PREDICTION AND CONTROL OF EROSION WEAR PATTERN IN SLURRY PUMP CASING USING CFD

by

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CERTIFICATE

This is to certify that the thesis entitled PREDICTION AND CONTROL OF EROSION WEAR PATTERN IN SLURRY PUMP CASING being submitted by Vipin Tyagi to the Indian Institute of Technology, New Delhi (India) for the award of the degree of Master of Science (Research) in Mechanical Engineering Department is a bonafide research work carried out by him under our supervision and guidance. The research reports and the results presented in this thesis have not been submitted in parts or in full to any other University or Institute for the award of any degree or diploma.

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ABSTRACT

Slurry flow in a two dimensional domain of a centrifugal slurry pump casing is investigated with an underlying motivation to predict and control the erosion wear. The attendant wear problem around the casing wall is addressed and wear patterns based on numerical computations of the flow are obtained. Wear around the casing wall is non uniform and also varies with pump operating conditions and several geometry parameters. The present study is aimed to determine the pump operating conditions and geometry parameters that lead to nearly uniform wear and possibly reduction in the peak wear rate.

Finite Volume methodology as implemented in CFD software package FLUENT 6.1® has been adopted. Both dilute and dense slurry flows are considered. Discrete Phase Model (DPM) in FLUENT 6.1® is used in modeling dilute flow and Eulerian multiphase model in FLUENT 6.1® is used in modeling dense flow. In dilute flow, two-way coupling between the phases is considered. In this approach, the particles are considered as distinct entities and are tracked using the Lagrangian-Eulerian framework. In dense flows, the two phases (solid and liquid) are considered as inter penetrating continua. Mixture $k-\varepsilon$ turbulence model is used in modeling turbulence. This approach incorporates a $k-\varepsilon$ RANS (Reynolds Averaged Navier Stokes) viscous model, as opposed to previous studies using inviscid model and Galerkin finite element method.

Validation of present numerical predictions is carried out with mesh refinement studies and comparison with published results. Mesh independent solutions are obtained with the residual convergence of velocities and other scalar variables to a tolerance of $10^{-6}$. Particle velocities, concentration and carrier velocities, concentration are shown to bear mesh independent nature. For dilute slurry, actual particle trajectories inside a channel are compared with corresponding numerical results in the published literature. In dense slurry flows, particle velocities and profiles in a channel are validated against experimental data obtained from the published literature. Further, particle velocities and concentration are also compared along different pump cross-sections with existing numerical solutions. Apart from these, wear rate calculations are also validated with existing experimental data and numerical predictions.
The nature of wall stresses, solid velocities, solid concentration etc. are studied. These quantities are a pre-requisite to wear calculations. Their variations with various pump operating conditions and geometry modifications has been described.

Wear rate is obtained around the casing wall. Wear coefficients are used for correlating the amount of energy a particle loses on hitting the wall to the actual wear rate. These wear coefficients are obtained from the open literature. Impact wear rate is the only dominant wear causing mechanism in dilute slurry, while, for dense slurry flow, both impact wear and sliding wear become important, and are addressed. These wear rates are plotted as a function of casing wall (shell) length. The operational conditions of the pump varied are pump flow rate and pump speed (RPM). The geometric parameters include tongue curvature, impeller diameter and casing width. Several criterias are defined to quantify the changes in geometry. Apart from these parameters, effect of particle diameter and average inlet particle concentration on the wear rate are also considered. Three pump casings are considered for slurry flow modeling.

Aim of the work is to identify design and operational parametric changes to reduce the wear rates and to make it more uniform as far as possible. Extensive validation and mesh studies for DPM predictions and dense slurry flow predictions lend confidence in accuracy of wear rate patterns around the pump casing. The ultimate use of the present work is made available in the form of several guidelines for wear reduction and uniform wear.
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