Studies on Hydrodynamics of Food Grains in a Circulating Fluidized Bed

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ABSTRACT

Circulating Fluidized Beds are currently used in many industries for drying, catalytic and non-catalytic reactions and other applications. The circulating fluidized bed consists of a riser in which a gas-solid suspension is transported upward. The two-phase mixture is separated at the top of the riser and solids are recycled to the bottom via a stand-pipe. Hydrodynamics plays an important role in defining the performance of circulating fluidized bed as a reactor. Hence, the present work focus to study the hydrodynamic characteristics of food grains in the riser of the circulating fluidized bed covering a wide range of operating parameters. The column was made of plexi glass with 1.6m in height and 0.05m in diameter. The effects of operating conditions on axial distributions of solids holdup and particle velocity has been studied.

Keywords : Circulating Fluidized Bed, Food Grains, Hydrodynamics, Solids holdup.

1 INTRODUCTION :

Fluidization is a process in which a granular material is converted into fluid-like state. This process occurs when a fluid (liquid or gas) is passed up through the granular material. This method of contacting has a number of unusual characteristics and fluidization engineering is concerned with its effort to take advantage of this behaviour and put into various industrial uses. The characterization of diverse flow regimes in gas-solid fluidization based on transition velocities and pressure fluctuations are explained in the following literatures [1],[2],[6] and [7].

Because of their many advantages, such as being a constant process together with high throughput of gas and solids and the ease of solids handling, circulating fluidized bed reactors have been widely employed in commercial industry applications, covering chemical, petrochemical, metallurgical, pharmaceutical and energy related industries. In the circulating fluidized bed reactor , the riser is the part that the reaction normally occurs. Considering this section, the suitable geometric design can greatly improve the reaction characteristics. There are many research groups focussing on designing the riser section. The core-annulus structure was changed due to exit bended angle[8] and if the riser is separated into stages it could reduce back-mixing of gas and particles in the system. A more capable design for CFB reactors requires a quantitative understanding of the complex hydrodynamics in CFB reactors. There are various works which focus on the studies on hydrodynamics were explained in the following literatures [3], [5] and [11].

2.MATERIALS AND METHODS :

Experimental Description :

The column consists of a riser made of 50mm internal diameter and 1600mm height. Six pressure tapings and six temperature tapings are located at the riser column of 500mm, 700mm, 900mm, 1100mm, 1300mm and 1500mm from the riser bottom respectively. The solids enters into the riser at controlled flow rate from the hopper. The solids and gas are separated in a gas-solid separator at the top of the riser. Air enters through distributor plate of 0.8mm diameter at the bottom of the riser. Poppy seed particles of mean diameter 0.425mm and density 558.3kg/m^3 were used.

3.RESULTS AND DISCUSSIONS :

3.1 Determination of transport velocity:

The transport velocity is determined by emptying time technique, used in [4] and [5], which determines the time required for all the solid particles to leave the bed as a function of superficial gas velocity. It has been observed from Fig 1 that the time required for emptying of solid particles decreases with increase in velocity. As the velocity increases the bed could be emptied in a short period of time. The transport velocity is determined by drawing two lines having different slopes at lower and higher Utr. The intersection of these two lines gives transport velocity and it is found to be 5.385m/s for poppy seeds of diameter 0.425mm.

Axial Variation of Pressure with Gas Flow Rate :

The axial variation of pressure drop with different gas flow rate is shown in Fig 2. It has been seen from the figure that a typical variation of the pressure drop along the length of the riser decreases. Since air is passed at the bottom of the riser, the pressure drop is more at the lower part of the riser, while the pressure drop is less at the upper part of the riser. Also, the pressure drop increases with gas flow rate along the length of the riser.

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Axial Variation of Pressure Drop with Solid Circulation Rate:

The lower part of the riser is the region of higher holdup with high solids concentration while the upper part of the riser is the region of lower holdup with low solids concentration. The axial variation of pressure drop with different solid circulation rate is shown in Fig 3. The initial portion corresponding to the lower portion of the riser is the region of higher solids holdup and the final portion, corresponding to the upper portion of the riser is the region of lower solids holdup. It has been observed that to reduce the homogeneity in solids concentration along the riser length, horizontal perforated plates were placed in the riser.

Axial Variation of Pressure Drop with Gas Flow Rate and Solid Circulation Rate:

The axial variation of pressure with solid circulation rate and gas flow rate is shown in Fig 4. The pressure drop is high at high solids circulation rate and decreases with decrease in solid circulation rate. At high solids circulation rate, the pressure drop is high and reaches an asymptotic value. Also, the pressure drop decreases with increase in gas flow rate.

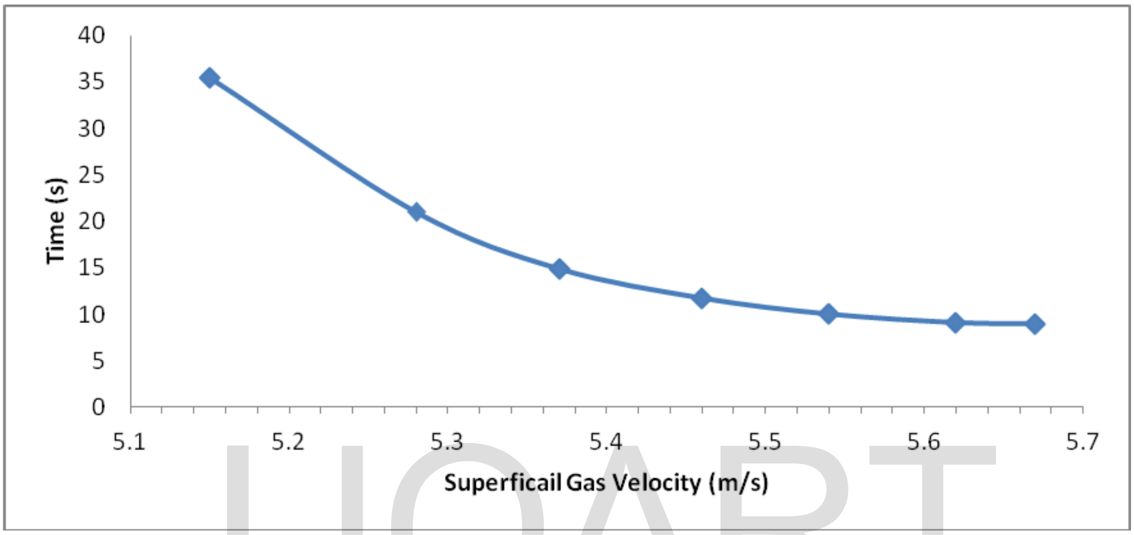

Fig 1 : Determination of Transport Velocity by Emptying Time Technique

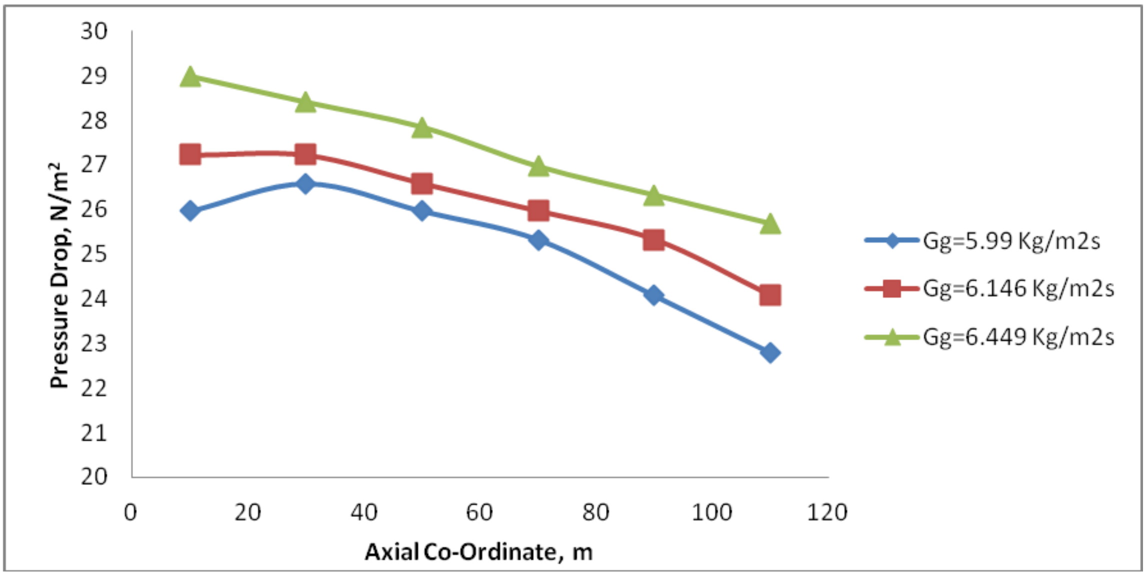

Fig 2 : Axial Variation of Pressure with Gas Flow Rate

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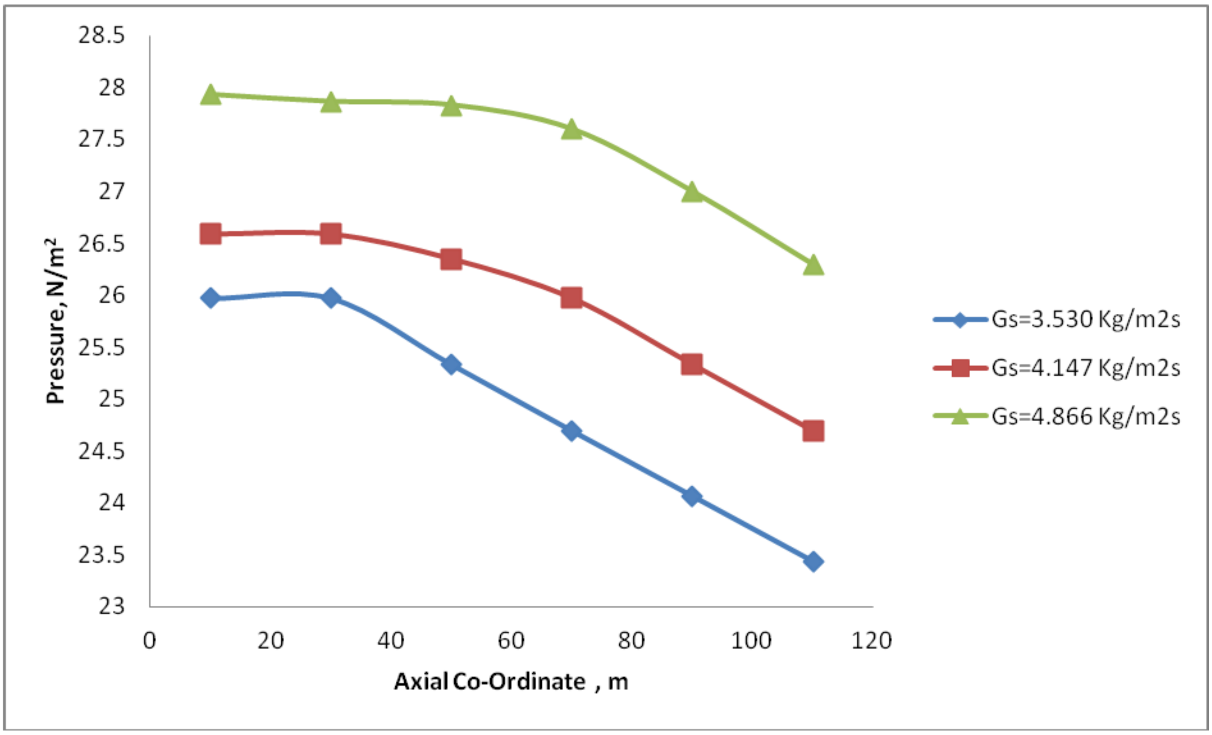

Fig 3 : Axial Variation of Pressure with Solids Circulation Rate

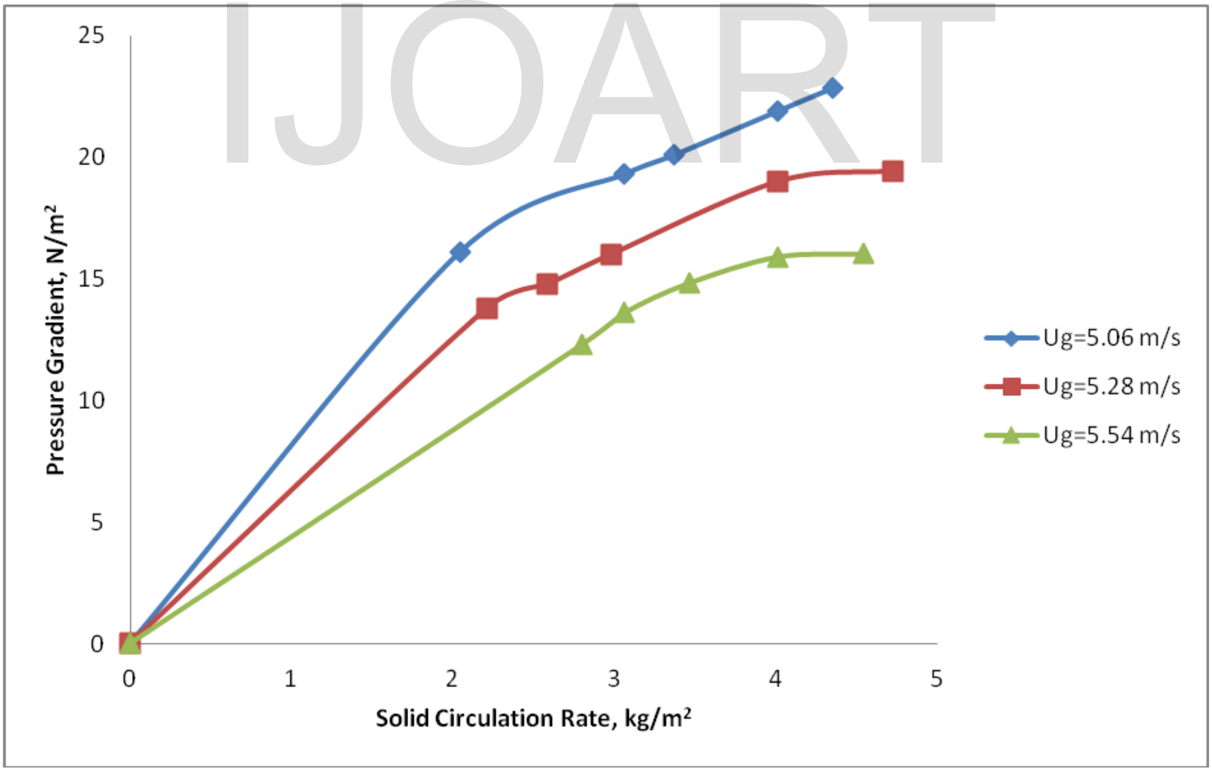

Fig 4 : Axial Variation of Pressure with Solid Circulation Rate and Gas Flow Rate

CONCLUSIONS :

The solid particles could be emptied in a short period of time with increase in gas velocity. The pressure drop is high at the lower part of the riser, which is the region of higher solids holdup and the pressure drop is low at the upper part of the riser, which is the region of lower solids holdup. The pressure increases with increase in gas flow rate and solid circulation rate.

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