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Estimating the Minimum Fluidization and De-Fluidization Velocities of Geldart's Classified Powders

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ABSTRACT

This scientific research presents a study of Fluidization and De-Fluidization of different packing materials which are classified according to the Geldart's Classification in a fluidized bed reactor in order to estimate the minimum Fluidization and De-Fluidization velocities and pressure drop of different materials like sand, wheat, flour and milk powder. For this purpose experiment is carried out in a fluidized bed reactor and on the different flow rates from minimum to maximum flow rates the height of bed and pressure drop is noted for Fluidization process and from maximum to minimum flow rates height of bed and pressure drop is noted for De-Fluidization for each packing materials. To analyze our experimental data graphical method is used and the results show that the minimum Fluidization and De-Fluidization for Milk Powder is 25.2 and 25, for Sand 25.1 and 25, for Flour 20.3 and 20, and for Wheat 29 and 29.1 liter per minute respectively. The results also show that the minimum fluidization velocity and de-fluidization velocities are increases as the particle diameter and density increases. The trend of increase in velocities is given by Wheat > Milk Powder > Sand > Flour. The pressure drop also increases as the flow rate increases but after a certain limit of flow rate it becomes constant for all four groups of particles.

Key words: Fluidization and De-Fluidization Fluidized Bed Reactor, Pressure Drop in Fluidized Bed Reactor, Minimum Fluidization Velocity, and Geldart Classification.

INTRODUCTION

Fluidization is a process similar to liquefaction in which solid gets the liquid properties when they are converted from static to dynamic state by means of a gas or liquid depending upon the process [1-2] . The fluidization principle is simple and that is based upon the passing of gas or liquid upwards using a gas or liquid flow rate respectively from the bottom of the packed bed filled with a solid material it will produce a pressure drop due to drag force. When this drag forces become equal to the height of the bed the fluidization process will be start. At this stage where the process of fluidization is start the velocity is called as minimum fluidization velocity. By increasing the velocity from the minimum fluidization velocity the pressure drop increase but after a certain limit it does not increase and usually it remains equal to bed per unit area. When the gas or liquid velocity depending upon the process is increase three to five times from the minimum fluidization velocity the fluid look like a violently boiling liquid like water etc [3-4]. The behavior of gas-liquid-solid particle interaction in fluidization strongly depends upon the solid particle size as well as gas and liquid velocities. At high velocities the bed expansion is usually large and fluidization behavior depends upon the type of fluid in this case that either it is liquid or gas. In case of liquids the fluidization process is known as particulate fluidization. In case of gases uniform and sooth fluidization without any large bubbling is observed at low velocities while in case of liquids it can be observed at high velocities [5-7].

Fluidized Bed Reactors are very useful in the chemical process industries. Due to uniform operating conditions, high surface area, high conversion, high selectivity, less dead zones formation, less clogging and uniform mixing fluidized bed reactors are useful in process industries like chemical & petrochemical industry, combustion/pyrolysis operations, physical operations, advanced materials industry, pharmaceutical industry, food industry, waste water treatment and recovery of various substances [8-13]. In 1973 Geldart classified powders into four groups according to their fluidization properties at ambient conditions. The Geldart Classification of Powders is now used widely in all fields of powder technology [14-18].

Group A: These particles are Aeratable having small particle diameter (30-100 µm) and density. They have large bed expansion before bubbling is start. There minimum fluidization velocity is smaller than minimum bubbling velocity. There is a maximum bubble size. Examples: FCC, milk flour.

Group B: These particles are bubbling; their particle diameter range is (100-1000 µm). Their minimum fluidization velocities are equal as minimum bubbling velocities. Their Solids recirculation rates are smaller. There is no observable maximum bubble size. Example: sand

Group C: They particles are cohesive; due to channeling possibilities they are difficult to fluidize. The range of particle diameter is (0-30 µm). Example: flour, cement.

Group D: They particles are Spoutable. They are very large and high density particle with a particle diameter range is greater than (1000 mm). Bubbles rise more slowly than the rest of the gas percolating through the emulsion. Due to a dense phase it has low viodage. Examples: Coffee beans, wheat, lead shot.

EXPERIMENTAL SETUP

The experiment is carried out in lab in a fluidized bed reactor by using four different powders materials according to the Geldart's Classification of powders. The Milk powder belongs to Group A, sand particles belongs to Group B, flour belongs to the Group C, and wheat particles belongs to the Group D according to the Geldart's Classification of powders in order to estimate the minimum fluidization and D-Fluidization velocities of these particles. For this purpose the experiment is performed in laboratory and experimental data is collected for these four experiments which are given below.

For Milk Powder Particles (Group A)

Table-1 Fluidization

Sr. No.	Inlet Flow Rate	Height of Bed	Pressure Drop
Units →	Litre/min	cm	Cm of Hg
1	0	10	0
2	4.5	10	2.7
3	5	13.5	2.85
4	5.5	15	2.90
5	8	16	2.4
6	11	17	2.35
7	15	17.5	2.35
8	19	20	2.3
9	23	23.5	2.3
10	25	25	2.2
11	27	26.3	2.2
12	30	27.5	2.2

Table -2 De-Fluidization

Sr. No.	Inlet Flow Rate	Height of Bed	Pressure Drop
Units →	Liter/min	cm	Cm of Hg
1	30	25	1.65
2	27	23.5	1.65
3	25	20	1.65
4	23	17.5	1.65
5	19	17	1.75
6	15	15.5	2.5
7	11	13.3	2.9
8	8	11.1	2.6
9	5.5	10.5	2.3
10	5	10	2.1

For Sand Particles (Group B)

Table -3 Fluidization

Sr. No.	Inlet Flow Rate	Height of Bed	Pressure Drop
Units →	Liter/min	cm	Cm of Hg
1	0	12	0
2	0.9	12	13.3
3	2.4	13.5	14.8
4	4.7	14.7	15.15
5	7.5	16	15.5
6	12.5	16.5	15.9
7	20	17	16.2
8	25	18.3	16.2
9	30	20.5	16.2
10	35	23	16.2

Table -4 De-Fluidization

Sr. No.	Inlet Flow Rate	Height of Bed	Pressure Drop
Units →	Liter/min	cm	Cm of Hg
1	35	23	16.2
2	30	20.5	16.2
3	25	18.3	16.2
4	20	17	16.2
5	12.5	16.5	14.35
6	7.5	14.7	13.7
7	4.7	13.2	13.3
8	2.2	12.4	12.8
9	0.9	12	12.5
10	0.8	12	11

For Flour Particles (Group C)

Table -5 Fluidization

Sr. No.	Inlet Flow Rate	Height of Bed	Pressure Drop
Units →	Liter/min	cm	Cm of Hg
1	0	12.5	0
2	1	12.5	3.65
3	1.2	13.2	4.65
4	2.3	16.8	5.0
5	5	17.5	5.2
6	12	18	4.35
7	16.5	20.3	3.0
8	20	23.2	3.0
9	23	25.5	3.0
10	25	27	3.0

Table -6 De-Fluidization

Sr. No.	Inlet Flow Rate	Height of Bed	Pressure Drop
Units →	Liter/min	cm	Cm of Hg
1	25	25.5	3.9
2	23	23.2	3.9
3	20	20.3	3.9
4	16.5	18	3.9
5	12	17.5	5.0
6	5	14	4.8
7	2.3	13	4.5
8	1.3	12.5	4.35
9	1.2	12.5	0

For Wheat Particles (Group D)

Table -7 Fluidization

Sr. No.	Inlet Flow Rate	Height of Bed	Pressure Drop
Units →	Liter/min	cm	Cm of Hg
1	0	12.5	0
2	21	12.5	8.1
3	24	12.8	9.1
4	26	13	9.8
5	27	13.2	10
6	28	13.5	10.2
7	29.5	14	10.35
8	30.5	16	10.35
9	33	17.5	10.35
10	35	20	10.35

Table -8 De-Fluidization

Sr. No.	Inlet Flow Rate	Height of Bed	Pressure Drop
Units →	Liter/min	cm	Cm of Hg
1	35	20	10.35
2	33	17.5	10.35
3	30.5	16	10.35
4	29.5	14	10.35
5	28	13.5	10.2
6	27	13	9.65
7	26	13	9.32
8	24	12.8	8.4
9	21	12.8	6.2
10	0	12.5	0

RESULTS AND DISCUSSIONS

The results are presented and discussed by using graphical method in order to estimate the minimum fluidization and de-fluidization velocities of these particles. For this purpose superficial velocity is plotted at x-axis while pressure drop is plotted at y-axis.

For Milk Powder Particles (Group A)

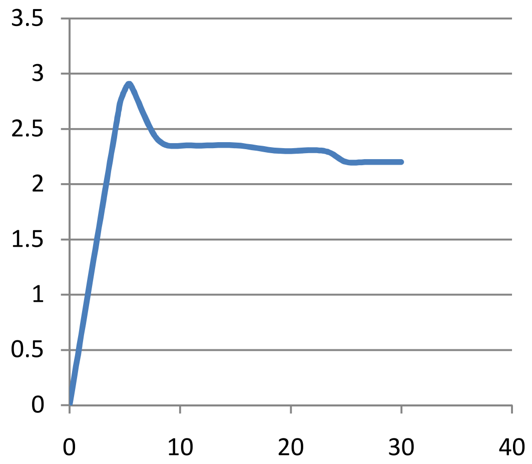

Fig. 1 Fluidization

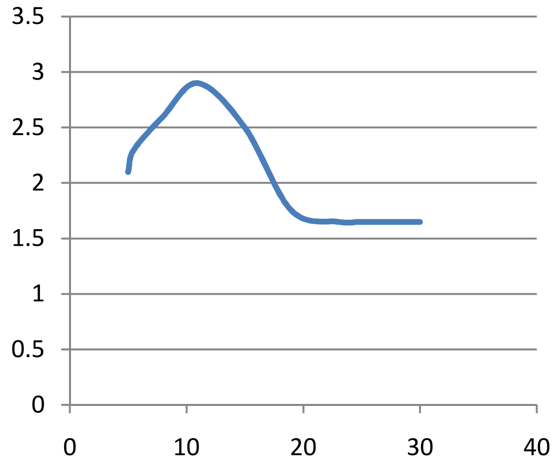

Fig. 2 De-Fluidization

For Sand Particles (Group B)

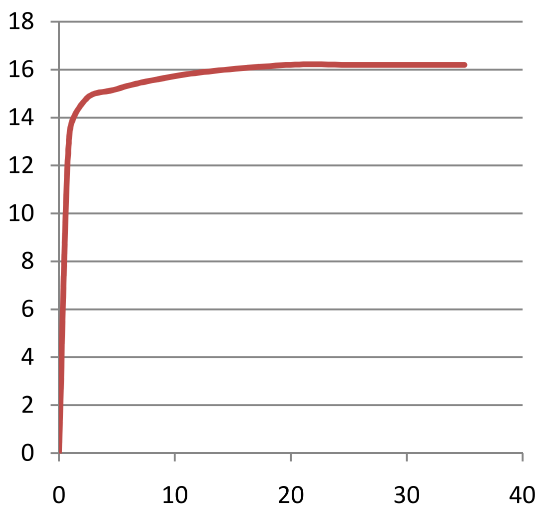

Fig. 3 Fluidization

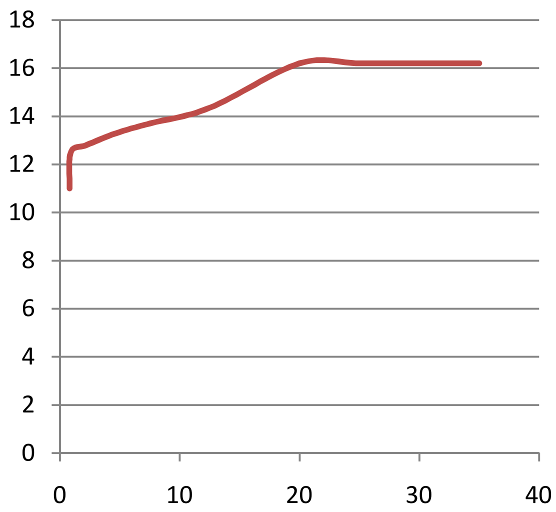

Fig. 4 De-Fluidization

For Flour (Group C)

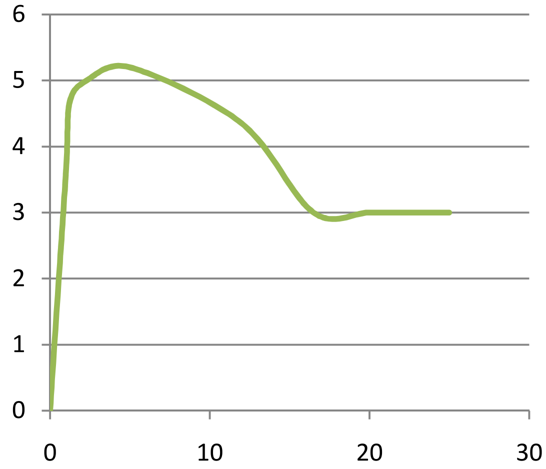

Fig. 5 Fluidization

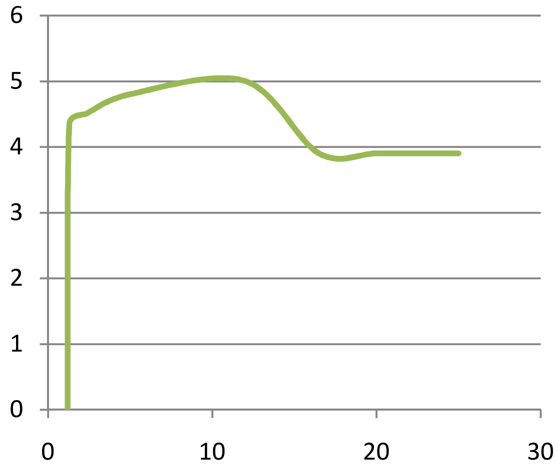

Fig. 6 De-Fluidization

For Wheat (Group D)

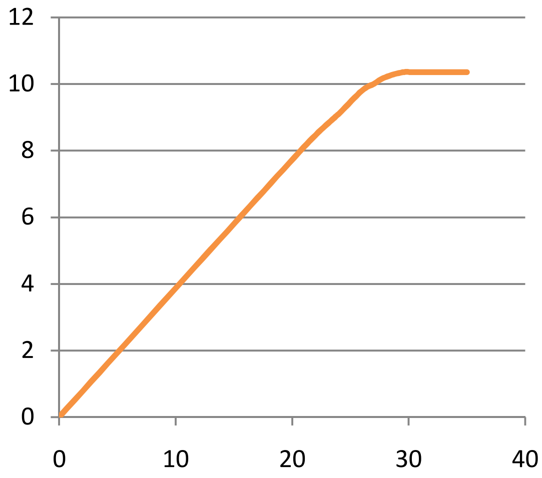

Fig. 7 Fluidization

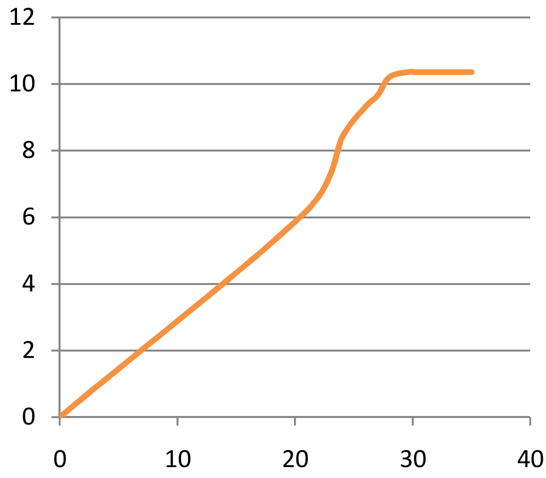

Fig. 8 De-Fluidization

CONCLUSIONS

The approximately minimum fluidization and de-fluidization velocities are found out from the above graphs which are given in the Table -9.

Sr. No.	Powder Type	Minimum Fluidization Velocities	Minimum De-Fluidization Velocities
Units →		**Liter/min**	**Liter/min**
1	Milk Powder	25.2	25
2	Sand	25.1	25.2
3	Flour	20.3	20
4	Wheat	29	29.1

It is concluded that the minimum fluidization velocity and de-fluidization velocities of all four types of particles are approximately equal. The minimum fluidization velocity and de-fluidization velocities are increases as the particle diameter and density increases. The pressure drop also increases as the flow rate increases but after a certain limit of flow rate it becomes constant for all four groups of particles. The trend of increase in velocities is given by.

Wheat > Milk Powder > Sand > Flour

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Conflict of Interest

The author(s) declare(s) that there is no conflict of interest regarding the publication of this manuscript.

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