CFD MODELLING FOR HYDRAULIC AND PNEUMATIC CONVEYING THROUGH PIPELINE

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by

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CERTIFICATE

This is to certify that the thesis "**CFD MODELLING FOR HYDRAULIC AND PNEUMATIC CONVEYING THROUGH PIPELINE**" being submitted by **Mr. Arvind Kumar** to the ***Indian Institute of Technology, Delhi (India)*** for the award of the degree of Doctor of Philosophy in Civil Engineering Department is a bonafide research work carried out by him under my supervision and guidance. The thesis in my opinion, has reached the standard fulfilling the requirements for the Doctor of Philosophy Degree. The research report 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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(Arvind Kumar)

ABSTRACT

Hydraulic and pneumatic conveying of solids through pipeline is widely used due to its many advantages. The prediction of two-phase flow of solid-fluid in hydraulic and pneumatic conveying remains a major challenge in many engineering and industrial applications. In recent years, new findings of turbulent flows and their modelling have provided the basic framework for development of mathematical models of solid-fluid flows. The emergence of powerful numerical techniques and computational fluid dynamics along with the accessibility of powerful computers has made it possible to test such models and to carry out investigations of the basic phenomena using computer simulation. The present research was undertaken to gain insight in the modelling of solid-fluid flows.

The flow behaviour of solid-liquid mixture in hydraulic conveying through slurry pipeline is very complex due to its dependence on large number of geometrical and dynamical parameters and their interdependence. In the present study, bench scale tests have been carried out to determine the physical properties of solids, carrier fluids and slurries to be transported through slurry pipeline. These physical properties are required as essential input to design any slurry pipeline system. Computational Fluid Dynamics (CFD) based commercial software FLUENT has been used to determine the pressure drop, solid concentration and velocity distribution in horizontal slurry pipeline and bend. In the development of the simulation method, single phase water flow has been considered as a basis for extension to the multiphase flow. Simulation results show good agreement with experimental data available in literature for flow of water, mono-sized

silica sand slurry and bimodal (silica sand mix with flyash) slurry in horizontal pipeline and bend.

In order to understand the flow mechanism and to calculate the energy dissipation in slurry pipeline, knowledge of the solid concentration distribution is essential. Kaushal and Tomita (2002) model for the prediction of solid concentration distribution gives good results across mid-vertical plane in horizontal slurry pipeline except near pipe bottom. A mathematical model is developed in the present study incorporating proposed correlation for settling velocity of particles near pipe bottom. The proposed model gives fairly accurate predictions for the experimental data considered in the present study from literature for solid concentration distribution in mi- vertical plane of horizontal slurry pipeline.

A mathematical model is proposed to predict the solid concentration distribution in lateral plane of horizontal slurry pipeline incorporating the effect of particle size in existing Sharp and O'Neill (1971) model. The proposed model gives fairly accurate predictions for the experimental data considered in the present study from literature for solid concentration distribution in lateral plane of horizontal slurry pipeline.

CFD based simulations have been carried out to investigate the pressure drop prediction capabilities of commercially available FLUENT software across horizontal and vertical 90^0 bend in pneumatic pipeline for conveying of cement. On comparison with experimental data from literature considered in the present study, broad qualitative agreement and large quantitative disparity is observed. At lower solids loading ratios the mixture model and steady state analysis have been found more appropriate. At large solids loading ratios, the deviation is large between measured and predicted values and requires further investigation.

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