ABSTRACT

Pneumatic conveying, in pipelines, of granular and powdery solids is a popular means of material transport in the industry. The material must be introduced into the air stream through suitable feeders, which minimise air leakage through them. Among the various types of feeders, injector feeder is one of the feeders which are frequently used in industry as feeding devices for bulk solids and for short conveying lengths.

In order to study the influence of design parameters on the flow rate of conveyed material, it became necessary to develop a feeder. A few trial hopper-cum-feeders were fabricated and they helped to make some preliminary observation on the free flow of material down the hopper. The final version of the hopper cum feeder is termed as the box type injector feeder. The injector feeder consists of two nozzles, a primary nozzle (convergent) and a secondary nozzle, having inlet, mixing and diffuser sections. The primary nozzle converts the pressure energy into velocity energy. The air coming out from the primary nozzle entrains the granular material fed from the auxiliary hopper into the secondary nozzle and then through a pipe line.

The dimensions and geometrical design of the injector feeder are known to influence its performance and hence its design is essentially based on empirical approach. The effects of the following
parameters on the mass flow rate of conveyed material (m_p) are investigated in this work.

1. The distance between the primary nozzle and the secondary nozzle (S).
2. The secondary nozzle inlet tube angle (2α).
3. The mixing tube length of the secondary nozzle (L_m).
4. The mixing tube diameter (d_m).
5. The diffuser angle (2θ).
6. The mass flow rate of air (m_a) and
7. The primary nozzle throat diameter (d_p)

In addition, a limited study of the effect of fluidization has also been made. The special cases namely a convergent-divergent nozzle and a straight tube feeder have also been studied.

An experimental set up has been fabricated to test different injector feeders. On the upstream side is connected a compressor. On the downstream side a conveying pipe of 27m in length is available. The air and solid are separated by a cyclone separator. The material falls back in the hopper, for recirculation. Wheat and ragi are the materials used for the various studies. For each experiment conducted, the dependent parameters i.e. mass flow rate of material and the static pressures along the secondary nozzle are measured. A part of the air is taken through an auxiliary pipe to give incipient fluidization of the materials in the box type feeder. The mass flow rate of air through the main pipe and auxiliary pipe is measured with
As \( \dot{m}_p \) depends on \( L_1, L_m, L_0, d_m, d_p, \dot{m}_a \) and \( S \), an empirical relationship is developed by a preliminary equation considering certain constraints in the system. This equation is then generalised heuristically for the experimental data and a final equation is obtained. From the above mathematical relationship and analysis it is found that the change in \( \dot{m}_p \) is fully explained for different values of \( S \). Hence a general \( n \)th degree polynomial equation is also developed with the optimum coefficient of correlation close to unity. It is found that the fitted curves due to the polynomial relationship and due to that of actual experimental results are in agreement with each other.

The effect of \( S \) on \( \dot{m}_p \) is a very important parameter playing a vital role in the design of the system. For the experimental set up \( S = 20.0 \, \text{mm} \) is found to be a good choice. However for a general case, it is worth experimenting on the actual design to fix this parameter; \( \dot{m}_p \) is significantly high for the tube having \( \alpha = 15^\circ \). The proportion of the mixing tube length in the range 7 to 9 \( d_m \) is a good choice. Among the various \( \beta \) used, the value of \( \beta = 2^\circ \) suits well for the maximum flow rate of material. As far as \( d_m \) is concerned, the value in the range 0.7 to 0.8 \( d_0 \) gives rise to maximum material flow rate. The value of \( d_p \) is more dependent on the characteristics of the material. Any increase in \( \dot{m}_a \) will give a corresponding increase in \( \dot{m}_p \) for the system designed.
The two special cases considered give lower $\dot{m}_p$ than that of the secondary nozzle having inlet, mixing and diffuser tubes. When the injector feeders is given incipient fluidization, there is an increase of $\dot{m}_p$. Higher ratio of $\dot{m}_{aux}/\dot{m}_a$ will give rise to increased flow rate of material.

It is observed from the static pressure distribution along the secondary nozzle that there is a substantial increase in static pressure during the flow of material through the inlet tube. There is decrease in static pressure along the mixing tube length and marginal increase along the diffuser tube. Further it is observed that when the feeder is fluidized with higher $\dot{m}_{aux}$, there is a reduction in the static pressure along the length of the secondary nozzle. The above studies of the various design parameters which influence the performance of an air solid injector feeder will help designers to fix proper dimensions for the injector feeder used in pneumatic conveying.