IDENTIFICATION OF THE POSSIBILITY OF AUTOMATIC SUCTION OF POWDERED AND GRANULAR MATERIAL, USING DILUTE PULL/PUSH TYPE PNEUMATIC CONVEYING SYSTEM.

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ABSTRACT

Pneumatic conveying systems are simple and are very suitable for the transport of powdered and granular materials in factory, site and plant situations. System requirements are a source of compressed air/gas, a feeding device, conveying pipeline as per the requirement of the layout, and a receiver to separate the conveyed material and carrier air/gas. The use of venturi feeding system is very popular in the field of pneumatic conveying system. Mostly venturi feeder is used where manual feeding is used. The experimental analysis of venturi feeding system, which can be used for the suck blow type pneumatic conveying system, is presented. The objective of the work was to develop the venturi feeding system to create automatic suction effect, and to convey material further in the stream of air. The first part of the experimentation i.e. creation of the automatic suction effect was presented in the last edition of ICAME [1]. This paper deals with the experimental work related to the identification of use of such suction effect to convey material further in the stream of air. Venturi feeder system such type of feeding system can be then used for many industrial applications, for example automatic feeding of bulker with powdered or granular material. The five systems having different configurations were fabricated for the analysis purpose, and centrifugal blower was used as a source for air and trials were taken for the powdered as well as granular material.

1. INTRODUCTION

Pneumatic conveying systems are simple and are very suitable for the transport of powdered and granular materials in factory, site and plant situations. System requirements are a source of compressed air/gas, a feeding device, conveying pipeline as per the requirement of the layout, and a receiver to separate the conveyed material and carrier air/gas. The system is totally enclosed, the system can operate entirely without moving parts coming into contact with the material to be conveyed, if required. Dry air can be used to convey hygroscopic materials; inert gas such as nitrogen can be used for conveying explosive materials. Pneumatic conveying finds applications in the chemical industries to convey soap powders, detergents etc., food processing industries to convey sugar, flour, in cosmetics such as t alc, face powder or in power plants to convey coal and ash, in cement industries to convey cement, fly ash. Some other industries in which bulk materials are conveyed include agriculture, mining, oil industries, pharmaceuticals, paint manufacture, and metal refining and processing.

Based on the quantity of air used and pressure of the system, pneumatic conveying system is divided in to two types viz. dense phase pneumatic conveying system and dilute phase pneumatic conveying system. In dilute phase conveying, solid particles are introduced into a fast flowing gas stream where solids remain suspended. Such process systems operate at relatively low pressure and consequently are comparatively inexpensive to install [2]. Dense-phase pneumatic conveying, is defined as the conveying of particles by air along a pipe which is filled with particles atone or more cross-sections. There is much confusion over the use of the term dense-phase conveying and, as a result, many different definitions have been proposed, based on the solid loading ratio, pressure and quantity of air used [3]. Easiness in controlling and flexibility in installations are some of the favourable features of pneumatics applications in many industrial and non-industrial fields. It has a wide range of applications, with examples ranging from domestic vacuum cleaners to the transport of some powder materials over several kilometers [4]. Pneumatic conveying systems may also be differentiated as low, medium or high pressure. Blowers for industrial applications develop a conveying pressure of approximately 0.5 to 1 bar positive pressure, which corresponds to a vacuum of 0.3 to 0.5 bars. The three well-known pneumatic conveying systems used are positive pressure system, negative pressure system and combined negative positive pressure system.

In positive pressure system, the absolute pressure of conveying gas inside the piping system is always greater than atmospheric pressure. This system is recommended when the product is introduced at one point and transported to different delivery points. In negative pressure system gas pressure inside the system is lower than atmospheric pressure. Typical examples of this system are stationary, mobile, self-traveling, or floating pneumatic ship unloaders, used for grain and oil seeds carried in ocean going and inland vessels, barges, rail wagons and trucks. To overcome the weaknesses and combine the advantages of positive and negative pressure systems, some plants can be seen in operation combining both these...
configurations together. This type is also termed as ‘suck-blow’ system where multiple feeding as well as multiple deliveries is easy to perform.

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

The basic objective of this work is to use the venturi feeder system for the pull push type pneumatic conveying system, thereby achieving the automatic suction of the material for industrial applications. The work is divided into two parts i.e. to develop the feeding system for automatic feeding of material into the system and secondly take the trial on this feeding system for the transportation of the material may be powdered or granular material. As first part is already presented in the last edition of conference i.e. ICAME4, this work is an attempt to present the experimental work related to use of the automatic suction effect to transport the powdered and granular material. The venturi feeder is a commonly used device for manual feeding purpose, but the main objective of the work was to use venturi-feeding system for pull-push type pneumatic conveying system to create automatic suction effect. Such type of work is not carried in the field of pneumatic conveying system.

Venturi feeders work on the principle of reducing the pipeline cross-sectional area [5] in the region where the material is fed from the supply hopper, as shown in figure 2.2. 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.

If venturi feeding is required to be used for the pull push type pneumatic conveying system, the feeding system has to perform two functions viz. to create the suction effect followed by the pushing the material through the pipeline in the stream of air. Then certain changes are required to be done in the basic venturi feeder. The cone type provision for the feeding purpose is shown in the figure 2.1. This cone type feeding arrangement is required to be replaced by the short pipe which can be used for the automatic suction purpose. The typical system is shown in figure 2.2.

![Figure 2.1 Basic type of venturi feeder](image1)

![Figure 2.2 Systems used for experimentation](image2)

![Figure 3.1 pneumatic conveying system used for trials](image3)

3. TRIAL AND ANALYSIS OF THE SYSTEM
The pneumatic conveying system used for the trial [6] is shown in figure 3.1. In this experimentation centrifugal blower is used for the source of pressurized air. Venturi feeder is used as feeding system. Since the system pressure is low this dilute phase pneumatic conveying system.

Five such systems of different dimensions were fabricated and tested. These systems were tested for four different powdered and granular materials viz. jowar, wheat flour, wheat and fly ash. Pressure at inlet and throat of venturi meter is measured with the use of U-Tube manometer. The dimensions used for the different configurations used for the system along with the parameters considered and their values obtained during the experimentation are given in the table 1.

Pneumatic conveying is used for transportation of bulk material, it is a method in which one has to deal with the two-phase system i.e. gas solid system. It is very complicated system from the analysis point of view, still lots of research and study is required for the complete understanding of the system. Every problem in the pneumatic conveying system is different, and there is no specific method is available. As such kind of pneumatic conveying system is not used for loading the bulk tanker, so we were not having any particular base for the design of such kind of system. Hence we decided to go for experimental method and study certain parameters governing the system, so that we can form some base for this system.

In this analysis, we considered certain parameters such as pressure at the different points, velocity of air and solid, effect of inlet diameter to throat diameter ratio on the material transfer rate. Here we observed that the ratio of inlet to throat diameter as a great effect on the mass flow rate. The maximum value inlet to throat diameter used during the experimentation is 2.7 and the least value is 1.3. From the trials it is observed that the mass flow rate of solid increases as the ratio of inlet to throat diameter decreases. The mass flow rate is maximum for the ratio of 1.5. Further decrease in the ratio of inlet to throat diameter causes the decrease in mass flow rate. So for the maximum mass flow rate the ratio of inlet to throat diameter should be 1.5. It can also be seen from the observations that maximum suction created at the loading point that is at the throat of the venturi is also for the ratio of 1.5.

Graphical analysis for the mass flow rate of jowar, wheat flour, wheat fly ash against the ratio of inlet to throat diameter is carried out. Nature of the curves obtained for the mass flow rate for the different materials involved in the trials against the ratio of inlet to throat diameter is same. Maximum mass flow rate of the solid is obtained for the ratio of 1.5 for all the materials. The mass flow rate depends on the quantity of air used, blower outlet pressure, solid loading ratio, diameter of the pipes used for the system. For this analysis the blower pressure was restricted to 1.2 bar considering the safety of the system. Use of higher pressure will definitely increase the mass flow rate, but care must be taken to avoid the degradation of the solid.

### 4. CONCLUSION

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 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 pipe line. The attempt to create suction effect by using venturi effect was successful. But the output i.e. mass flow rate was low. This is because the maximum pressure used to create the suction effect was restricted to 1.2 bars only. So if the higher value of blower pressure can give better mass flow rate. Dense phase pneumatic conveying system is required to be tested which is able to give higher mass flow rate because higher solid loading ratio.

### Table I Observation and trial results

<table>
<thead>
<tr>
<th>SYSTEM</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>V</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inlet Diameter (mm)</td>
<td>126</td>
<td>76</td>
<td>64</td>
<td>76</td>
<td>76</td>
</tr>
<tr>
<td>Throat Diameter (mm)</td>
<td>47</td>
<td>41</td>
<td>42</td>
<td>52</td>
<td>63</td>
</tr>
<tr>
<td>Outlet Diameter (mm)</td>
<td>100</td>
<td>76</td>
<td>64</td>
<td>76</td>
<td>76</td>
</tr>
<tr>
<td>Diameter ratio (Inlet/Throat)</td>
<td>2.7</td>
<td>2.0</td>
<td>1.65</td>
<td>1.5</td>
<td>1.3</td>
</tr>
<tr>
<td>Inlet Pressure (bar)</td>
<td>1.0492</td>
<td>1.046</td>
<td>1.0423</td>
<td>1.046</td>
<td>1.043</td>
</tr>
<tr>
<td>Throat Pressure (bar)</td>
<td>1.0087</td>
<td>0.9987</td>
<td>0.9928</td>
<td>0.9910</td>
<td>0.9915</td>
</tr>
<tr>
<td>Jowar (kg/hr)</td>
<td>150</td>
<td>140</td>
<td>164</td>
<td>260</td>
<td>240</td>
</tr>
<tr>
<td>Wheat Flour (kg/hr)</td>
<td>82</td>
<td>70</td>
<td>90</td>
<td>105</td>
<td>100</td>
</tr>
<tr>
<td>Wheat (kg/hr)</td>
<td>140</td>
<td>130</td>
<td>164</td>
<td>240</td>
<td>225</td>
</tr>
<tr>
<td>Fly Ash (kg/hr)</td>
<td>90</td>
<td>75</td>
<td>100</td>
<td>125</td>
<td>120</td>
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</table>
The most important investigation of this experimentation is the identification effect of inlet to throat diameter ratio on the suction effect generated at the throat. This system has potential to create suction effect and further research on the system can result into increased suction effect thereby enabling the automatic loading of bulk tankers.

REFERENCES


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