HYDRAULIC TRANSPORTATION OF SOLIDS THROUGH HORIZONTAL PIPES

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CERTIFICATE

This is to certify that the thesis entitled 'HYDRAULIC TRANSPORTATION OF SOLIDS THROUGH HORIZONTAL PIPES' being submitted by Mr. Gh. Ahmad Wani to the Indian Institute of Technology, Delhi for the award of the degree of DOCTOR OF PHILOSOPHY is a record of the bonafide research work carried out by him. Mr. Gh. Ahmad Wani worked under our guidance for the submission of this thesis which to our knowledge has reached the requisite standard.

The thesis or any part thereof has not been submitted to any other University or Institution for the award of any degree or diploma.

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ABSTRACT

Hydraulic transportation of solids through pipelines can be considered to be economical, efficient, reliable and safe. This mode of transportation is particularly suitable for large scale production, movement and distribution of materials like coal, sand, and minerals, etc. in highly remote areas and through difficult terrains.

A review of available literature revealed that a large volume of experimental data as well as a number of empirical correlations for prediction of head loss and critical velocity, most essential for designing a pipeline, existed in published form. These correlations however, were found to have been developed from experimental data conducted with solids having narrow particle size distribution, flow under specific flow regimes.

These correlations alongwith some of the assumption on the associated flow conditions were considered to be unreliable for predictive and design purposes, particularly for solids having wide range of size distribution. Hence, the present study including selective experimental trials as well as obtaining improved and reliable ones for solids having a breadth of size distribution.

Experiments were conducted on pipeline transportation of sand - water slurry in a laboratory set-up consisting of a pipeline having 2.54 cm. nominal diameter. Head loss data were obtained for 9 sand samples with different size distribution under heterogeneous flow conditions. The data collected covered slurry velocities upto 3.2 m/sec, and in-situ solid concentrations, measured for part of the data, upto 20 percent by volume. Additional head loss data were obtained from published literature.

A flow regime delineation procedure for classification of data into homogeneous, heterogeneous and saltation regimes was formed out of the existing regime delineation criteria after testing them on some data for which flow conditions were known. The available data were then classified into flow regimes for the present study.

Some of the existing head loss correlations were tested for the experimental data with multisize particles conducted under present study as well as literature data where size distribution were known. Most of the correlations were found to give predictions with relatively large errors. It was considered that the existing correlations did not account for the width of size distribution. Hence, improved correlations incorporating breadth of size distribution were attempted for homogeneous, heterogeneous and saltation

regimes. Better predictions of head loss were obtained from these correlations.

Most of the earlier correlations seemed to have neglected relative velocities between solid and liquid, and had used delivered concentration for predictive equations. However, relative velocities do exist and in-situ concentration should be different from delivered concentration. It was considered worthwhile to attempt developing improved predictive equations based on realistic parameters, such as in-situ concentration, relative velocities between solid and liquid, etc. Assuming a simplified flow model of solids and liquid in a pipeline, an empirical correlation was first developed for in-situ concentration prediction using experimental data where such concentrations were measured. This correlation was then used to find in-situ concentrations for the bulk of the data for which such concentrations were unknown.

A head loss correlation was developed for slurry flow through a horizontal pipe, based on in-situ concentration and the relative velocity between solid and liquid. The constants in the derived equation were evaluated using only selective experimental data conducted in the laboratory. The correlation was then tested for head loss prediction on bulk of the available data, and was found to give relatively

satisfactory predictions. Also the correlation was observed not to require delineation between heterogeneous and homogeneous regimes.

The effect on head loss due to change of parameters, such as weighted mean particle diameter, standard deviation of particle sizes, mean slurry velocity and in-situ concentration was analysed graphically through constant head loss contours using two independent variables at a time (other two being kept constant).

Correlations for critical velocity prediction in pipeline transportation of solids settling in Stokes and Intermediate ranges were attempted, incorporating the breadth of size distribution using literature data. The correlations were tested against a limited amount of data and found to give satisfactory predictions.

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