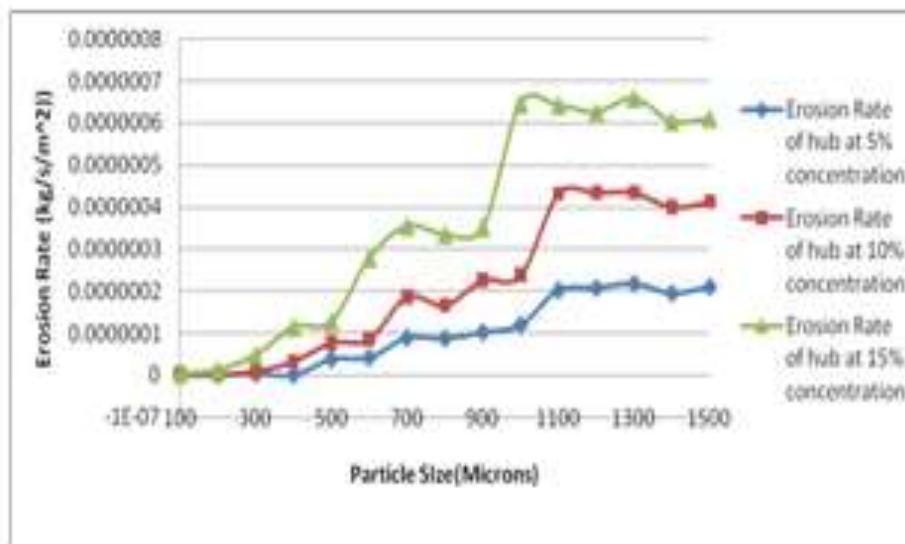
(b)

Figure 1.4(a) Erosion rate along stream wise direction (b) Experimental results shows complete wear of blades near the inlet.

Figure 1.4(a) shows the erosion wear rate along the stream wise direction from inlet to outlet. High value of erosion rate takes place at nearer to inlet in a very limited area; however the erosion rate at the trailing edge is less. The highest value of erosion rate density at inlet is approximate three times more than erosion rate density at trailing edge. This has been visualized on Figure 1.4(b).



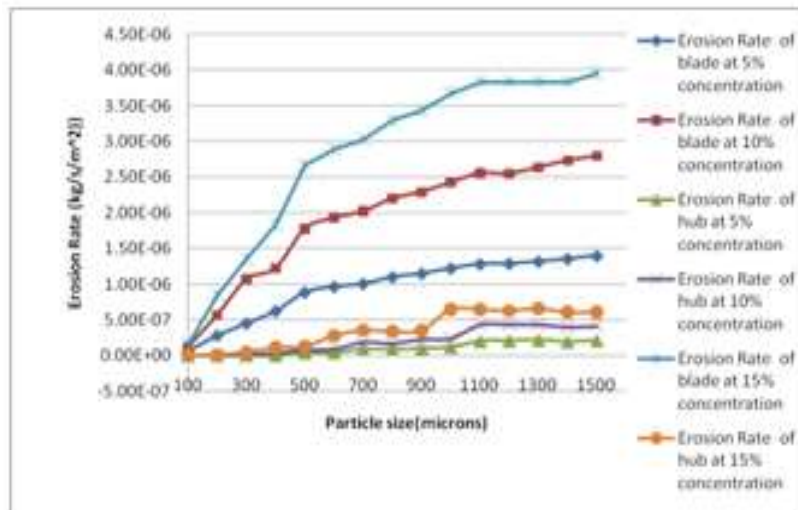
(a)



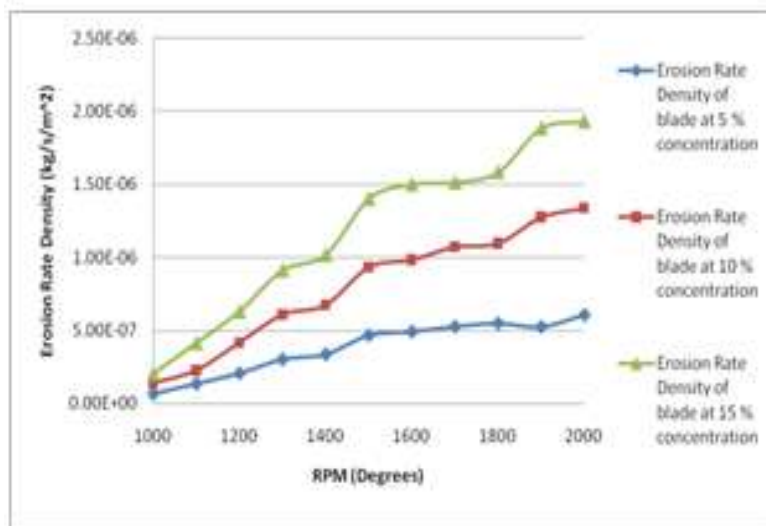
(b)

Figure1.5 (a) Erosion rate-Particle size (blade) (b) Erosion rate-particle size (hub)

Figure 1.5(a) and 1.5(b) show that the Erosion wear rate distribution at blade and hub with particle size distribution. Erosion wear density rate increases as particle size increases only up to certain limit of the particle sizes. The simulation is conducted at 5%, 10% and 15% concentration of sand and a similar trend is observed. However, the erosion wear density rate trend is different at the blade and the hub for same angle of attack.



(a)



(b)

Figure1.6 (a) Erosion rate vs. flow rate (b) Erosion rate vs. speed

Figure 1.5(a) shows that the erosion wear rate distribution at blade with mass flow rate ranges from 8-18 litres/s. The erosion wear rate increase is in similar pattern with mass flow rate for 5%,10% and 15% concentration of sand by weight. Figure 1.5(b) shows that the erosion wear rate distribution at blade with the operating speed

range from 1400-1700 rpm. The Erosion wear rate gradually increases with speed up to 1500 rpm. However above 1500 rpm erosion wear rate increases rapidly.

V.CONCLUSION

A numerical model of an impeller has been generated and the complex internal erosion wear distribution is investigated by using the Ansys-CFX computational code. The effect of erosion wear is more at leading edge than at trailing edge of blades so that the selection of optimum inlet blade angle can play a major role in reducing erosion wear and providing smooth flow for fluid. Erosion wear distribution on the impeller blade has also direct influence due to operating speed, mass flow rate, concentration of solid-liquid mixture. Similar computational simulation models can also be used for analyzing the pressure and velocity of the turbines, compressor, fan and blower.

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