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Recent Advances in Chemical Engineering

Studies on Design of Bio Semi Fluidized Bed Reactor

K.Kalaivani[1] & K.Saravanan[1]*

[1*]Department of Chemical Engineering, Kongu Engineering College, Perundurai- 638 052, Erode, Tamil Nadu.

***Corres.author: kalai95@gmail.com**

Abstract: Mixing is an important unit operation encountered in chemical and allied industries. Mixing can be achieved by many ways. One such way is fluidized bed. The efficiency of conventional fluidized bed is enhanced by semi- fluidized bed reactor. It is a novel type of fluid-solid contacting device. The semi fluidized bed is characterized by a fluidized bed and a fixed bed in series with single contacting vessel. Any improvement in the fluidized section of semi fluidized bed will increase overall efficiency of semi fluidized bed. This can be achieved by employing stirrer/mixing elements in fluidized section of semi fluid bed reactor. To design the semi fluidized bed as a reactor the knowledge of hydrodynamics, mass transfer, suspension characteristics and Residence time should be known. For this purpose, experiment was conducted in 0.1m internal diameter semi fluidized bed. Hydrodynamic behavior was studied and finally a correlation for pressure friction factor was derived based on the experimental results.
Keywords: Semi fluidized bed, Mixing, Hydrodynamics and Residence Time.

1. Introduction

Recent literature revels, 80 % losses in Chemical, Biochemical and allied industries is due to improper mixing. Mixing can be achieved by many ways. One such way is fluidized bed. The efficiency of conventional fluidized bed is enhanced by semi- fluidized bed reactor. It is a novel type of fluid-solid contacting device. The semi fluidized bed is characterized by a fluidized bed and a fixed bed in series with single contacting vessel.

The phenomenon of semi fluidization was first reported which was related to mass to mass transfer in a liquid solid system[1,3]. A semi fluidized bed is formed when a mass of fluidized particles is compressed by fluids with a porous retaining grid at the top. Fixed bed or packed bed, batch and continuous fluidization and semi fluidization all are two phase phenomena. In case of batch fluidization if the free expansion of the bed is restricted by the introduction of porous disc or sieve and the fluid velocity is increased the particles are fluidized and the expansion starts with further increase in velocity of fluid the particles will be carried and formation of a fluid bed results at the top. So by the introduction of restraint some of the particles are distributed to the bottom section which is in the form of a packed bed[2]. This is known as semi fluidization which can be considered as a new type of solid fluid contacting method which combines features of both fixed and fluidized beds.

Semi fluidization is a new and unique type of fluid-solid contacting technique which has been reported recently[4]. This type of technique overcomes the disadvantages of fluidized bed namely back mixing of solids, attrition of solids and problems involving erosion of surfaces.

This also overcomes certain drawbacks of packed bed, viz. non-uniformity in temperature in the bed, channel flow and segregation of solids. An extensive review relating to various aspects of hydrodynamics, heat and mass transfer and special features of semi fluidized bed reactor has been given by Murthy and Roy[5].

Any improvement in the fluidized section of semi fluidized bed will increase overall efficiency of semi fluidized bed. This can be achieved by employing stirrer/mixing elements in fluidized section of semi fluid bed reactor. In the present work, an attempt was made to study the hydrodynamic characteristics of semi fluidized bed with internals. For this purpose, tap water and quartz were used as solid and liquid phases respectively. Kenics mixing element is employed as a mixing element.

2. Experimental setup

Semi Fluidized bed is constructed in a single contacting vessel with the arrestor and Internals which is shown in figure 1. It is connected to the overhead tank, to the sump and pump. The pressure drop is measured using U-tube manometer. The particle used is quartz and size varying from 0.0114 cm to 0.0324 cm. The height of fluidized bed and packed bed were altered using movable arrestor.

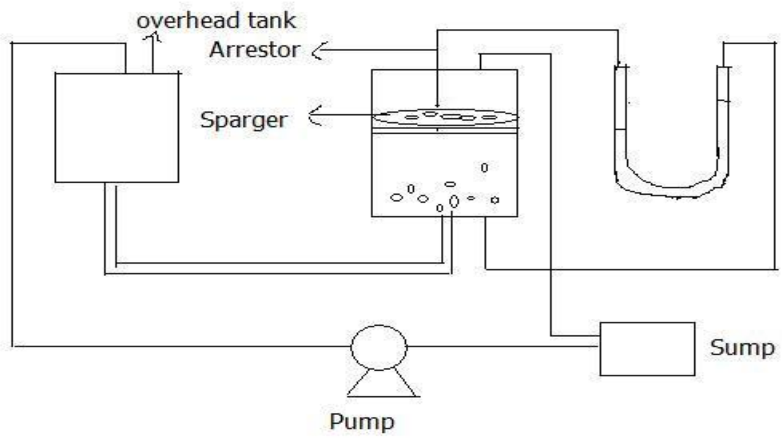

Figure 1: Semi Fluidized Bed Reactor- Experimental Set up

3. Results and Discussion

The Experiments were conducted by varying the flow rate of water from 40cc/min to 400 cc/min, particle size from 0.0114 cm to 0.0324 cm and arrestor position from 16.5 cm to 29.5 cm. For a given flow rate of water, keeping particle diameter, quartz as particles and arrestor keeping constant, pressure drop across the entire bed was measured using U-tube filled manometer.

3.1 Effect of Particle Diameter

The effect of particle diameter was studied for bare tube and with internals. From the graph it can be seen that the friction factor increases with increase in particle diameter. This may be due to increase in particle settling velocity which is more for higher particle diameter. The friction between the bare tube and twists internals is almost 12%.

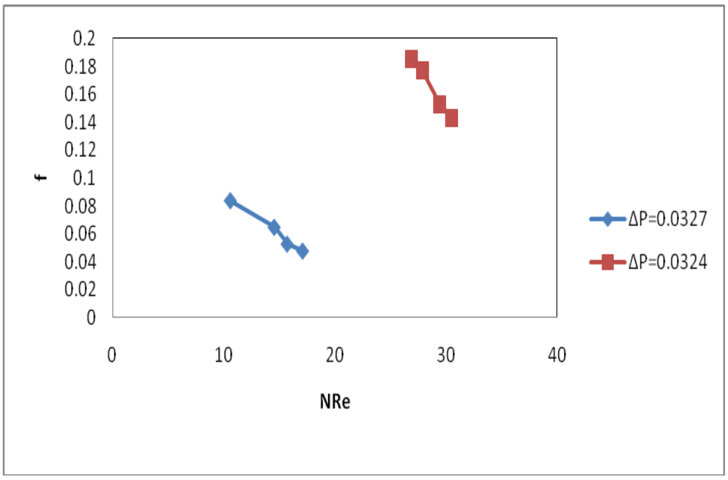

Figure 2: Effect of Particle diameter

3.2 Effect of friction factor on twist ratio

The effect of friction factor for different twist ratio of kenics element was studied. The result is shown in figure 3. From the figure it can be seen that the increase in friction factor a given Reynolds number for different twist ratio were obtained and percentage increase is 3.9%

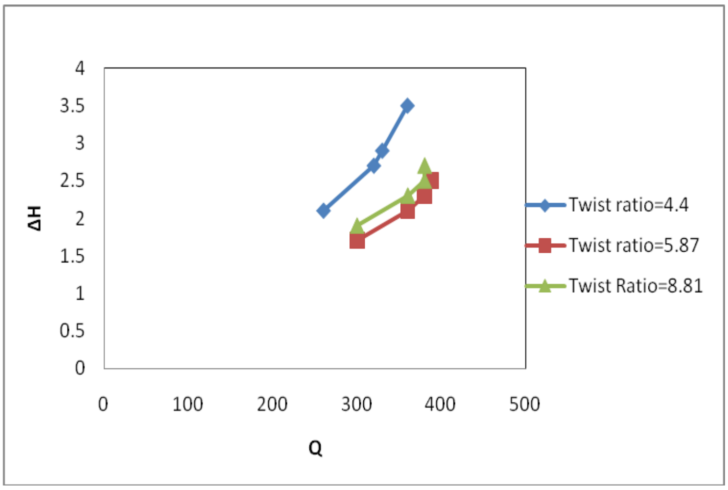

Figure 3: Effect of Twist ratio

3.3 Effect of Arrestor Position

The effect of arrestor position was studied. The experiment result is shown in figure 4. From the figure it can be seen that formation of packed bed decreases with decrease in arrestor position. The formation of packing in the semi fluidized bed increases with increase in arrestor position. Based on the experiment result, and attempt was made to derive a correlation for friction factor.

A correlation of type $f_p = m\ NRe^{a}\ (tr)^{b}$ was used for this purpose.

$f_p=(0.059)\ (NRe)^{-0.08(tr)^{\wedge}(0.874)}\ tr^{(-0.0810)}$

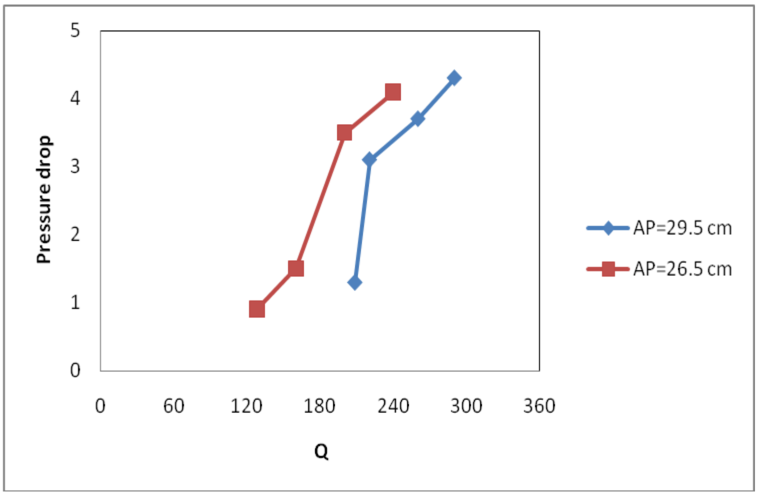

Figure 4: Effect of Arrestor Position

4. Conclusion

The efficiency of Semi Fluidized bed column was enhanced by using internals. The friction factor increases with increase in particle diameter. The increases in friction factor for a given Reynolds number for different twist ratio were obtained and percentage increase is 3.9%. The formation of packing in the semi fluidized bed increases with increase in arrestor position.

5. References

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