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Experimental Investigation of Effect of Concentration on Head Losses at Different Size Particle in Pipe Flow

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ABSTRACT

Thetransportation of solids using fluid as a carrier has been found to be in many instance, both convenient and economical.In many industrial process and operation such as paper making, mining, food and chemical processing, the handling of solid liquid flow is unavoidable.In this study the effect of concentration and particle size on pressure drop of slurry flow in horizontal pipe was presented experimentally. The test-section having a length of 3.51m and 80.1mm diameter was used. The particle size was used ranging (310µm-510µm) and (510µ-710µm). The experiment was conducted on Sand-Water Slurry and (Sand+Coal)-Water Slurry. The results of experiment shows that at particle size (310µm-510µm) on increase of concentration pressure drop will also increase and the nature of graph was similar to the water after certain velocity.At higher concentration pressure drop decreases after certain velocity for Particle size(510µ-710µm). However due to the limitation of the experimental set-up, the maximum concentration of solids in the slurry could not be increased beyond 12.23%.

Keywards- Slurry Flow, Solid-Liquid Flow, Pressure Loss , Particle Size

I INTRODUCTION

Pressure loss in two-phase flows is important phenomena that are observed in many industrial fields. In this flow, the particle size affects the flow structure because it indicates the independent motion from the carrier flow. The flow becomes complicated due to the interaction between particles and fluid. Two phase solid-liquid flows have analyzed both theoretically and experimentally by many researchers the word over and they strived to optimized various parameters such as particle size destruction, solid concentration, flow velocity, and other related parameters involved in the hydraulic design of slurry pipeline. In 1977 the method for pressure drop was modeled based on the assumption that the total pressure drop in two phase flow can be split into two parts, pressure drop due to vehicle and excess pressure drop due to bed formation[1]. In 1991 Gallies has modeled a mass balance for two superimposed slurry layers. The lower layer consist of contact load contributing to sliding frication at the pipe wall and upper layer comprises of suspended load for which the immersed weight is transferred to the career fluids[2].

Kaushal et.al.has conductedthe study of effect of partial size on pressure drop[3]. Study of relation between the flow frication and the flow pattern in pipe transporting in a sand water mixture was carried out[4]. Experimental analysis of head loss in rectangular pipe was performed in (2002). The experiments were conducted by using five effiuxconcentration ranging from 4% to 26% at flow velocity from 1.0 to 4m/s for each efflux concentration [5]. Newton et.al, developed a mathematical model for solid-liquid flow to be homogenous.[6].

Durand and C.ondolios gave the following classification as shown in (Table.1) for specific gravity about 2.65 and lowest velocity[7].

Before transporting the solid- liquid slurry in a horizontal pipeline, system operating parameters such as critical flow velocity, and required pressure drop must be known. The pipeline energy must be sufficient to prevent the formation of settled bed at the bottom of pipeline. The pressure drop in slurry flow is minimum at the critical velocity[8]. The flow behaviour of some high ash Indian coal-water slurry for long-distance transportation has been investigated[9].

From the above literature survey it was observed that number of analysis carried out for solid-liquid flow each carrying single component particle. In practices there are numerous application where mixed particle where flowing with water. There was a gap in this area. This study will help to the researchers to understand the flow behavior in a mixed system.

Table. No 1Flow Regimefor Water for Different Particle Size Range

S.N	Flow Regime for Water	Particle Size Range
1	Homogenous Suspension	d<40 micron
2	Hetrogenous Suspension	Between 40 micron to 0.015
3	Suspension and Saltation	0.15≤d≤1.5mm
4	Saltation	d>1.5mm

II EXPERIMENTAL APPARATUS AND MEASUREMENTS

2.1 Experimental Setup

The experimental setup is a recirculation type consists of closed cricket system as shown in Fig.1. The suction of the non-clog centrifugal pump (capacity = 34liters/sec, B.H.P =30.3, Head = 18.29m ,N= 980rpm) is connected to the supply or mixing tank and the discharge tank through 101.6mm dia G.I pipe. Discharge of pump comeback to the mixing tank through 80.1mm dia and 12.6m long delivery pipe. By manipulation of quick closer valves, the flow of pipe can be delivered into the measuring tank to measure the flow rate of the pump discharge. There is provision of by-passing to vary the flow through main pipe.

Considering the acceleration region of the flow, pressure measurement in the straight portion of the pipe where made at point more than 50D(D is the nominal dia)from the bands, in the straight portion of the pipe 3.51m were consider for the present investigation . S1& S2 are the Pressure taping in the pipe.Testsection is as shown in Fig. 2.

2.2 Pressure Measurement

The head loss in the straight portion of the pipeline was measured by differential carbon- tetra chloride water manometer. The two pressure points in the pipeline were connected to the manometer through the filter boxes. The filter box considered of a hollow cylinder 300mm diameter and 1.35m height having a fine screen fixed in it as shown on Fig.3. The bottom of filter box was connected to the pressure point in the pipeline through a polythene tube of 8mm diameter and the top of the box to the manometer thus allowing only clean water in the manometer.

2.3 Mixing Tank

The mixing if solid-liquid were preparedin the mixing tank. The mixing is affected by three stage , agitator having three blades per impeller 120^0 apart and inclined at 30^0 from the horizontal. The agitator is operated by a 2H.P .variable speed geared motor. The dimension of slurry tank is as follows: total height ofthe tank is 2.275m, from bottom up to 1.64m height, its cross-section uniformly increases at 1.64m height, above 1.64m height to above it has its constant cross-section having (1524^3)mm.

2.4 Discharge Measurement

The slurry volumetric flow rate is measured by using an electromagnetic flow meter as shown in Fig.4. It will gives directly discharge in terms of liter^{3}m/s. The accuracy of electromagnetic flow meter was 3% of the actual discharge. The actual discharge of the solid-liquid slurry was measured by the measuring tank. The total height of the measuring tank was 1.65m. From bottom up to 0.35m its cross-section increases gradually and above 0.35m it had constant cross-section (1220^2) mm square. A quick closer valve was providedto quickly divert the flow in the measuringtank.

2.5 Concentration Measurement

To determine the concentration of the slurry, some quantity of the slurry was collected from the system and weighted. The sand and coal mixture was filtered, dried and weighted. The weight concentration $C_w$and$C_v$can be determine by using the equation 1 & 2. The schematic diagram of the vacuum filter is as shown in Fig.5.

$$C_w = \frac{\text{Dry solid weight}}{\text{Slurry Weight}} \text{.............}(1) \quad C_v = \frac{\text{Volume of dry solid}}{\text{Volume of the slurry}} \text{..........}(2)$$

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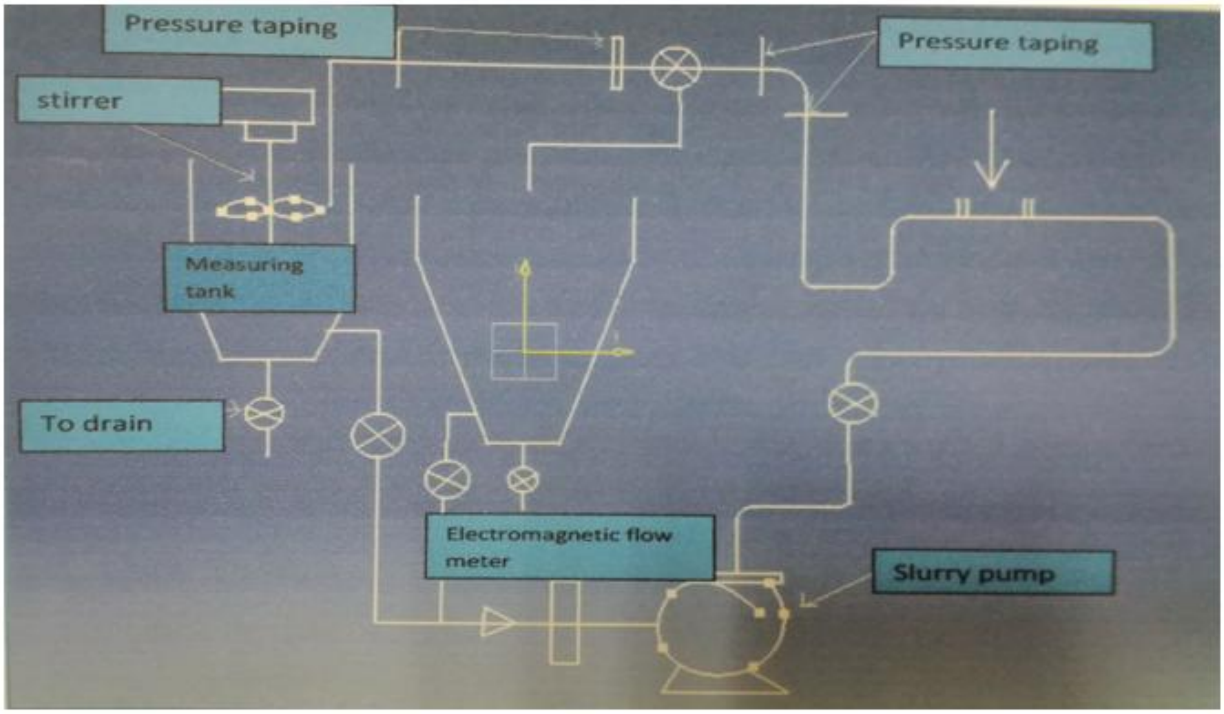

Fig.1. Schematic Diagram of the Pilot Plant test loop

Fig.2. Schematic diagram of fabrication of test-section for pressure measurement

Fig.3. Schematic Diagram of the Filter Box

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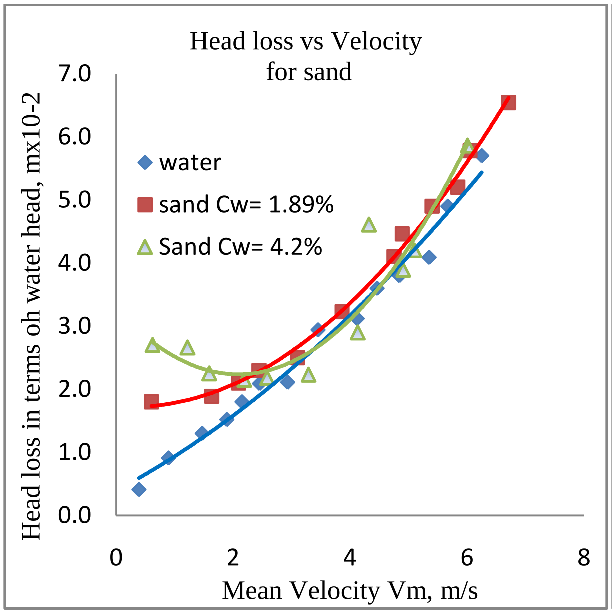
Fig.5. Electro-magneto Meter for Discharge Measurement

Fig.6. Vacuum Filter for the measurement of concentration

III RESULT AND DISCUSSION

The head loss per unit length of the pipe versus mean velocity of flow was presented in Fig.7-10. Head loss verses velocity curve for water was used as reference. Fig.7. show the head loss for sand-water slurry (510-710µm) in the ratio of 1:1 & Fig.8 shows(sand+coal)-water slurry (510-510µm) in the ratio of 1:1 concentration by weight. Fig.9. shows the head loss for (sand +coal)-water slurry (310-510µm) in the ratio of 1:1& Fig.10. represents head loss of (sand +coal)-water slurry (310-510µm) in the ratio of 2:1 concentration by weight. The curve are drawn for the weightconcentration C_w =1.89% , 4.2%,4.6%, 12.23%, 8.29%, 2.12% .It was observed that for sand-water slurry as the C_w increases head losses is also increases at lower velocity but at higher velocity curve is similar to the water velocity due to homogenous mixing of sand in water.



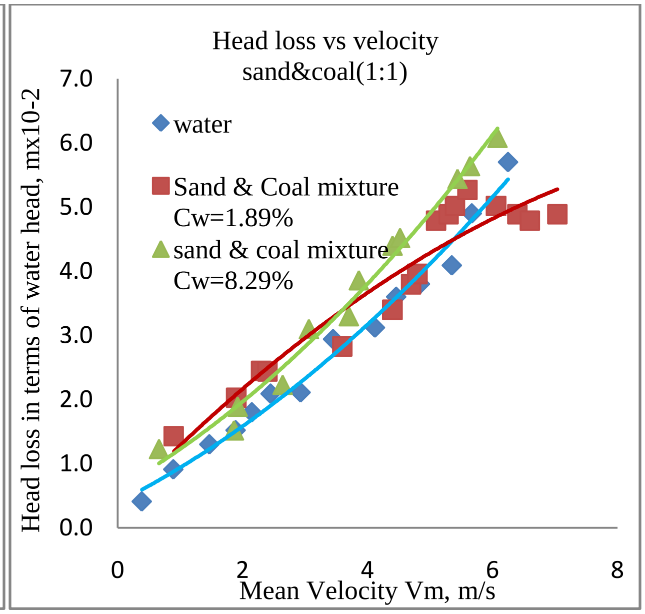
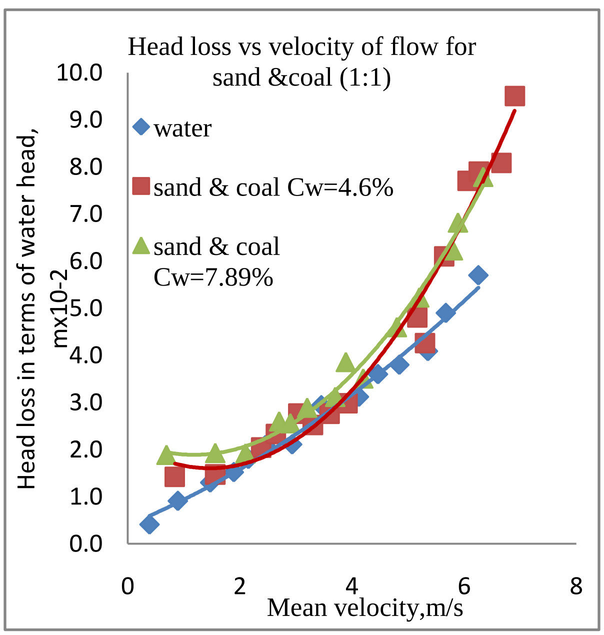


Fig.7. Head loss vs velocity for sand-water (510µm to 710µm) slurry

Fig.8. Head loss vs velocity for sand & coal mixture (510µm to 710µm)slurry



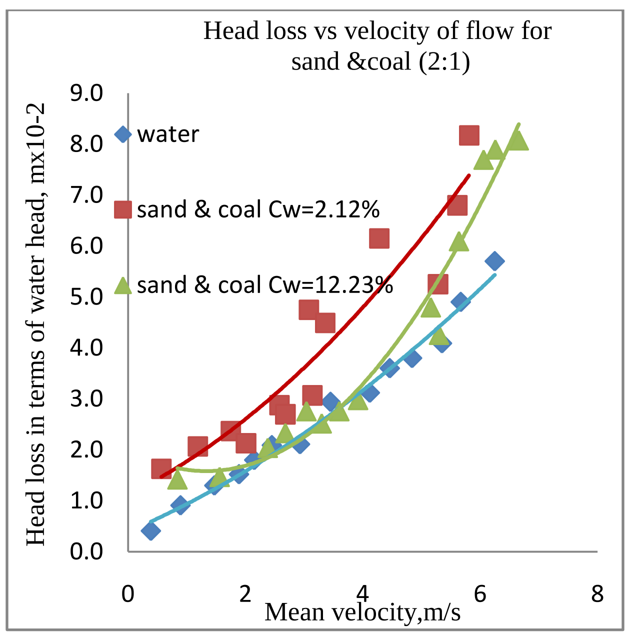


Fig.9.Head loss vs velocity for sand and coal mixture mixture (310µm to 510µm)slurry(310µm to 510µm)slurry

Fig.10.Head loss vs velocity for sand and coal

IV CONCLUSION

The aim of this study is to clarify the effect of particle size on head loss in horizontal pipes. The solid particle laden water pipe flow in horizontal pipes is experimented. The flow velocityis measured by using electromagnetic flowmeters. In this paper two types of slurry sand-water and (sand+coal)-water in the ratio of 1:1&2:1 is performed. Two range of particle size is used for the investigation (510µm to 710µm) and (310µm to 510µm). following conclusion is drawn.

1. There was continuous increase of head loss in the horizontal pipe flow for the particle size (310µm to 510µm) with of concentration. This report does not support the previous report by V.Matousek.
2. For particle size (510µm to 710µm) sand-water slurry head loss decreases with the increase of concentration at lower velocity however at higher velocity this phenomenon is reversed.
3. For particle size 310-510µm (sand+coal)-water slurry in the ratio of 1:1 head loss is increases with the increase of concentration.
4. For particle size 310-510µm (sand+coal)-water slurry in the ratio of 2:1 head loss is decreases with the increase of concentration due to the homogenous mixing.

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