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Fabrication and Implementation of Venturi Feeder Device in Pneumatic Conveying System for Optimal Material Transfer

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Abstract— **The Venturi meter which has long been used in hydraulics is here applied in dilute phase pneumatic conveying system for creating a considerable pressure difference so as to increase the velocity of air to convey the material form one place to another. The design of venturi meter is one of the most important factors for creating a negative and positive pressure difference to create a pull push system. This paper mainly deals with the fabrication and implementation of venturi feeder and selection of proper venturi feeder suitable for optimal material transfer.**

Keywords— **Pneumatic Conveying System, Pressure difference, Venturi feeder**

I. INTRODUCTION

Pneumatic conveying systems are generallysinuous. A very wide variety of materials can be handled and they are fully enclosed by the system and pipeline. This means that potentially hazardous materials can be conveyed quite safely. Based on the quantity of air used and pressure of the system, pneumatic conveying system is divided into two typesnamely dense phase pneumatic conveying system and dilute phase pneumatic conveying system. In dense phase conveying two modes of flow are recognized. One is moving bed flow, in which the material is conveyed in mounds on the bottom of the pipeline, or as a pulsatile moving bed, when viewed through a sight glass in a horizontal pipeline. The other mode is slug or plug type flow, in which the material is conveyed as the full bore plugs separated by air gaps. Dense phase conveying is often referred to as non-suspension flow. Almost any material can be conveyed in dilute phase, suspension flow through a pipeline, regardless of the particle size, shape or density. It is often referred to as suspension flow because the particles are held in suspension in the air as they are blown or sucked through the pipeline [8]. A relatively high velocity is required and so power requirements can also be high but there is virtually no limit to the range of materials that can be conveyed. Hence keeping the power requirement same the velocity of conveying medium i.e. air can be increased by implementing venturi feeder. Venturi feeder consists of a short length of pipe shaped like a vena contracta, or the portion with the least cross-sectional area, which fits into a normal pipe-line. The hindrance caused to the flow of liquid at the throat of the venturi produces a local pressure drop in the region that is proportional to the rate of discharge. The throat diameter is typically between 1/3 and ¾ of the inlet pipe diameter [2]. A particular advantage of the venture feeder, compared with many other feeding devices, is that it is small, occupies little space, and can be relatively cheap. It also requires very little headroom, which is often of benefit where pneumatic conveying systems may need to be fitted into existing plant with little room for modifications. They are often used in combustion applications, for the firing of coal dust and petroleum coke into boilers and furnaces, where individual burners may be fired directly from their own venturi feeder. L. P. Dhole, L. B. Bhuyar and G. K Awari et al [1] implemented venturi feeder to create a pull push type pneumatic conveying system in which it was found that the throat pressure was below the atmospheric pressure which was responsible for pulling the powdered material. Lots of investigations have been done on the bulk transportation using pneumatic conveying system. R. Pan and P.W. Wypych [5] presented test design procedure for low-velocity slug flow pneumatic conveying of bulk solid materials with irregular-shaped materials like muesli, maize germ. Based on the particle properties and data from a simple vertical test chamber, the pressure drop and slug velocity in low-velocity slug flow can be predicted accurately by this method in large-scale systems.WANG Xiaofang, JIN Baosheng et al [7] carried out computational study on the flow behavior of a gas-solid injector by Eulerian approach and found that as a whole, the static pressure distribution change trends were found to be independent on driving gas velocity, backpressure and convergent section angle. However, the static pressure increased with increase of convergent section angle and gas jet velocities. The difference of static pressure to backpressure increased with increasing backpressure. The characteristics of low-velocity conveying of particles having different hardness are experimentally investigated by Yuji Tomita, Vijay Kumar Agarwal et al [11] in a horizontal pipeline in terms of flow pattern and pressure drop to show that the slug flow can be classified into two types depending on the settling of particles along the pipeline, and the period is small for slug flow without the settled layer, which is called solitary slug flow. In this paper an attempt has been made to increase the velocity of conveying air at the expense of pressure drop by implementing venturi feeder such that settling of particles get reduced to a considerable amount.

II. Plan of Experiment

The experimental setup which is so designed consists of a blower, Venturi feeder, inclined tube manometer, rotary valve, hopper, and a container. The pipes are kept horizontal for some distance and then the bends of different radius are connected by means of socket. The two extreme ends i.e. the inlet and the outlet of the pipe are connected to an inclined manometer by means of flexible pipes having equal diameters to determine the pressure at inlet and outlet.The venturi feeder is being implemented in pneumatic conveying system to create a pressure difference which in turn is responsible for pull push effect. Three different venturi feeders were designed and fabricated and the experiments were performed on each of venturi feeder. The convergent section of venturi feeder acts as a nozzle and it increases the kinetic energy of air at the expense of its pressure drop. The throat is found to have negative pressure head and the pressure at divergent section of venturi feeder increases gradually, thus pulling and then pushing the powdered materials eventually increases the amount of discharged material which would not have been possible without implementing venturi feeder.

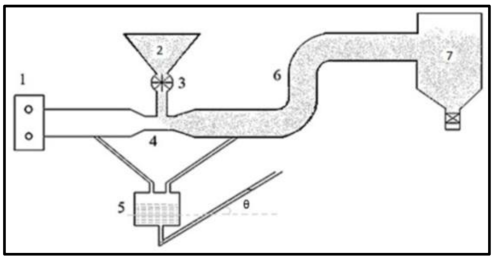

Fig 1 Pneumatic Conveying System

1. Blower
2. Hooper
3. Rotary Valve
4. Venturi feeder
5. Inclined manometer
6. Bend pipe
7. Container

In this experimental study our aim was to transfer the powdered material from one place to another place in an optimized way and minimize the losses by applying venture feeder. First we conducted the experiment for different blower opening with divergent cone having 5^0 included angle. The pipe diameter used in this system was same at all stages. The throat diameter of divergent cone having included angle of 5^0 will be large then the 10^0 and 15^0 angles i.e. the throat diameter of 15^0 angle will be small than other two. Due to the lesser throat diameter of venture feeder having the 15^0 included angle of divergent cone more pressure differential was created as compared with that ofthe 5^0 and 10^0 angles.

III. Experimental Work

The material to be conveyed was sand. Initially 0.5 kg of sand was weighed in digital weighing machine and the material was conveyed at different flow rates by using a rotary valve for divergent cone having included angle of 5°. And then same was repeated with divergent cone having 10^0 and 15^0 included angle. The material collected was weighed and recorded. The inlet and outlet pressure for venture feeder having different included angles were recorded by using inclined tube manometer.

Table 1 Divergentcone having 5^0 included angle

Blower Opening	Inlet Pressure (Pa)	Outlet Pressure (Pa)
3	267.813	41.202
4	305.581	51.5025
5	387.9855	58.3695
6	549.36	65.2365
7	672.966	78.9705

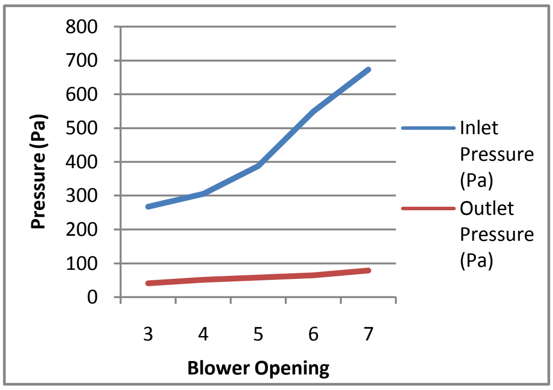

Fig 2 Graphical representation of inlet and outlet pressure vs. blower opening for divergent cone having 5^0 included angle

The graph is plotted between inlet and outlet pressure versus different blower openings for Venturi feeder with divergent cone having 5^0 included angle and it can be seen that there is a considerable pressure drop in the system with the increase in blower opening which increases the velocity of conveying air. A graphical representation of pressure drop versus blower opening for divergent cone having 5^0 included angle has been shown in fig 5.

Table 2 Divergent cone having 10^0 included angle

Blower Opening	Inlet Pressure (Pa)	Outlet Pressure (Pa)
3	336.483	13.734
4	460.089	20.601
5	580.2615	27.468
6	824.04	51.5025
7	1033.4835	54.936

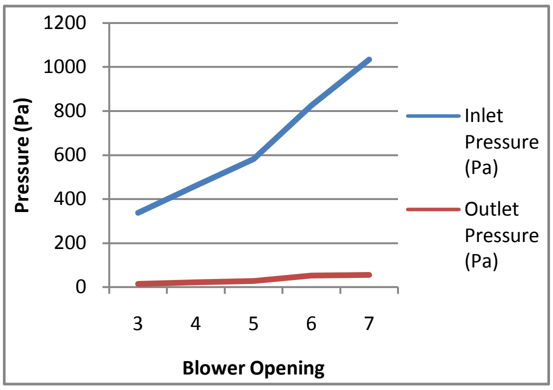

Fig 3 Graphical representation of inlet and outlet pressure vs. blower opening for divergent cone having 10^0 included angle

The graph is plotted between inlet and outlet pressure versus different blower openings for Venturi feeder with divergent cone having 10^0 included angle and it can be seen that there is a considerable pressure drop in the system which is more than the pressure drop with divergent cone having 5^0 included angle with the increase in blower opening which increases the velocity of conveying air. A graphical representation of pressure drop versus blower opening for divergent cone having 10^0 included angle has been shown in fig 5.

Table 3 Divergent cone having 15^0 included angle

Blower Opening	Inlet Pressure (Pa)	Outlet Pressure (Pa)
3	638.631	10.3005
4	889.2765	20.601
5	1174.257	30.9015
6	1459.2375	37.7685
7	1751.085	44.7355

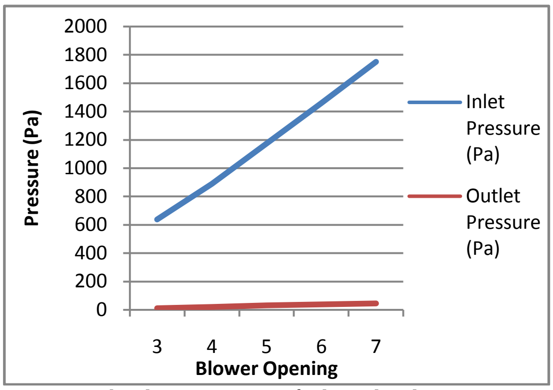

Fig 4 Graphical representation of inlet and outlet pressure vs. blower opening for divergent cone having 15^0 included angle

The graph is plotted between inlet and outlet pressure versus different blower openings for Venturi feeder with divergent cone having 15^0 included angle and it can be seen that there is a considerable pressure drop in the system which is more than the pressure drop with divergent cone having 10^0 and 5^0 included angle with the increase in blower opening which increases the velocity of conveying air. A graphical representation of pressure drop versus blower opening for 5^0, 10^0 and 15^0 divergent cones has been shown in fig 5.

Table 4 Divergent cone having 5^0, 10^0 and 15^0 included angle

Blower Opening	Pressure Drop for 5^0 included angle (Pa)	Pressure Drop for 10^0 included angle (Pa)	Pressure Drop for 15^0 included angle (Pa)
3	226.611	322.749	628.305
4	254.079	439.488	868.6755
5	329.616	552.7935	1143.356
6	484.1235	772.5375	1421.469
7	593.995	978.5475	1706.45

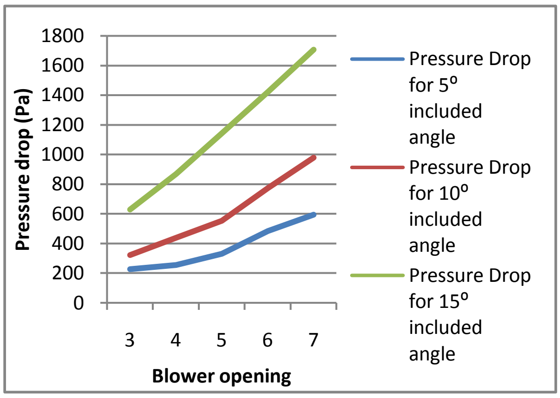

Fig 5 Graphical representation of pressure drop for divergent cone having 5^0, 10^0 and 15^0 included angle vs. Blower opening

The graph is plotted for divergent cone having 5^0, 10^0 and 15^0 included angle vs. blower opening. It can be seen that the pressure drop for divergent cone having 15^0 included angle is more as compared with divergent cone having 5^0 and 10^0

included angle. The effect of pressure drop for divergent cone having 5^0, 10^0 and 15^0 included angle on weight of sand discharged is shown in figure 6.

Table 5 Discharge of sand for divergent cone having 5^0, 10^0 and 15^0 included angle

Blower Opening	Weight Of Sand Discharged for Divergent Cone Having 5^0 Included Angle (kg)	Weight Of Sand Discharged for Divergent Cone Having 10^0 Included Angle (kg)	Weight Of Sand Discharged for Divergent Cone Having 15^0 Included Angle (kg)
3	0.36	0.37	0.39
4	0.38	0.40	0.42
5	0.42	0.43	0.44
6	0.44	0.45	0.46
7	0.46	0.47	0.48

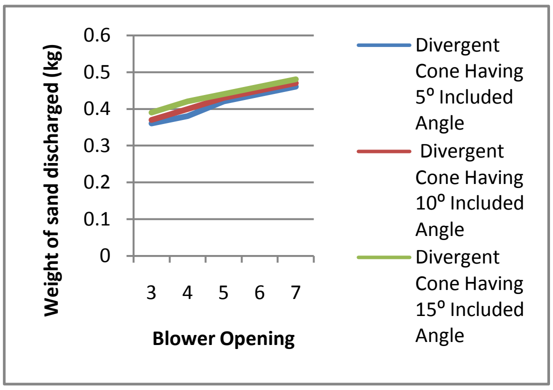

Fig 6 Graphical representation of weight of sand discharge for divergent cone having 5^0, 10^0 and 15^0 included angle

IV. CONCLUSION

Venturi feeder angles are a critical aspect of any pneumatic conveying system layout, and selection of the most appropriate angles configurations is a critical aspect of system design and operation. Improper selection of venturi angles can result in conveying capacity limitations. From the experimental study which we have done in this paper we can see that the selection of included angle for divergent cone has significant influence on creating pressure difference which in turn influences the powdered material to be transferred which is shown in figure 5. The more pressure difference more powdered material can be transferred. The divergent cone having 15^0 included angle has been found to create more pressure difference as compared with divergent cone having 5^0 and 10^0 included angle which is shown in figure 4.The advantage of using small throat diameter is that it leads to higher pressure differential and hence higher sensitivity and accuracy.

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