VENTURI FEEDER SYSTEM FOR PULL PUSH TYPE PNEUMATIC CONVEYING SYSTEM

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ABSTRACT
Pneumatic conveying systems are particularly versatile. A very wide range of materials can be handled and they are totally enclosed by the system and pipeline. The basic objective of the work is to develop venturi feeding system for the pull push type pneumatic conveying system, thereby creating the suction effect at the venturi throat. It will help to create the automatic suction of the material into the system through the inlet provided at the throat. This system then can be operated by the single person and has numerous practical applications for the automatic transportation of powdered and granular material. Initially five such systems were developed and tested [1], and based on the experimentation and analysis of these systems, four modified systems developed are presented here.

1. INTRODUCTION
The entrainment of solid particles in a high velocity flow of air is a well known phenomenon, with examples ranging from sand storms to domestic vacuum cleaners and it is therefore not surprising that it should be the basis of an essentially simple and reliable method for the controlled conveying of bulk solids. Pneumatic conveying, as the method is called, may be formally defined as the transportation of dry bulk particulate or granular materials through a pipeline by a stream of gas. Whilst the gas concerned would normally be air, other gases are occasionally used, such as nitrogen in situations where there is a fire or explosion risk. Pneumatic conveying systems are basically quite simple and are eminently suitable for the transport of powdered and granular materials in factory, site and plant situations [2]. A number of applications of operational principles of pneumatic transport could be seen in last decade of the 19th century at some places in Europe [2,3] and especially, in the grain transport and handling field [3]. We have fabricated five systems and achieved suction effect at the inlet provided at the throat. This suction effect is also capable to transfer the powdered as well as granular material through the throat. This system then can be operated by the single person and has numerous practical applications for the automatic transportation of powdered and granular material. Initially five such systems were developed and tested [1], and based on the experimentation and analysis of these systems, four modified systems developed are presented here.

In vacuum systems the material feeding is invariably at atmospheric pressure and so the pipeline can either be fed directly from a supply hopper or by means of suction nozzles from a storage vessel or stockpile. The main point to bear in mind, however, is that there will be no adverse pressure gradient against which the material has to be fed. The feeder, therefore, does not have to be designed to additionally withstand a pres-sure difference. With no adverse pressure drop to feed across it also means that there will be no leakage of air across the device when feeding material into the pipeline. Separation systems in these cases, therefore, by necessity, do have to operate under vacuum conditions.

In positive pressure systems, separation devices invariably operate at atmospheric pressure. Pipeline feeding in positive pressure systems represents a particular problem, however, for if the material is contained in a storage hopper at atmospheric pressure, the material has to be fed against a pressure gradient. As a consequence of this there may be a loss of conveying air. The feeding device in this case has to be designed to withstand the pressure difference in addition.

In certain cases this air flow can hinder the downward gravity flow of material into the feeder and hence interfere with the feeding process. Also, if the loss is significant, the volumetric air flow rate will have to be increased to compensate, for the correct air flow rate to the pipeline must be maintained for conveying the material. This loss, therefore, represents a loss of energy from the system.

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The selection of material feeding devices primarily depends on the three factors viz. pressure drop across the pipeline, Maintenance, and Material flow properties. Many diverse devices have been developed for feeding pipelines. Some are specifically appropriate to a single type of system, such as suction nozzles for vacuum systems. Others, such as rotary valves, screws and gate valves, can be used for both vacuum and positive pressure systems. Developments have been carried out on most types of feeding device, both to increase the range of materials that can be successfully handled, and to increase the operating pressure range of the device. Each type of feeding device, therefore, can generally be used with a number of different types of conveying system, and there are usually many alternative arrangements of the feeding device itself.

The basic problem with feeding positive pressure systems is that the air leakage arising from the adverse pressure gradient can interfere with the flow of...
of the material into the pipeline; this situation can be improved, to a certain extent, by using venturi feeders. These work on the principle of reducing the pipeline cross-sectional area in the region where the material is fed from the supply hopper. It will be seen that there are no moving parts with this type of feeding device, which has certain advantages with regard to wear problems. There are, however, no inherent means of flow control either, and so this has to be provided additionally.

2. VENTURI FEEDING SYSTEM FOR PULL-PUSH TYPE PNEUMATIC CONVEYING SYSTEM

The main objective of the work was to use venturi feeding system for the pull-push type pneumatic conveying system, thereby developing the suction effect at the venturi throat. This will help to create the automatic suction of the material into the system through the inlet provided at the throat. This system then can be operated by the single person and has numerous practical applications for the automatic transportation of powdered and granular material. We have fabricated five systems (S1 to S5) and observed suction effect at the inlet provided at the throat. This suction effect was also capable of transferring powdered as well as granular material through the pipe line. The attempt to create suction effect by using venturi effect was successful and the results were presented [1]. But the output i.e. mass flow rate was low.

3. EXPERIMENTATION ON PULL-PUSH TYPE PNEUMATIC CONVEYING SYSTEM USING VENTURI FEEDER DEVICE

If we want to improve the performance of such system, it is required to increase the material flow rate of the system. In order to increase the material flow rate as compared to systems S1 to S5, four systems S6 to S9 were developed. In these systems venturi feeders are designed considering the principles of fluid mechanics.

The suction effect and material flow rate achieved for the systems S1 to S5 are presented in the previous sections [1]. The reciprocating compressor was not used as a source of compressed air for these systems for experimentations as the results were not as per the expectations for systems S1 to S5. The centrifugal blower used for taking trials created the suction effect at the throat opening for the systems S6 to S9. The diameter of the inlet and outlet pipe for the systems were 76.2 mm (3") whereas the different throat diameters were selected for systems S6 to S8. Though the throat diameters were same for S6 and S9 but the inclination of the suction pipe for system S6 was 45° and for the system S9 was 90°.

Blower discharge for full opening was 0.521m³/sec. The blower efficiency was around 35%. The objective of these experimentations was firstly to measure the suction pressures developed at the inlet provided at the throat and then check for the material flow rate. The experimental set up and the experimentation procedure used is similar to that of systems S1 to S5. The compressed air will be supplied by the centrifugal blower, and the inlet pressure and throat pressure will be measured by U tube manometer in the first stage of this experimentation. The pressure developed at the inlet of the venturi and at the throat opening [6] and dimensional details of the systems the systems S6 to S9 are shown in Table 1. The effect of blower opening on throat and inlet pressure for system S6 to S9 are shown in figure 3.1 graphically.

Table 1 Experimental readings using centrifugal blower for systems S6 to S9

<table>
<thead>
<tr>
<th>System No.</th>
<th>S6</th>
<th>S7</th>
<th>S8</th>
<th>S9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length of conveying part (mm)</td>
<td>162.24</td>
<td>78</td>
<td>165</td>
<td>162.24</td>
</tr>
<tr>
<td>Diameter of conveying part (mm)</td>
<td>179.24</td>
<td>109</td>
<td>245</td>
<td>179.24</td>
</tr>
<tr>
<td>Diameter of throat inlet (mm)</td>
<td>38.1</td>
<td>56</td>
<td>25.7</td>
<td>38.1</td>
</tr>
<tr>
<td>Inclination of throat inlet (°)</td>
<td>45°</td>
<td>45°</td>
<td>45°</td>
<td>90°</td>
</tr>
<tr>
<td>Inlet pressure (bar)</td>
<td>1.035</td>
<td>1.0118</td>
<td>1.0220</td>
<td>1.0385</td>
</tr>
<tr>
<td>Throat pr. (bar)</td>
<td>0.9530</td>
<td>1.0092</td>
<td>1.0077</td>
<td>0.9831</td>
</tr>
<tr>
<td>Jawar (kg/hr)</td>
<td>472</td>
<td>270</td>
<td>212</td>
<td>--</td>
</tr>
<tr>
<td>Wheat (kg/hr)</td>
<td>415</td>
<td>249</td>
<td>192</td>
<td>--</td>
</tr>
<tr>
<td>Wheat Flour (kg/hr)</td>
<td>192</td>
<td>142</td>
<td>112</td>
<td>--</td>
</tr>
<tr>
<td>Cement (Kg/hr)</td>
<td>235</td>
<td>175</td>
<td>135</td>
<td>--</td>
</tr>
</tbody>
</table>

Figure 3.1 Effect of blower opening on throat and inlet pressure for system S6 to S9

The second stage of this experimentation is to use the negative pressure developed at the throat to suck the material inside the system for transportation. This will fulfill the objective of the study to use venturi-feeding system for developing the pull push type pneumatic conveying system. Suction pressure will help to create the automatic suction of the material into the system through the inlet provided at the
throat and the compressed air in the system will transport the material further into the system. This system then can be operated by the single person and has numerous practical applications for the automatic transportation of powdered as well as granular material.

In the experimentation to measure the material flow rate, the compressed air is supplied through the blower. Inlet provided at the throat is inserted into the heap of material, so that suction effect developed at the throat can suck the material into the system. All the four materials considered for the experimentation were tested to determine the material flow rate. The material flow rate achieved for jawar, wheat, wheat flour and cement during the testing is presented in table I. The graphical results for the experimentation are shown in the figure 3.2 to 3.3.

4. CONCLUSION

The material flow rate can be increased if the suction effect can be increased. The suction effect can be increased by increasing the system operating pressure and quantity of air supplied. The suction effect was observed on all the systems for all the conditions of blower opening. The significant material flow rate was not observed for 1/4, 2/4, 3/4 blower opening. This was due to the quantity of air for these conditions were not sufficient to carry the material with it. So the material flow rate for these conditions was not presented in the table I. Exhaustive experimentation is required to study the behavior of system under varying conditions of air supply and operating pressure. Computational Fluid Dynamics (CFD) analysis will be helpful to save the time required for the experimentation and analysis of the system. Hence it was decided to go for the CFD analysis of the system, which will also be helpful for the validation of the system. Experimental results obtained during the trials were used to model the CFD analysis of the system.

REFERENCES