PREDICTION OF PARTICLE DISTRIBUTION IN THE FLOW OF MULTISIZED PARTICULATE SLURRIES THROUGH CLOSED DUCTS AND OPEN CHANNELS

by

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Dedicated
to my
Father

CERTIFICATE

This is to certify that the thesis entitled **PREDICTION OF PARTICLE DISTRIBUTION IN THE FLOW OF MULTISIZED PARTICULATE SLURRIES THROUGH CLOSED DUCTS AND OPEN CHANNELS** being submitted by **Deo Raj Kaushal** to the **Indian Institute of Technology, Delhi (India)** for the award of the degree of **Doctor of Philosophy** in **Applied Mechanics Department** is a bonafide research work carried out by him under our supervision and guidance. The thesis in our 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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ABSTRACT

Transportation of slurries through closed ducts (circular and noncircular) and open channels is encountered in a large number of engineering applications. Circular pipes are normally used for long distance transportation of variety of materials in bulk quantities. Noncircular closed ducts (like rectangular or square) may be more energy efficient due to larger bed area and the formation of secondary currents. However such systems are limited at present, to in-plant applications only. Transportation of solids in open channels under gravity occurs at many diverse situations like sediment transport, soil erosion and slurry transportation in the mining and mineral processing industries. For commercial slurries where the size ratio of largest to smallest particle could be greater than 1000, the design procedure of closed ducts and open channel transporting such slurries is quite complex. Thus, the approach of the scientists over the years has been to build analytical models based on extensive experimental data so that they can be used as design tools. However, it has not been possible to propose a single model which is universally applicable to all types of slurries. Hence, in the present work, an attempt has been made to propose analytical models on the basis of existing models and data base both generated in the present study and available in the literature for the prediction of some of the parameters involved in the design of closed ducts and open channel. The design parameters for which analytical models have been proposed in the present study are concentration and particle size distribution across the cross-section of closed ducts and open channels, pressure drop and deposition velocity in closed ducts.

Concentration profile, particle size distributions, pressure drop and deposition velocity were measured experimently for multisized zinc tailing slurry flowing through a pipe of 105 mm diameter and a 2-D rectangular duct of 200 mm width and 50 mm depth fitted in pilot plant test loop existing in the Fluid Mechanics Laboratory of I.I.T. Delhi. Measurements have been made over a wide range of flow velocities and

concentrations. The extensive data base on concentration profile and particle size distributions for pipe, 2-D duct and open channel has been generated with the help of experimental data collected in the present study and those available in literature. These data in the closed ducts and open channels have been compared with predictions of concentration profile and particle size distribution using model proposed by Karabelas [29] and the limitations of this model are analysed. To make this model more realistic, modifications have been incorporated by taking into the account the effect of solid concentration on settling rate and particle diffusivity. Then the whole data base is compared with the predictions of concentration profile and particle size distribution in closed ducts and open channel using the modified Karabelas model. It is observed that the modified Karabelas model for the prediction of concentration profile and particle size distribution gives good results for the entire range of efflux concentrations in all the three cases namely pipe, 2-D duct and open channel.

The data collected in the present study for pressure drop on zinc tailings slurry flowing through pipe and 2-D duct was analysed and compared with the predicted pressure drops as calculated by the procedure proposed by Wasp et. al.[80]. It was found that the deviations were large particularly in the region close to deposition velocity. Hence a modified pressure drop prediction method has been proposed which shows improvement in pressure drop prediction near deposition velocity.

An analytical method based on modified Karabelas model for the prediction of deposition velocity has been proposed. The data collected in the present study for deposition velocity on zinc tailing slurry transporting through pipe and 2-D duct and those available in literature have been analysed. On the basis of analysis of this data base, a critical value for the ratio of overall local concentration at the bottom to the static settled concentration at which deposition starts has been obtained.

TABLE OF CONTENTS