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Fluidisation Enhancement Of Swirling Fluidised Bed Dryer With Distributor And Plenumchamber Modification

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ABSTRACT

The hydrodynamic properties and mixing pattern in gas -solid fluidized beds are dependent on many parameters, such as gas properties, solid properties, gas entrance conditions, and distributor geometry. The fluidized bed is seen as a mass oscillating on top of an air-filled cavity called plenum chamber.

. The swirling fliudised bed dryer plenum chamber section plays a vital role in distributing the fluid before it enters the distributor. The quality of distribution affects the performance of the fluidized bed.

Most researchers who investigate the hydrodynamics of fluidized beds did not take the effect of the plenum into account. Here fluidization enhancement of a swirling fluidized bed dryer with plenum chamber and distributor plate is taken into account and remodification is done.

1. INTRODUCTION

Fluidized beds makes an important role in many industries such as oil, gas, petrochemicals, and power plants, because of their multifunctional applications, such as mixing, drying, coating, granulation, separation, combustion, etc..The fluidized bed is seen as a mass oscillating on top of an air-filled cavity called plenum chamber. This is usually achieved by the introduction of pressurized fluid through the particulate medium. This results in the medium then having many properties and characteristics of normal fluids, such as the ability to free-flow under gravity, or to be pumped using fluid type technologies. The resulting phenomenon is called fluidization.

The section of a fluidized bed below the distributor plate is called the plenum chamber. This section plays a vital role in distributing the fluid before it enters the distributor. The quality of distribution affects the performance of the fluidized bed.

The swirling fluidized bed is a relatively new variant of the fluidized bed. In a swirling fluidized bed, the air enters the bed at an angle through the inclined openings of the distributor. The vertical component of the air velocity causes fluidization and the horizontal component causes swirl motion. The bed, if shallow, swirls as a single mass. On the other hand, as the bed height increases, two layers will form with a swirling bottom layer and a bubbling top layer. Swirling fluidized beds have several advantages over conventional fluidized beds. Quality fluidization with distributors having low distributor pressure drop is possible in a swirling fluidized bed. Due to the cross flow of the particles, no stable jet formation occurs in the swirling fluidized bed. The toroidal motion in the bed mixes the particles in the radial direction.

1.1 Service Models

COMPONENTS OF SWIRLING FLUDIZED BED

1. **Plenum Chamber**
2. Fluidization Zone
3. **Distributor**
4. Blower
5. U-Tube Manometer

1.1.1 Plenum Chamber

The distributer is placed on the plenum chamber. The chamber is made of mild steel plate. It has a tangential inlet pipe from blower facilitating an initial circulatory motion of air before entering the distributor. It is provided with a flange which is welded to the chamber. The plenum chamber was divided in to three zones viz zone 1, inner zone; zone 2, middle zone and zone3, outer zone. The air entering the chamber was made to flow through the outer and middle zone, while the inner zone had no air flow in it. This was done to maintain sufficient velocity for fluidization and to prevent particle accumulation at the center. The air flowing in the two zones does not interfere with each other inside the chamber. A tapered duct was provided from the blower so that the drag could be minimized. The inlet to the plenum chamber is divided in to four sections i.e. a horizontal and a vertical division is provided. Butterfly valves are provided at the inlet to the chamber in order to control the mass flow inlet. A spiral duct is also provided in the inlet so that air follows a spiral path.

2. IMPLEMENTATION

2.1. COMPONENTS FOR EXPERIMENTAL SET UP AND PROCEDURE

1. A swirling fluidized bed dryer
2. A rectangular passage
3. Airpro Anemometer
4. Blower
5. Pitot tube.
6. Bed particle

2.1.1 Swirling fluidized bed dryer

The fluidized bed dryer used in the experiment has four main parts, a rectangular inlet which has four ducts, a plenum chamber, a distributor plate and fluidization zone which is open to atmosphere.

Pressure of the region just below the distributor plate needed to be measured. For that, pressure tappings were taken from below the distributor plate.

Disributor plate has a dimeter of 90 cm with oval shape.

2.1.2. Rectangular Passage

A rectangular passage connected the blower outlet to the inlet of plenum chamber. This passage gad a hole at its top side centre position to fix the pitot tube for velocity measurement.

2.1.3. Airpro Anemometer

The FCO520 AirPro Pressure & Flow Meter is a hand held instrument which measures low differential pressure in various types of units and can measure velocity when paired with a Pitot tube and can also measure temperature with a separate probe, it is ideal for commissioning engineers because of its compact size.

The AirPro can also be used to measure air temperature by a thermistor built into the Pitot static tube or by a separate temperature probe. In addition, an optional absolute pressure sensor built into the AirPro measuring instrument can measure and display either absolute or gauge pressure. With both temperature and absolute devices fitted, the AirPro can calculate measure and display mass flow.

Features:

- On board memory with RS232
- Large LCD numeric display
- Backlit display

2.1.4. Blower

The blower used in the experimental set up could produce air velocity at the maximum of 8 m/s

Blower Model	A46.3600
Motor HP	3
Blower capacity	2400 CMH
Fan speed	12440 rpm
Standard pressure	90 MMWC

.Table 4.1. Blower specifications

2.1.5. Pitot tube

The airpro meter used for measuring velocity and pressure needed to be coupled with a pitot tube for measurement of velocity. Thus a pitot tube was fixed on the rectangular passage which transfers air from blower to the plenum chamber.

2.1.6. Bed Particles

Coffee beans were used as bed particles whose properties can be summarized as:

- Average particle diameter = 9.12mm.
- Average particle density = 785 kg/m^3

3.RESULTS AND DISCUSSION

3.1VELOCITY DISTRIBUTION

Air velocity distribution across the plenum chamber and at the fluidization zone has direct impact on the performance of swirling fluidized bed dryer. A more uniform velocity distribution is always desirable so as the fluidization to occur uniformly over the entire zone. Velocity contour of the entire geometry of 4 duct and 6 duct design were plotted at the inlet velocity of 8 m/s for comparison.

From the top view of the velocity contour, it is evident that the velocity distribution is non uniform and there is a localized turbulence which can result in non uniform fluidization.

Velocity contour of 6 duct design plotted at 8 m/s inlet velocity shows a uniform velocity distribution at the top of distributor plate which is called the fluidization zone. There is no localized swirling. This ensures a uniform fluidization compared to the 4 duct design.

4. PRESSURE DISTRIBUTION

Pressure at the top of distribution plate should be just high enough to stabilize the bed. Pressure should be uniformly distributed so as to maintain uniform fluidization of the bed.

Pressure contour plotted above the distributor plate of the 6duct and 8duct designs shows that pressure is higher for the 6 duct design. Pressure above the distributor reduced with the increase in number of inlet ducts possibly due to more surface area of contact with the duct. As the number of inlets increased, the pressure above the distributor channel has decreased.

5. CONCLUSION

Based on the analysis done on the swirling fluidized bed dryer, it has been observed that the available blower capacity is not enough for the effective fluidization of the particles. To rectify this issue, solutions other than changing the blower were to be optimized. Pressure drop across the fluid bed was measured using pressure tappings. A different geometry was created which had eight ducts instead of four or six and the ducts opened into the plenum chamber at angles of 120^o. The velocity and pressure contours were obtained using fluent. Also the pressure vs Velocity curves were plotted. It was observed from the results that the velocity distribution is more uniform for the eight duct model compared to the six duct model above the distributor plate which ensures more uniform fluidization. But the pressure drop across the plenum chamber was higher due to the more surface area of contact between the duct walls and air.

It was observed from the pressure velocity curves plotted for comparison of 6 duct and 8 duct plenum chamber swirling fluidized bed that the with 3 outlets showed a uniform velocity distribution and swirling was spread in a wider area. and swirling which may result in a non uniform bed density.

Also.a distributor plate with more number of orifices with oval shapes enhances the performance of swirling dryer to a great extent.

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