6.1 CONCLUSION

The influence of design parameters of an injector feeder on the mass flow rate of material transported by pneumatic means, has been established in this work, for the first time [24,25]. A large number of experiments have been conducted using injector feeders of different dimensions for the study. The whole experimental set up is unique in that it allows free flow of granular materials to the injector feeder and for every set of dimensions of injector feeder, the position of primary nozzle can be varied to find the effects on mass flow rate of conveyed material. The effects of various design parameters which will help designers to fix proper dimensions for the injector feeders used in pneumatic conveying are summarised below.

6.1 EFFECT OF GEOMETRIC PARAMETERS

The effect of $S$ on $\tilde{m}_p$ is a very important parameter playing a vital role in the design of the system. It is for the first time such a parameter has been studied experimentally for an injector feeder. As the primary nozzle is moved away from secondary nozzle, there exists a significant increase of $\tilde{m}_p$. However there is a limit at which choking occurs. 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.

The next important parameter is the secondary nozzle inlet tube angle ($2\alpha$). Among the five inlet tubes used the value of $\tilde{m}_p$ is significant for the tube having $\alpha = 15^0$. Increasing the value of $\alpha$ beyond $15^0$ may reduce the overall length of the nozzle. This value is found to be approximately same as the corresponding value of $\alpha$ used for jet pumps.
The proportion of the mixing tube length in the range 7 to 9\( d_m \) is a good choice. Moreover, it lies within the range of 5 to 10 \( d_m \) used for jet pumps.

As far as \( d_m \) is concerned, the value in the range 0.7 to 0.8 \( d_o \) gives rise to maximum flow of material.

The diffuser angle \( (2\theta) \) must be low to prevent the formation of eddies. Too rapid a divergence immediately after the mixing tube is not desirable. Among the various \( \theta \) used, the value of \( \theta = 2^\circ \) suits well for the maximum flow rate of material, and this value is the lower end of the range of 2 to 5^\circ used for jet pumps.

When \( d_p \) is decreased the velocity of the injecting air increases resulting in more material flow rate. However, conveying the material with very high transport velocities may cause particle degradation. The degradation of the particle must be within tolerable range based on judgement. Hence the degradation characteristics of the material also must be considered before fixing this parameter.

It is well known that any increase in \( \dot{m}_a \) will give a corresponding increase in \( \dot{m}_p \) for the system designed. This is usually fixed on the quantity of material to be transported and conveyor pipe diameter.

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 a decrease in static pressure along the mixing tube length. This decrease in pressure may be attributed to the particle acceleration and wall friction. There is only a marginal increase in static pressure in the diffuser tube.
6.2 SPECIAL CASES

Two special cases of the secondary nozzle namely a convergent-divergent nozzle and straight tube have been used. It is found that in both cases the $\dot{m}_p$ is less than that of the secondary nozzle having inlet, mixing and diffuser tubes.

6.3 EFFECT OF FLUIDIZATION

When the injector feeder is given incipient fluidization, there is an increase of $\dot{m}_p$. During fluidization, it is found that $\dot{m}_p$ depends on $\dot{m}_{aux}$ also in addition to the parameters $L_1$, $L_m$, $L_0$, $d_m$, $d_p$, $\dot{m}_a$ and $S$. It is found that higher ratio of $\dot{m}_{aux}/\dot{m}_a$ will give rise to increased flow rate of material. 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.

6.4 REGRESSION EQUATIONS

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 taking into consideration that there will not be any flow of material when the parameters $d_m$, $d_p$ and $\dot{m}_a$ do not exist and there exists the flow of material even when the distance between the primary and secondary nozzles equal to zero. The empirical relation is given as (Equation (3.5))

$$\dot{m}_p = a_0 (L_1 L_m L_0)^{a_1} (d_m d_p m_a)^{a_2} e^{a_3 S}$$

The constants $a_0$, $a_1$, $a_2$, $a_3$, $a_4$, $a_5$, $a_6$ and $a_7$ with the above relationship are to be determined from the experimental results available for different geometry of primary and secondary nozzle combinations and for different $\dot{m}_a$. The constants $a_0$,..., $a_7$ are determined statistically. With a few distinct data and a preliminary equation is developed by means of regression analysis. The above equation is then generalized heuristically for the experimental data and a final equation is developed. For example, the final equation (3.8) for wheat is
\[ m_p = a_o \left( \frac{L_1}{55.0} \right)^{a_1} \left( \frac{L_m}{150.0} \right)^{a_2} \left( \frac{L_o}{105.1} \right)^{a_3} \]
\[ \left( \frac{d_m}{22.5} \right)^{a_4} \left( \frac{d_p}{10.0} \right)^{a_5} \left( \frac{m_a}{1.764} \right)^{a_6} e^{a_7S} \]

which is valid in the range 0 to 23.0 mm for S. The coefficients of correlation for the final equation for wheat and ragi are 0.667 and 0.502 respectively. Further with the above parameters a general \( n^{th} \) degree polynomial equation (3.10) as

\[ m_p = a_0 + a_1S + a_2S^2 + a_3S^3 + ... + a_n S^n \]

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.

6.5 SCOPE FOR FUTURE WORK

The granular materials wheat and ragi were used in the box type injector feeder. Other granular and fluidizable materials can be used and the effect of the various design parameters on the material flow rate can be studied. The inlet tube diameter of the secondary nozzle during the experimental studies were kept at 50.0 mm. The effect of changing this diameter for a given 2a may also be attempted. Detailed theoretical analysis of the system, taking all the design parameters into consideration may be investigated. The dimensions and the number of orifices used in the distributor may be changed and the effect of the same on the mass flow rate may also give scope for future work.