STUDY THE FRICTIONAL PRESSURE DROP IN FLUDIZED BED

Upasana Prajapati[1], Pranay Boradhara[2], Bhaumil Patel[3], Endrick Contractor[4]

[1,2,3] student, Chemical Engineering, Department of Chemical Engineering,
Shroff S R Rotary Institute of Chemical Technology. Ankleswar-Valia Road At & Post-Vataria
[4] Assistant Professor, Department of Chemical Engineering,
Shroff S R Rotary Institute of Chemical Technology. Ankleswar-Valia Road At & Post-Vataria

ABSTRACT

A fluidized bed is a packed bed through which fluid flows at such a high velocity that the bed is loosened and the particle-fluid mixture behaves as though it is a fluid. There have been widespread applications of fluidized beds in industries which are related to the combination of liquid-solid particles during the last decade. High capacity of fluidized bed in heat and mass transfer has made this device very popular. So in order to decrease Pressure drop, we can change various parameters like diameter of the column, length of the column (L), fluidizing medium, packing used, void fraction (ε). In our experiment, the use lab scale fluidized bed as modeled using glass as the solid packing and liquid as the high velocity fluid. Types of packing materials were used to effect the range of Reynolds number and subsequent pressure drop. From experiments it is found that there is a significant relationship between pressure, frictional factor and Reynolds number with respect to flow rate and pressure so we perform this experiment by changing above parameters and packing to decrease the pressure drop and pumping cost there by optimize the operating cost. The calculated pressure drop across a packed bed is compared with theoretical values calculated by Ergun's equation.

Keyword: - *Fluidization; Frictional pressure drop; Void fraction; Porosity; Ergun's equation.*

---

1. Introduction

If a fluid is passes downwards through bed of solids, no relative movement between the particles takes place, unless the initial orientation is unstable. If the flow is streamline, the pressure drop across the bed will be directly proportional to the rate of flow, but at higher rates will rise more rapidly.

If the fluid passes upwards through the bed, the pressure drop will be the same as those for downward flow at low rates, but when the frictional drag on the particles becomes equal to their apparent weight (actual weight less buoyancy), the particles become rearranged so that they offer less resistance to the flow of fluid and the bed starts to expand. This process continues as the velocity is increased, with the total frictional force remaining equal to the weight of the particles, until the bed has assumed the loosest stable form of packing. If the velocity is then increased still further, the individual particles separate from one another and become freely supported in the fluid and the bed is said to be ***fluidized.*** Further increase in the velocity causes the particles to separate still further from one another, and the pressure difference remains approximately equal to the weight per unit area of the bed.

1.1 System Behavior

Up to this stage the system behaves in a similar way whether the fluid is a liquid or gas, but at high fluid velocities, when the expansion of the bed is large, there is a fairly sharp distinction between the behaviors in the two cases. With a liquid, the bed continues to expand as the velocity is increased and it maintains its uniform character, with the amount of agitation of the particles increasing progressively. This type of fluidization is known as ***particulate fluidization***. With a gas, however, uniform fluidization is frequently obtained only at low velocities. At high velocities two separate phases may form; a continuous phase which is often referred to as the *dense* or *emulsion* phase, and a discontinuous phase known as the *lean* or *bubble* phase. The fluidization is then said to be ***aggregative***. Gas bubbles pass through a high-density fluidized bed with the result that the system closely resembles a boiling liquid, with the lean phase corresponding to the vapor and the dense or continuous phase to the liquid. The bed is then often referred to as a boiling bed, as opposed to a quiescent bed at low flow rates.

Thus, as the flow of the gas is increased, its velocity relative to the particles in the dense phase may not change appreciably, and it has been shown that the flow relative to the particles can still remain streamline even at very high overall rates of flow. If the rate of passage of gas is high, and if the bed is deep, coalescence of the bubbles takes place and in a narrow vessel slugs of gas occupying the whole cross-section may be produced. These slugs of gas alternate with slugs of fluidized solids which are carried upwards and subsequently collapse, causing the solids to fall back again.

1.2 Equations

The rate of momentum transfer from the fluid to the solid particles and therefore, the pressure drop for flow through the bed are related to the physical mechanism by which flow occurs. In a packed bed the flow path is made up of many parallel and interconnecting channels and flowing through these the fluid phase is repeatedly accelerated and decelerated, experiencing repeated kinetic energy losses. In addition, rough surfaces of the particles produce the usual form drag and skin friction losses. At low rates of flow through very small passages, the kinetic energy losses are small compared to the from drag losses, but for high rates of flow through large passages the kinetic energy losses may be very much greater than the form drag losses. The friction factor f, for flow through ducts is given by,

$$f = \frac{2\Delta PD}{V^2 \rho L} = \phi(\mathrm{Re}) = \phi\left(\frac{DV\rho}{\mu}\right)$$

2. Material and Methods

The experimental setup consists of a glass column of 50 mm internal diameter and 500 mm length. Pressure tapings are provided at the bottom and top of the column to measure the pressure drop. Fluidizing Medium- water is supplied with the help of 0.5 HP monoblock pump through the supply valve. Water flow rate through the column can be controlled by the bypass and supply control valve. Manometer is provided to measure the pressure drop across the column. Water is supplied by a sump tank and is collected in a collection tank. Collection tank is provided with a valve at the bottom, which remains open except for the time to measure the flow rate of water through the column, the entire setup is mounted in MS framework.

Fig -1: Fluidization Experimental setup

2.1 Materials

Rasching rings are pieces of tube, approximately equal in length and diameter, used in large numbers as a packed bed within columns for distillations and other chemical engineering processes. They are usually ceramic or metal and provide a large surface area within the volume of the column for interaction between liquid and gas or vapour. Raschig rings are named after their inventor, the German chemist Friedrich Raschig, They are also used for devices where gas and liquid are put in contact for purposes of gas absorption, stripping or chemical reaction, and as a support for biofilms in biological reactors, Rasching rings made from borosilicate glass are sometimes employed in the handling of nuclear materials, where they are used inside vessels and tanks containing solutions of fissile material,

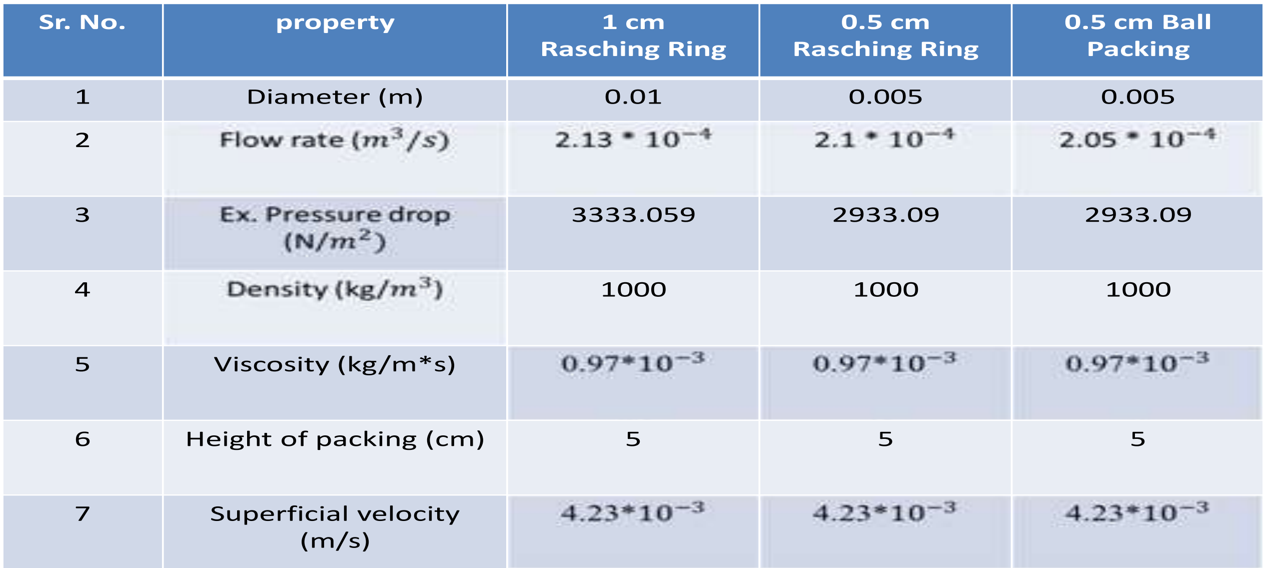
Fig -2: Rasching rings

2.2 Method

Fill the sump tank with tap water to about 80 % of its height. Check the connections of manometer manifold with the fluidization column tapings. Keep the air vent vales provided on the manometer manifold open. Drain the collection tank, if needed before switching ON the pump and keep its drain valve open till its time to collect the predetermined quantity of water in the collection tank. Keep the bypass valve provided on the pump fully open and supply valve fully closed. Switch on the pump and slowly open the supply valve, allowing water to enter in to the column till the manometer reading is observed. After the water starts flowing out of the air vent valves, provided on the manometer manifold close them. Close the drain valve of the collection tank and collect predetermined quantity of water in the collection tank. Note down the time required for the same. Drain the collection tank in the supply tank and increase the flow rate of water through the column by opening the supply valve and/ or closing the bypass valve. For each flow rate, record the flow rate and manometer readings and make a visual observation of the bed. Stop increasing the flow rate of water when the bed is fully fluidized.

3. Result

Data and observation of Equipment parameters as well as Materials:



Sr. No.	property	1 cm Rasching Ring	0.5 cm Rasching Ring	0.5 cm Ball Packing
1	Diameter (m)	0.01	0.005	0.005
2	Flow rate (m^3/s)	$2.13 * 10^{-4}$	$2.1 * 10^{-4}$	$2.05 * 10^{-4}$
3	Ex. Pressure drop (N/m^2)	3333.059	2933.09	2933.09
4	Density (kg/m^3)	1000	1000	1000
5	Viscosity (kg/m*s)	$0.97*10^{-3}$	$0.97*10^{-3}$	$0.97*10^{-3}$
6	Height of packing (cm)	5	5	5
7	Superficial velocity (m/s)	$4.23*10^{-3}$	$4.23*10^{-3}$	$4.23*10^{-3}$

Table-1: Data and Observation

3.1 Theoretically

We can find theoretical pressure drop by ergun equation which is combine form for laminar and turbulent form to find pressure drop by following equation**.**

$$\frac{\Delta P}{L} = \frac{150 * V_S * \mu * (1-\epsilon)^2}{{\emptyset_S}^2 * {D_P}^2 * \in^3} + \frac{1.75 * \rho * {V_S}^2 * (1-\epsilon)}{\emptyset_S * D_P * \in^3}$$

Materials	Pressure drop (N/ m^2)
Ball material	2933.09
1.1cm Rasching ring	2933.09
0.5cm Rasching ring	3333.059

Table-2: Theoretical Data

3.2 Experimentally

We can find the pressure drop by Manometer in experimental setup for Minimum Fluidized and Fully Fluidized condition for various pickings.

Materials	Pressure drop (N/ m^2)
Ball material	2933.09
1.1cm Rasching ring	2933.09
0.5cm Rasching ring	3333.059

Table-3: Practical Data

3.3 Comparison of Minimum and Fully Fluidized condition:

Packing Material	Practically Pressure Drop (N/m^2)	Theoretically Pressure Drop (N/m^2)
1) Ball packing 0.005 m		
a. Minimum fluidized	2666.44	2757.96
b. Fully fluidized	2933.09	3005.54
2) Rasching Ring 0.005 m		
a. Minimum fluidized	2399.8	2501.9
b. Fully fluidized	2933.09	3005.54
3) Rasching ring 0.01 m		
a. Minimum fluidized	2799.76	2915.05
b. Fully fluidized	3333.059	3466.87

Table-4: Comparison between Minimum Vs. Fully Fluidized condition

4. CONCLUSIONS

We observed and studied the behavior of a solid bed during fluidization and found friction factor from pressure drop and volumetric flow rate data which is obtained from experiment and compare it with the theoretical data of friction factor which is obtained from Reynolds number vs. frictional factor data, we get almost same data from practical as well as theoretical calculations. We can use this pressure drop data to choosing of Best Packing Material for the fluidization process which is carried out in industry as for different perspective.

5. ACKNOWLEDGEMENT

It is great pleasure and privilege to have an opportunity to take this work entitled **"**TO FRICTION PRESSURE DROP IN FLUIDIZED BED**"**. We would like to express our deepness of gratitude to our project work guide Mr. ENDRICK CONTRACTOR (Asst. Prof. C.E Dept.**)**, for his inspiring guidance and invaluable suggestions that he had given throughout the project work. We would like to express our deep sense of gratitude to all faculty members of the department of chemical engineering. At this junction, it is appropriate to express our gratitude to the people who have been with us throughout & have helped us to successfully accomplish this work. Last but not least, we are grateful to our family & friends to provide us support & guidance mentally as well as financially to finish & submit our work successfully. Errors and deficiencies are likely to be there; therefore we apologize for the same in advance.

6. REFERENCES

[1]. G. V. Vunjak-Novakovii! And D. V. Vukovi, H. Littman Hydrodynamics of Turbulent Bed Contactors. 2. Pressure Drop, Bed Expansion, and Minimum Fluidizing Velocity

[2]. Jena, H.M, Roy, G.K., & Meikaap B.C. (2009). Hydrodynamics of a solid-liquid-gas fluidized bed with hollow cylindrical particles. Chemical Engineering and Processing, 49, 278-287.

[3]. W.L. McCabe and J.C. Smith, "Unit Operations of Chemical Engineering," 3rd Edition, p. 146- 150, 159-160, McGraw-Hill, New York (1976).

[4]. R.B. Bird, W.E. Stewart, and E.N. Lightfoot, "Transport Phenomena," p. 190-194, John Wiley and Sons, New York (1960).