EXPERIMENTAL INVESTIGATIONS ON VARIATION IN PARTICLE SIZE ON PRESSURE DROP DURING GAS FLUIDIZATION OF SOLIDS IN STATIONARY LIQUID

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Abstract

For investigating the effect due to the variation in particle size on pressure drop across the column in gas fluidization of solids in stationary liquid has been done by conducting experiments. The investigations have been performed on three different particle sizes of coal in three different pools of liquids at various flow rates. The experimentations have been conducted using three different liquids which are taken as water, kerosene and turpentine. The air flow rate is measured by the air rotameter. For different air flow rates, corresponding column pressure drop, have been measured across the fluidized bed for three different sizes of solids. For the purpose of experimentation, an experimental set-up has been fabricated. The standardization of the experimental setup and the methodology of experimentation have been finalized by applying the gauge repeatability and reproducibility theory. The fluidization is done in a fluidizing column. The results indicate that the column pressure drops decreases with increase in particle size.

KEY WORDS:*Particle size, fluidization, pressure drop, stationary liquid*

1. Introduction

Three-phase fluidization has its applications in many industries such as thermal power plant, petrochemical industry, food processing, biochemical, effluent treatment process etc. In a pool of liquid, injection of gas causes the formation of the bubble and these newly formed bubbles rise due to the force of buoyancy. The bubble formation and bubble rise are affected by the properties of two fluids present in bed such as their densities, viscosities, surface tension etc. The bubble rise is obstructed mainly by the fixed bed of solids and then fluidized state. So it is also dependent upon the bed characteristics of the solids such as its density, size, sphericity, the surface structure and its affinity with the two fluids present in the bed.

The variation in size of the particles has a typical effect on the behavior of the gas fluidization of solids in stationary liquid. The related studies for predicting the significance of particle size on the bed pressure drop are limited. The objective of the study is to investigate the effects of particle size for increasing gas flow rates on the bed pressure drop.

2. Related studies

Epstein [1] suggested and explained the different types of fluidization models. In the present work, three-phase fluidization in stationary liquid has been undertaken to investigate the effect of variation in particle sizes on column pressure drop. Gabor et. al. [2] initiated the preliminary work over the gas fluidization of solids in a stationary liquid. However, some work have been reported in the field of bubble column regarding the bubble size, shape, their formation and rising velocity in the liquid column. Weiling Li et. al. [3] made investigations in a three-phase bubble column to study variations of bubble rise velocities. Chilekar et al. [4] studied and categorized the bubble sizes. The effect of solid concentrations on the bubble rising velocities in a three–phase slurry bubble column has been investigated by Li et al. [5]. The effect of particle size and concentration on the hydrodynamics of a slurry bubble column has been investigated by Rabha et al. [6].

3. Experimental setup

The experimental setup consists primarily of the following components as shown in figure

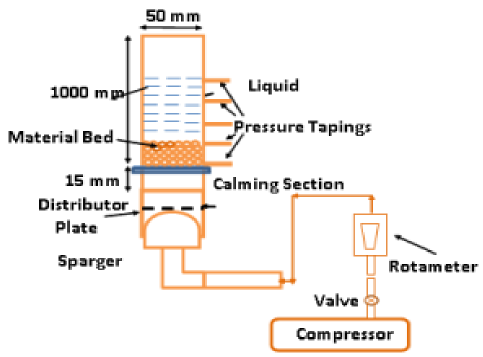

Fig.1: Schematic diagram of the experimental set-up

Fluidizing column or test section is a vertical cylindrical acrylic column of 100 cm height, 5cm internal diameter and 0.5 cm thickness. The fluidizing column is connected with calming and distributor section by means of flanges. The gas-liquid calming and distributor section is connected and fitted just below the fluidization column. The column is designed and fabricated for generation of the smooth swarm of bubbles. The gas phase flowed upward through this calming section of 0.1 m height and filled with 0.01 m steel balls. Air is entered into the bed through a wire screen supporting the particles. The gas inlet of 2.5 cm internal diameter is located centrally at the lower cross-sectional end and is fitted to the test section with a perforated distributor plate made of G. I. sheet of 0.1 cm thickness, 5 cm diameter having open area equal to approximately 20% of the column cross-sectional area which also supports 16 mesh stainless steel screen. A non-return valve is also fitted just below the distributor section for restricting the liquid movement in air pipeline. An air sparger of 35 mm diameter with 50 number of 0.1cm holes has been fixed below the distributor plate with a few layers the 18 mm steel balls to generate the uniformly distributed fine bubbles along the column cross-section. A double stage compressor (1-phase, 1Hp, 1440rpm) consists of a receiver which receives compressed air from the compressor. The air is entered into the column from the bottom and moves upward through a non-return valve through a control valve. A well-calibrated air rotameter is used for measuring the flow rate of air. The compressed air first enters from the bottom into the rotameter and then comes into the test section filled with liquid for fluidizing the solid material. The range of the air-rotameter which is used during the experimentation is of 0-100 lpm. The measurements have been made for pressure drop across the bed, the height of the solid bed and height for different air flow rates. The experimental set-up and process have been standardized by applying gauge theory [7].

3.1 Range of operating parameters

For analyzing the effect of variation in particle sizes on the column pressure drop the experiments have been performed in the following range

Table 1. Table for range of operating parameters

Sr.	Parameter	Range
01	Particle size of solids	2,4 and 6mm size
02	Liquids selected	Water, Kerosene, Turpentine
03	Solid selected	Coal
04	Liquid height in column	40 cm
05	Fixed bed height	10, 20 and 30 cm
06	Flow rate	7.5,15 and 30 lpm

4. Results and discussions

Experiments have been performed for measuring the effect of particle size variation on the column pressure drop. The liquid has been taken in column up to the height of 40 cm. The fixed bed height chosen for experimentations are 10, 20 and 30 cm which are less than the height of stationary liquid present in the pool. So the solids have been fluidized such that the fluidized bed height is less than the liquid height. The particles have been crushed and then categorized in three different average sizes as 2,4 and 6mm by doing the sieve analysis. The column pressure drop has been measured by manometer for three different flow rates. The data produced have been analyzed for following combinations

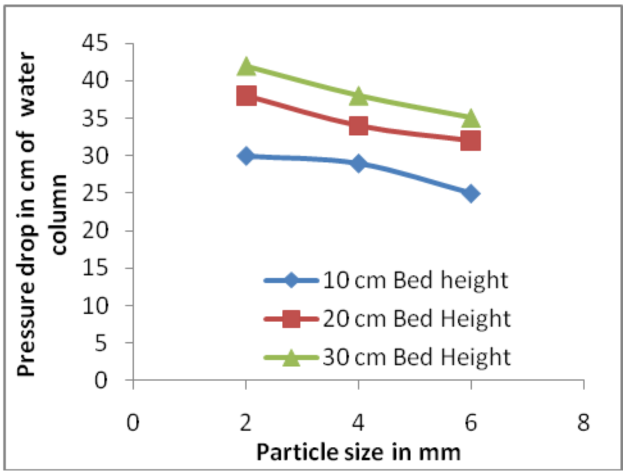

Figure 2. Effect of variation in particle sizes on pressure drop for coal in water at 7.5 lpm for different solid heights

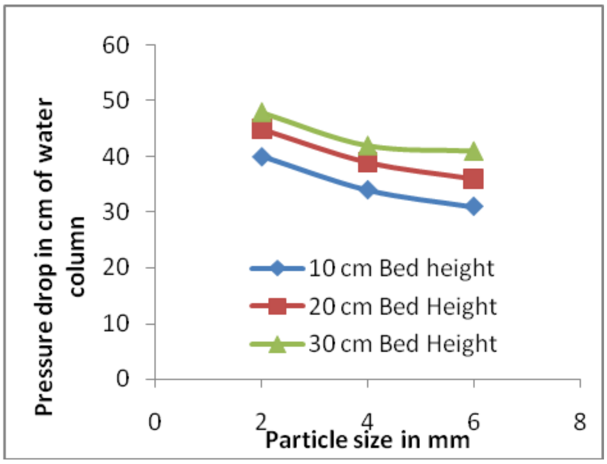

Figure 3. Effect of variation in particle sizes on pressure drop for coal in kerosene at 7.5 lpm for different solid heights

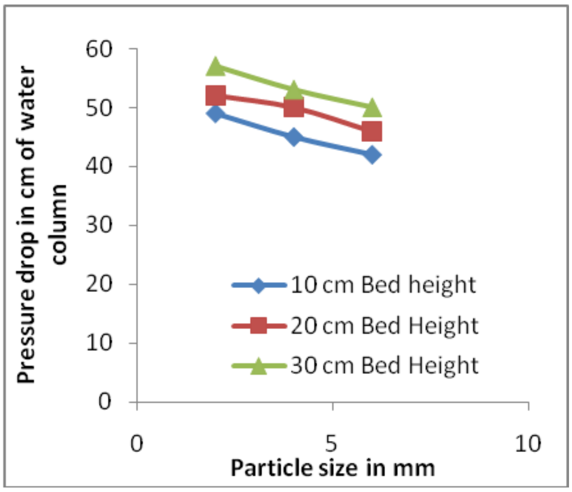

Figure 4. Effect of variation in particle sizes on pressure drop for coal in turpentine at 7.5 lpm for different solid heights

5. CONCLUSION

The effect of variation in particle size on pressure drop during gas fluidization of solids in the stationary pool of liquid has been studied. The trend of the plot indicates that pressure drop across the bed decreases for increasing particle sizefor the same air flow rate. However, it increases with increasing bed height. The experimentations have also been performed at 15 lpm and 30 lpmflowrates. For higher flow rates the column pressure drop increases but the nature of plot for increasing particle size remains same as declined trend. So it can be concluded that for at constant gas flow rates, column pressure drop decreases with increasing particle sizes present in the bed which is due to the more voidage and passages available for increasing particles size. Further, the packed bed density also decreases with increase in particle size which ultimately reduces the loading during fluidized state which causes a decrease in the pressure drop with increase in particle size.

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