Research Paper Engineering

Studies on Pressure Drop and Gas Holdup in Co-Current three Phase Fluidized Beds

P.Sreedhar Research Scholar,Dept of Chemical Engineering,S.V.U.C.E,S.V.University,Tirupati

Dr.P.Akhila Swathantra Assistant Professor, Dept of Chemical Engineering, S.V.U.C.E, S.V.University, Tirupati

C.Bharadwaj Kumar Research Scholar, Dept of Chemical Engineering, S.V.U.C.E, S.V.University, Tirupati

ABSTRACT

The study of hydrodynamic plays an important role in the economical design and operation of a three phase fluidization bed. The present work is an experimental investigation on the hydrodynamic behavior of a co-current three phase fluidized bed with liquid as a continuation phase in a 50mm id Perspex column with three different particle sizes of glass beads and rascing rings . Based on the experimental work, the effect of fluid rates on the various parameters such as pressure drop, gas hold ups were studied and the observed data was reported.

KEYWORDS Hydrodynamics, fluidized bed design, pressure drop, gas holdups.

INTRODUCTION

The three phase fluidized bed is a device in which the gas phase moves in the form of bubbles relative to the liquid phase and eventually reactive solid is fluidized in the liquid phase. The commercial application of three phase fluidization systems are in heavy oil, synthetic crude processing, coal liquefaction in the presence of catalyst, biological waste water treatment and fermentation .The hydrodynamic behavior of gas-liquid-solid fluidized bed is a complex subject and one of the most important for basic understanding of certain refinery and petrochemical industrial applications.

Gas-liquid fluidization is defined as an operation in which bed of solid particles are suspended in gas and liquid, which is due to the net drag force of the gas and or liquid flowing opposite to the gravitational force or the buoyancy forces on the particles. If gas is introduced in liquid-solid fluidized bed, it is possible to disperse the gas in the form of small bubbles and there by obtain a good contact between the gas, the liquid and the solids. It is called as Three phase or Gas-Liquid-Solid fluidized beds. An interesting phenomenon, in three-phase fluidization is the expansion or contraction of bed, due to the introduction of gas in the bottom of a bed of solids fluidized by a liquid at a constant liquid flow rate.

The successful design and operation of gas-liquid fluidization bed systems depends on the ability to accurately predict the fundamental characteristics of the system. Knowledge of minimum fluidization velocity is essential for the successful operation of three phase fluidized beds.

The experiments were conducted with water as continuous phase, air as dispersed phase and Glass beads and Rasching rings of different sizes were used as solid phase. In this presentation the effect of fluid rates on the various parameters such as pressure drop, gas hold ups were studied and the observed data was reported.

2.0 EXPERIMENTAL STUDIES

2.1Experimental Setup:

The experimental setup comprises three portions, one main column, second liquid flow system and third air flow system. The main column comprises an entering section through which both liquid and gas enter through separate paths. The entering section is followed by calming section filled with 1cm diameter marbles in order to provide uniform distribution of liquid and air. Both liquid and gas enters the calming section and flow through a strenuous path and enter into a test column. A distributor plate with 1mm holes arranged in triangular pitch is placed between the flanges connecting calming section and test section .Total column is constructed with copper except test column. Test column is the main soul of the experiment made up of Perspex and having an inner diameter of 5cm,6mm thickness and 70 cm long. Below and above the test section two “on-off” valves are provided for sudden closure to facilitate the holdup measurements. Above the test section there is a fluid disengaging section. From the top of the column a long pipe is connected normally leading the outgoing fluid into a circulation tank.

2.2 Experimental Procedure:

The experiment was conducted using three different sizes of glass bead particles 4mm, 5mm and 6mm and Rascing rings of 3.6mm,2.1mm& 50% both the sizes respectively with liquid as a continuous phase. Two sets of operating conditions were used. One by maintaining the gas phase flow rates constant and the other by keeping the liquid flow rates as constant. The height of the expanded bed was noted, when the steady state conditions were attained. The pressure drop across the fluidized bed was noted using the manometric method. The liquid holdup and gas holdup can be calculated by measuring the gas-liquid and liquid fluidized bed heights.

3.0 RESULTS AND DISCUSSIONS

The pressure drop, gas holdup and liquid holdup were calculated using the experimental data.

3.1. Pressure Drop: From the fig.2,3,4,5,6,7.,it can be inferred that as the air velocities are increased the pressure drop in the liquid side decreased. At higher air velocities the minimum fluidization is occurring at lower pressure drop. This is observed in case of all size of particles of the same material and also different density particles. The phenomenon of slugging is clearly observed at high gas velocities. The increase in liquid velocity results in continuous rise in pressure drop till complete fluidization has taken place.

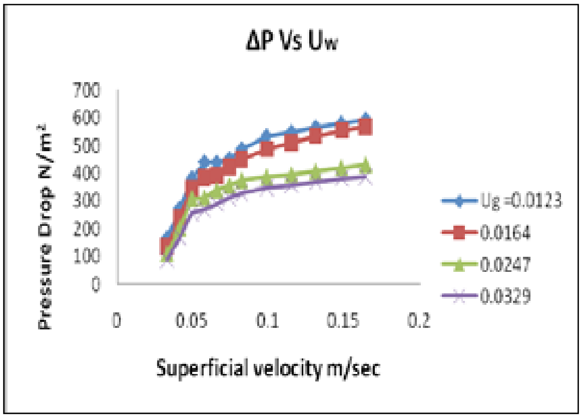

Fig.1.Effect of gas velocity on pressure drop(6 mm Glass Beads)

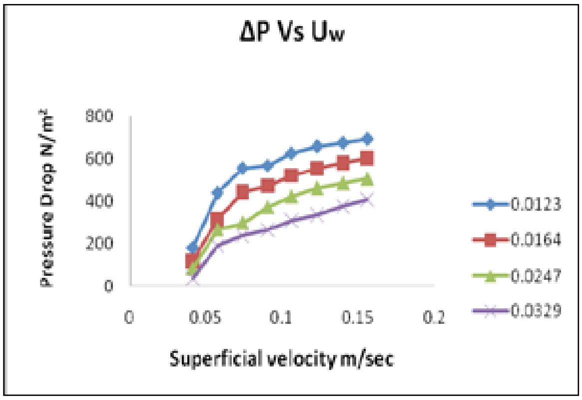

Fig.2.Effect of gas velocity on pressure drop(5 mm Glass Beads)

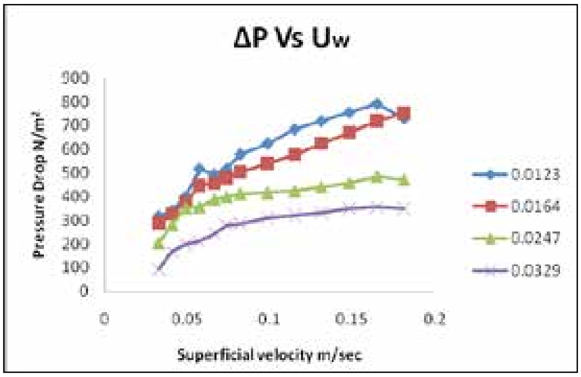

Fig.3.Effect of gas velocity on pressure drop(4 mm Glass Beads)

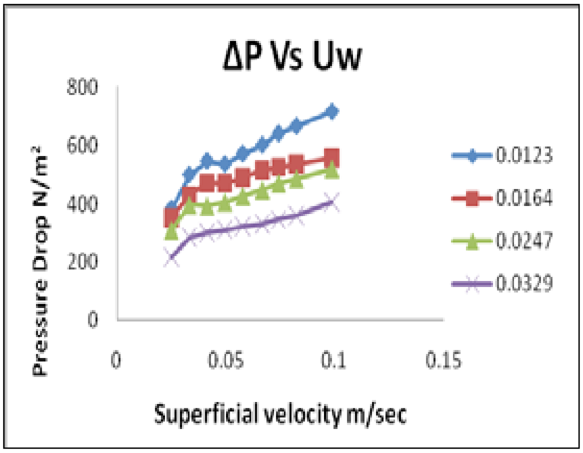

Fig.4.Effect of gas velocity on pressure drop(3.6 mm Rasching Rings)

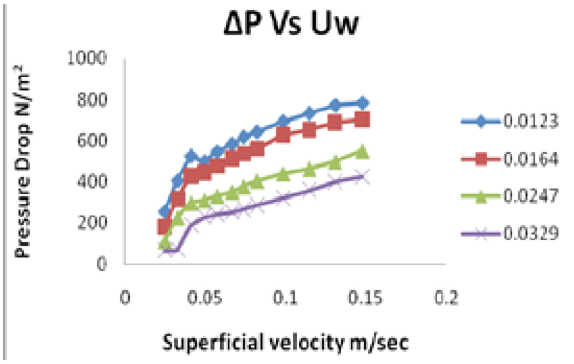

Fig.5.Effect of gas velocity on pressure drop(2.1 mm Rasching Rings)

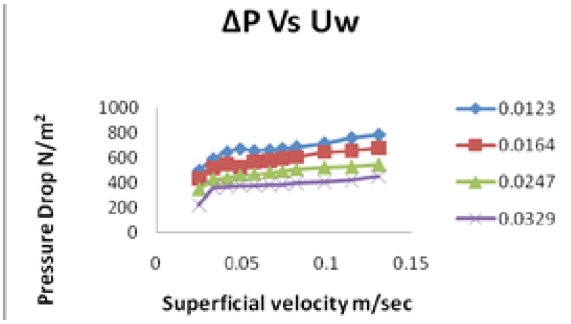

Fig.6.Effect of gas velocity on pressure drop (50% both 3.6 and 2.1mm Rasching Rings)

3.2.**Gas holdup**: From the fig 7,8 and 9,for beds of particle size say glass beads 4,5 and 6 mm and for rasching rings of size 2.1 ,3.6 mm the gas holdup increases with increasing superficial gas velocity and decreases with increasing superficial liquid velocity. The holdup was very high in low liquid flow rates and high gas rates, the influence of liquid velocity was more on gas holdup.

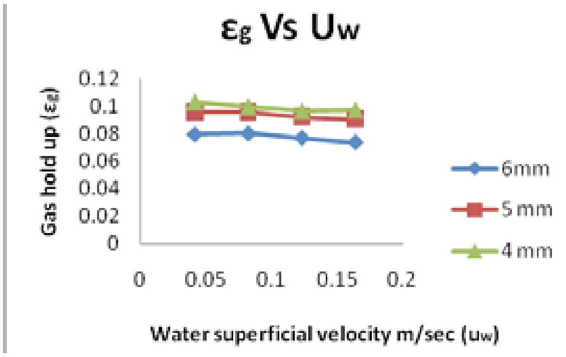

Fig.7.Effect of Liquid velocity on Gas Holdup (Glass Beads,U_g=0.0123m/s)

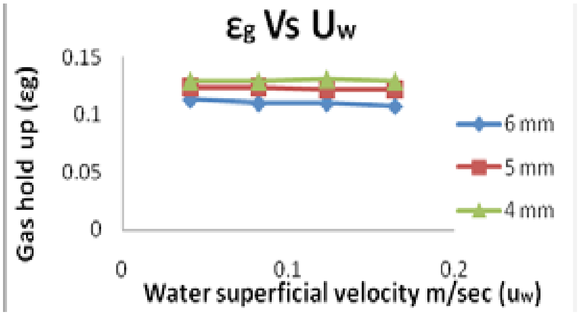

Fig.8.Effect of Liquid velocity on Gas Holdup (Glass Beads,U_g =0.0164m/s)

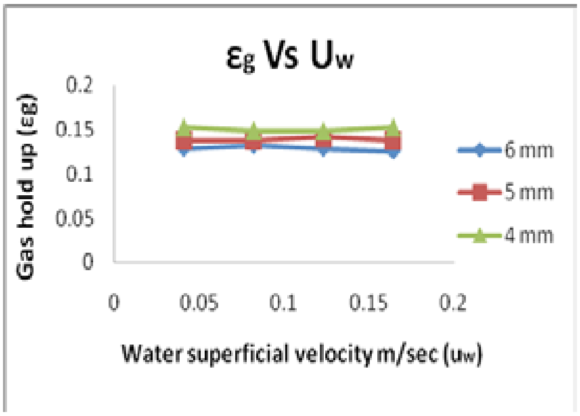

Fig.9.Effect of Liquid velocity on Gas Holdup (Glass Beads,U_g =0.0247m/s)

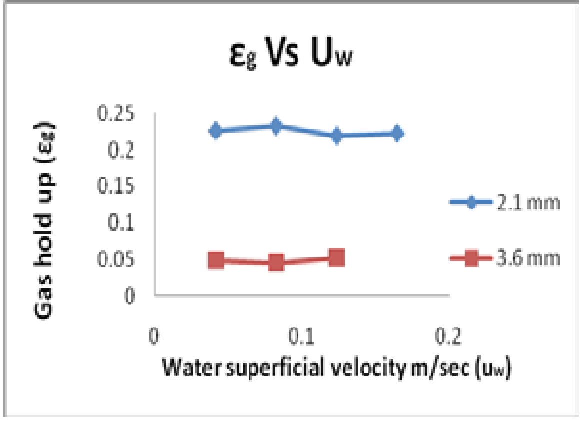

Fig.10.Effect of Liquid velocity on Gas Holdup (Rasching Rings,U_g =0.0123m/s)

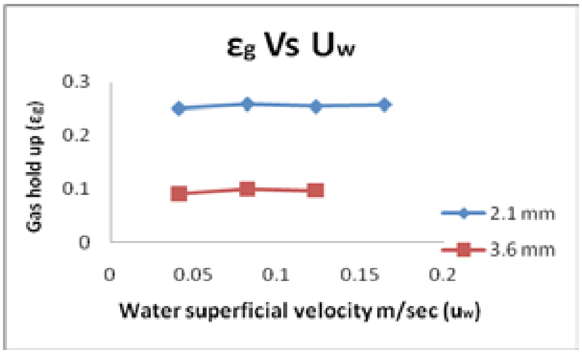

Fig.7.Effect of Liquid velocity on Gas Holdup (Rasching Rings,U_g =0.0164m/s)

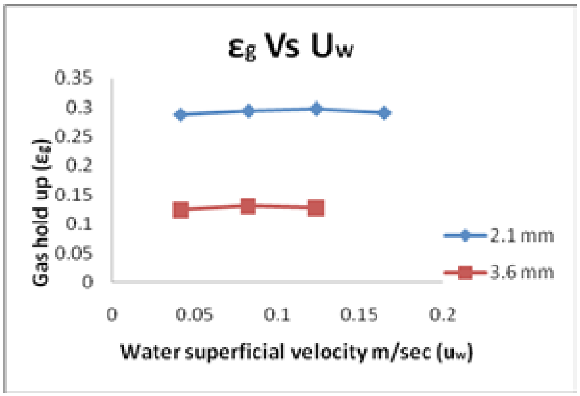

Fig.7.Effect of Liquid velocity on Gas Holdup (Rasching Rings,U_g =0.0247m/s)

4.0. CONCLUSION:

As the air velocities are increased the pressure drop and also the minimum fluidization velocity are observed to be decreasing. The same behavior is observed when the sizes of the particles are changed and particles considered are different. The pressure drops are higher for finer particles compared with coarser particles and the minimum fluidization occurred at higher superficial liquid velocities for large sized particles. The Gas Holdup is independent of liquid velocity. The Gas holdup is observed to be increasing with increase in the gas velocity and decrease with increase in particle size.

References:-

1. Dakshinamurthy.P, Veerabhadra Rao.K, and Venkata Rao.A.B, "Bed Porosities in Three Phase (Liquid-Liquid) fluidized beds",Ind.Eng.Chem. Processes.Dev.,Vol.18,No.4,1979.
2. Epstein.N,' Three Phase Fluidization: Some Knowledge Gaps Canad. J.Chem.Eng.59,p.649 (1981).
3. Lee.S.L.P. 'Three Phase Fluidized beds'-AICHE journal Vol.33,No.8,Aug1987.
4. Briens L.A,Briens.C.L,Margaritis.A, and Hay.J 'Minimum Liquid Fluidization Velocity in Gas-Liquid-Solid Fluidized Beds',AICHE Journal,Vol.43,No.5,May 1997.
5. Murthy.J.S.N,Ravi Kumar.M,Mohiuddin.M,Patnaik.K.S.K.R, 'Studies on Fluidization of Binary mixures of powders',IE(I) Journal –CH,Vol 80,March 2000.
6. Gas-Liquid-Solid fluidization Engineering by Liang-Shih Fan,Butter Worth Publishers,a division of Reed Publishing (USA,inc),80 Montvale Avenue,Stoneham,MA02180.