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Comparison of 6 duct to 4 duct inlet in a swirling fluidized bed plenum chamber

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In the present study, a swirling fluidized bed is examined for its hydrodynamic behavior experimentally and pressure versus velocity curves are plotted at various pressure tapping from the bottom of the distributor plate. A geometrically and hydro dynamically similar model of the fluidized bed set up is developed using ANSYS FLUID FLOW FLUENT. The model is studied for change in number of ducts of the plenum chamber and the properties are compared with the existing model.

The 6 duct design has shown a more uniform velocity distribution but a higher pressure drop across the plenum chamber.

Index Terms-- Zigbee; GPRS; Meter reading system; structure of Clusters; CC2430.

I. Introduction

Fluidized beds play 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 quality of the dried product, based on the colour and quantity of oil on the surface. is affected when higher air temperature or air velocity is used.

Agricultural produce which are seasonal and available in plenty in peak season are required to be dried for storing. Different investigators have attempted to study the drying characteristics of various agricultural produces in fluidized beds. If air is allowed to flow through a bed of solid powdered material in upward direction with a velocity greater than the settle rate of the particles, the solid particles will be blown up and become suspended in the air stream. At this stage, solid bed looks like boiling fluid; therefore the process is called fluidization.

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. When the pressure drop of the distributor is low, the air-supply system and especially the plenum chamber affects the bed. In most industrial cases, the pressure drop across the distributor is low. Therefore, the optimum design of the plenum chamber is the one that provides uniform gas distribution above the grid while offering a low pressure drop.

II. COMPONENTS OF SWIRLING FLUDIZED BED

A. PLENUM CHAMBER

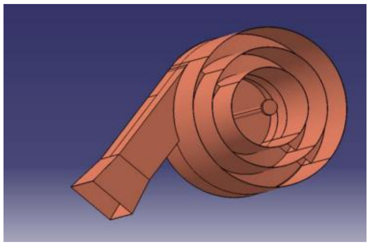

Fig 1. Fluidized bed plenum chamber

. 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.

B. FLUIDIZATION ZONE

Fluidization zone is the region of the swirling fluidized bed dryer where the particles are deposited in order to get dried.

C.DISTRIBUTOR

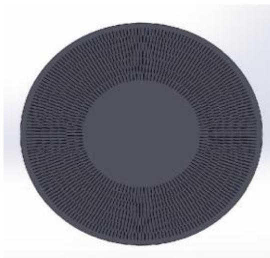

Fig 2. Distributor plate

The role of the distributor is to evenly distribute the fluidization gas across the bed inlet and hence to initiate effective gas-solids contacting.

D.BLOWER

The blower is used to supply air into the distributor at sufficient velocity and flow rate.

III. EXPERIMENTAL SET UP AND PROCEDURE

A.EXPERIMENTAL SET UP

Fig 3. Experimental set up

Main components of the experimental set up include:

- A 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.
- A rectangular passage- A rectangular passage connected the blower outlet to the inlet of plenum chamber.
- 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.
- Blower- The blower used in the experimental set up could produce air velocity at the maximum of 8 m/s
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- Pitot tube- The airpro meter used for measuring velocity and pressure needed to be coupled with a pitot tube for measurement of velocity.
- Bed particles- Coffee beans were used as bed particles.

B.EXPERIMENTAL PROCEDURE

The blower used for air inlet had a maximum velocity of only 8 m/s. Inlet velocity could be varied by adjusting the butterfly valves at the inlets of air ducts. Velocities ranging from a minimum of 2.3 m/s to a maximum of 7.8 m/s were obtained by adjusting the butterfly valves and pressure across the fluidization bed was measured using anemometer.

The pressure drop across each pressure tappings were noted down individually for all velocities. Eight different velocities used in the experiment were 2.3 m/s, 3.4 m/s, 4.2 m/s, 5 m/s, 5.5 m/s, 6.2 m/s, 7.1 m/s and 7.8 m/s.

IV. VALIDATION OF EXPERIMENTAL SET UP USING CFD

A.CFD MODEL

In order to analyse the various design parameters of an experimental set up using CFD, the CFD model created should be validated with the experimental set up. Numerical model was created using Solidworks Premium 2014 and was imported to ANSYS FLUENT for meshing and further analysis. Various view of the model created can be shown in the following figures.

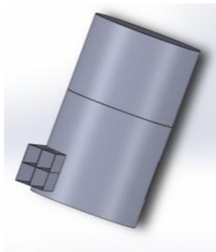

Fig 4. Fluidised bed with 4 inlets

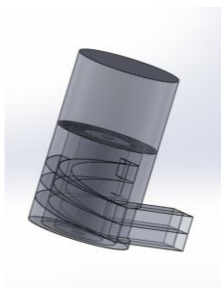

Fig 5. Swirl passage inside the plenum chamber

B. MESHING

Whole geometry was discretized into 3.6 million cells. Aspect ratio and orthogonal quality are the factors defining mesh quality. These parameters were provided as:

- Aspect ratio = 3.4 (upto 40 aspectable)
- Orthogonal quality = 0.78 (ranges from 0 to 1, closer to 1 is good)
- Mesh provided = TETRA MESH.

V. VALIDATION

A. COMPARISON OF PREESURE VELOCITY CURVES

For validation of the numerical model using experimental values, the Pressure Vs inlet velocity curves of the model for positions corresponding to pressure tappings on the experimental set up need to plotted and compared with the plot obtained from experimental analysis. If the graphs are found similar upto an extend, numerical model can be finalized as validated and further analysis can be conducted using the numerical model. Position of these pressure tappings were at radial distances 21 cm,24 cm, 30 cm, 33 cm and 36 cm respectively named as P1, P2, P3, P4 and P5. The comparison of plots obtained as listed in below figures.

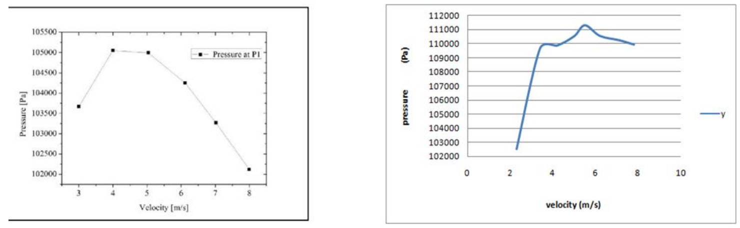

Fig 6. Pressure vs velocity curves comparison at P1

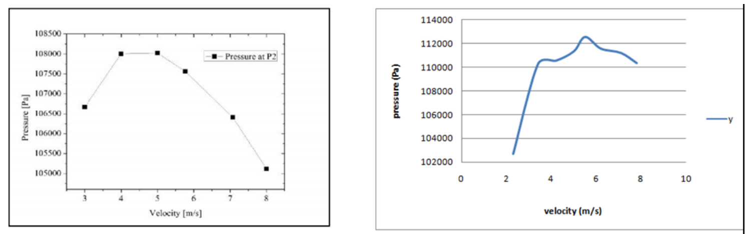

Fig 7. Pressure vs velocity curves comparison at P2

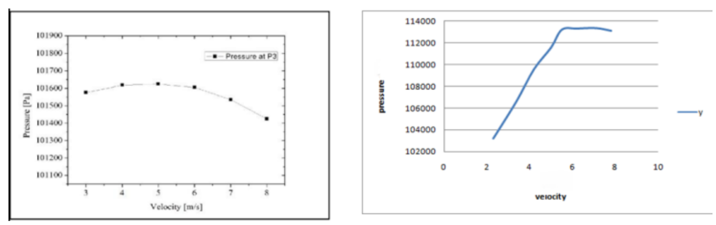

Fig 9. Pressure vs velocity curves comparison at P3

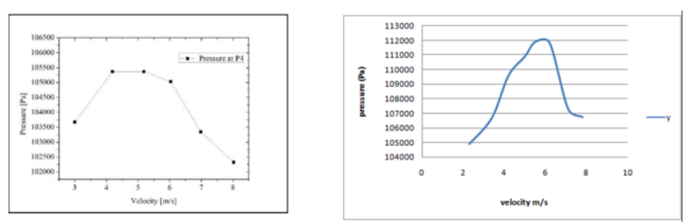

Fig 10. Pressure vs velocity curves comparison at P4

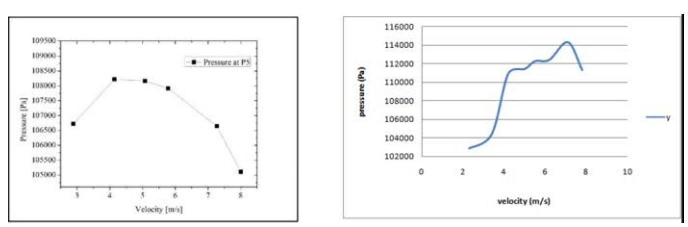

Fig 11. Pressure vs velocity curves comparison at P5

The comparison shows similarities well enough to conclude that the CFD model is validated.

VI. RESULTS OF EXPERIMENT

A.VELOCITY 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.

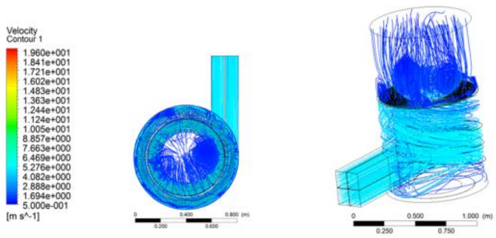

Fig 12.Velocity contour of 4 duct design

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.

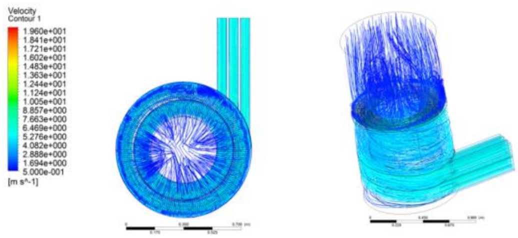

Fig 13. Velocity contour of 6 duct design

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.

B. 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.

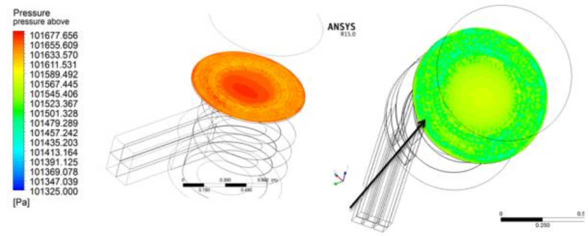

Fig 14. Pressure contour above distributor plate for 4 inlet and 6 inlet designs

Pressure contour plotted above the distributor plate of the 4 duct and 6 duct designs shows that pressure is higher for the 4 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.

C. PRESSURE VELOCITY CURVES

Pressure velocity curve is an important parameter in determining the performance of a swirling fluidized bed drier. Pressure velocity curves were plotted for the 6 duct design and 4 duct design for points P1, P2, P3, P4 and P5.

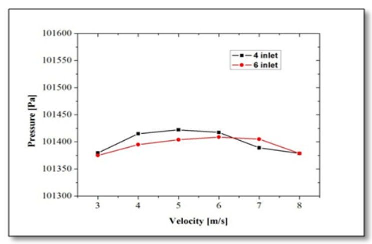

Fig 15. Pressure at point P1 for different velocities

At point P1, the 4 duct and 6 duct design shows almost similar curves eventhough the 6 duct design shows a slightly more uniform pressure distribution over different range of velocities.

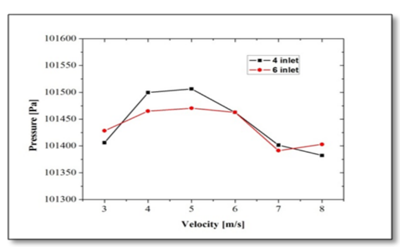

Fig 16. Pressure at point P2 for different velocities

At P2, 4 duct design shows a higher curve. At mid velocities i.e, 4-5 m/s, the pressure is found to be higher than the higher and lower range velocities probably due to the swirling being more concentrated at these areas.

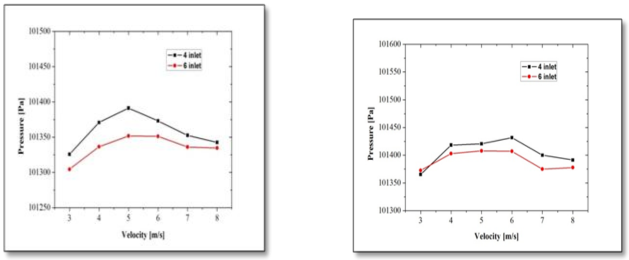

Fig 17. Pressure at point P3 and P4 for different velocities

At P3 and P4, the curves obtained are almost similar with the 4 duct design showing a slightly higher curve.

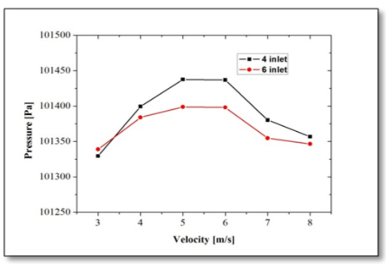

Fig 18. Pressure at point P5 for different velocities

At P5 also, almost similar curves are obtained with the 4 duct design having a higher curve.

VII. CONCLUSION

It was observed from the pressure velocity curves plotted for comparison of 4 duct and 6 duct plenum chamber swirling fluidized bed that the 6 duct design with 3 outlets showed a uniform velocity distribution and swirling was spread in a wider area. In the 4 duct design, even though the pressure drop in the plenum chamber is less, there is an occurrence of localized turbulence and swirling which may result in a non uniform bed density. Non uniform bed density can result in non uniform drying of the coffee beans. If the inlet velocity or blower capacity can be enhanced, the 6 duct design can be even more advantageuous.

IX. REFERENCES

[1]Sathiyamoorthy D. and Rao CH. S., (1981), "The Choice of Distributor to Bed Pressure Drop Ratio in Gas Fluidised Beds", Powder Technology, Vol 30, pp 139-143.

[2]Prakash S., Jha S.K. and Datta N .. (2004), "Performance evaluation of blanched carrots dried by different dries", Journal of" Food Engineering, Vol 62, pp 305-313.

[3]Niamnuy C. and Devahastin S .. (2004). "'Drying kinetics and quality of coconut dried in a fluidized bed"', Journal 01' Food Engineering, Vo166, pp 267- 271.

[4]Hatamipour M.S. and Mowla D., (2002), "Shrinkage of carrots during drying in an inert medium tluidized bed"', Journal ol Food Engineering, Vol 55, pp 247-252.

