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PRIMARY ARTICLE

Design And Development Of Pneumatic Conveying System For Chilli Handling And Experimentation

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ABSTRACT

In the industries where bulk material is to be transferred from one place in the process plant to the other, material handling systems are required. Various types of conveyors are available in the market having their own characteristic features. But in the industries where very high mass flow rates are required, pneumatic conveying system can be very useful. Various other conveyors are also present but some occupy a lot of space in the plant whereas some cannot give such high mass flow rates.

The design data for some materials are available in the different material handling design data books. If one wants to design a system for any new material the he can start the design by comparing the material physical properties with the materials which have already been conveyed. Pneumatic conveying system is a conventional material handling system like belt conveyor or chain conveyor. The main advantage of pneumatic conveying system is that material is transferred in close loop, thereby preventing the environmental effect on the material and vice versa. There is wide scope for experimentation in the field of pneumatic conveying system.

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1.Introduction:

Pneumatic conveying system is not a very new concept. A vast literature and research is available on pneumatic conveying system. But despite of such large literature available on pneumatic conveying system, we don't have a general design procedure for any such system since in pneumatic conveying system every problem is a unique problem. But definitely some general principles can be applied while designing a pneumatic conveying system which can lead to an optimum system design. A variety of materials can be conveyed using a pneumatic system with certain changes in the design of the system. We cannot predict the behavior of any pneumatic conveying system. The behavior of any system can only be known by fabricating the system and testing the conveying characteristics of the system for the particular material.

In the industries where bulk material is to be transferred from one place in the process plant to the other, material handling systems are required. Various types of conveyors are available in the market having their own characteristic features. But in the industries where very high mass flow rates are required, pneumatic conveying system can be very useful. Various other conveyors are also present but some occupy a lot of space in the plant whereas some cannot give such high mass flow rates.

Pneumatic conveying is based on the physical principle that air, under certain conditions, is able to convey heavy materials. In nature, air can carry many substances, such as sand, snow, leaves, and seeds. Pneumatic conveying causes air to flow by creating a pressure difference between the beginning and end of a pipe. From basic physics, it is known that the suction of liquid is theoretically limited to 10m height, but for granular material in suction mode, the conveying height is close to unlimited – on condition that an air stream at the necessary speed is available to carry the material. The first pneumatic conveying equipment was used to unload grain f room ships before the 19th Century. Later, this new continuous conveying method spread to small and middle size systems, as well as to other bulk products. Pneumatic conveying systems may be differentiating as low, medium or high pressure. Blowers for industrial applications develop a conveying pressure of approx. 0.5 to 1 bar positive pressure, which corresponds to a vacuum of 0.3 to 0.5 bar. The three systems used are: suction only, pressure only, and combined.

Pneumatic conveying is a practical method for in-plant distribution of large amounts of dry powdered, granular, and pelletized materials. Based on the quantity of air used and pressure of the system, pneumatic conveying system is divided in to two type's viz. dense phase pneumatic conveying system and dilutes 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. Dense-phase pneumatic conveying is defined as the conveying of particles by air along a pipe which is filled with particles at one 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. Easiness in controlling and flexibility in installations are some of the favorable 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. The industrial field where pneumatic conveying system is extensively used includes Chemical process industry, Pharmaceutical industry, Mining industry, Agricultural industry, Mineral industry, and Food processing industry. Virtually, all powders and granular materials can be transported using this method.Murilo D.M. Innocentinietal experimentally investigated the dehulling process of cracked soybeans in 2008 and it has been shown that the efficiency of the pneumatic device to remove hulls from the cracked soybean was very high, with the recovery of meats with purity around 99%. In Ref., a list of more than 380 different products, which have been successfully conveyed pneumatically, is presented. It consists of very fine powders, as well as the big crystals such as quartz rock of size 80 mm.

2. Concept for conveying chilli and Development:

The working of the system is quite easy to understand. The vacuum generator creates a negative pressure inside the suction chamber and the pressure outside is equal to that of the atmosphere. Due to this pressure difference, the air from the atmosphere rushes into the suction chamber and carries the material which is to be conveyed in the way along. The filter unit does not allow the material to enter the vacuum generator and thus it separates the material from the air. The air escapes through the exhaust and the material gets collected in the tank. When the butterfly gate is opened the material is delivered from the bottom of the tank and in this way the material is conveyed from the source to the destination.

Fig. Pneumatic Conveying System

Fig. Centrifugal blower

Fig. Rotary Airlock System (Side View)

Fig. Rotary Airlock System(Top View)

Fig. Cyclone

3.Design Procedure:

Calculation of motor Hp:
Ws = Wt. of solid flow = 2 kg/min
V = velocity of air flow lb/min = 2000 lb/min
Va = velocity of air flow ft3/min = 3500 fpm

A)Pressure drop due to movement of product

Pressure drop to accelerate solid to conveyer velocity in H_2O

$\Delta P_1 = (8.3 * 2 *(2000)^2)/ (3500 * 10^{-7})$
$= 1.897 * 10^{-3}$

2) Pressure drop to due to Raise the material from one level to another level in H_2O

$\Delta P_2 = (0.2*W_s *H)/Va \quad = 9.14 * 10^{-4}$

3) Pressure loss due to friction of solid in Pipe wall in H_2O

$\Delta P_3 = (0.2*W_s *L*f)/Va = 9.6* 10_{-4}$
f= coefficient of friction (f=0.7)
L= distance of conveying

B) Air Friction Losses

1)Pressure drop at entry in H_2O

$\Delta P_{B1} = 1.24*V_p \quad =1.55* 10_{-4}$
V_p = velocity head in H_2O $=V/(4000)^2$

2) Pressure drop in separation in H_2O

i)Cyclone, $P = 2*V_p = 2.5 * 10^{-4}$
Filter, P = 6 in H2O maximum
Total pressure drop
$\Delta P_{total} = \Delta P_A + \Delta P_B \quad = 6$ in H_2O
The horsepower for Air mover
Air Horsepower = $(V_a * \Delta P_{total})/(6356)$= 0.88 Hp
Motor Horsepower = (Air horsepower)/η
= 0.88/0.7

=1.2 Hp
η= 0.7, motor efficiency

4.Experimentation And Testing:

a)FOR CHILLY MATERIAL:

DIAMETER (inch)	HEAD (feet)	LENGTH (feet)	DISCHARGE (kg/min)
4	8	12	2
4	8	11	2
4	7	12	2.3

b) FOR DHANIYA MATERIAL :

DIAMETER (inch)	HEAD (feet)	LENGTH (feet)	DISCHARGE (kg/min)
4	8	12	2.8
3	8	12	3
2	8	12	3.7

c) FOR CHILLY POWDER MATERIAL:

DIAMETER (inch)	HEAD (feet)	LENGTH (feet)	DISCHARGE (kg/min)
4	8	12	3
3	8	12	3.2
2	8	12	3.8

Conclusion:

- After the design and fabrication of the pneumatic conveying system for dried red chilies, we came to the conclusion that it is very much possible and rather beneficial to convey the dried red chilies with the help of a pneumatic conveying system rather than by using a mechanical conveyor due to several reasons which we have already mentioned in this literature. We have successfully fabricated a working model of the system capable of conveying dried red chilies automatically and efficiently.
- Though we faced some difficulties during the fabrication of the system regarding unavailability of required components but definitely the system can be made to work using alternative components. We have also concluded that the behavior of the pneumatic conveying system cannot be predicted for any new material unless it is fabricated and tested for the same. Also there is a vast scope of research and development of the same

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