SUMMARY AND CONCLUSIONS

In the two phase flow of gas solid systems most of the work carried out so far deals with flow through the packed beds, batch fluidization and pneumatic transport in horizontal and vertical lines - covering the aspects of mass, momentum and heat transfer. The first work on continuous fluidization of solids by gas was reported by Lewis et. al. [1] and as no pressure drop data or momentum transfer mechanisms were published, the work was taken up by group of workers here in 1952 to have a thorough insight into the basic mechanism of momentum transfer occuring in continuous fluidization phenomenon. In the work of Gopichand et. al.[2] only conditions of lean bed fluidization were obtained and reported and a comparison of momentum transfer was made with that of in pneumatic conveyance phenomenon. The data of Lewis et. al. also fall in the region of lean bed fluidization.

From the observations of the present work it is clear that continuous fluidization in dense bed region exists as distinguished from the lean bed region. While

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1. Ind. Eng. Chem., 41, 1104 (1949).
2. Ind. Eng. Chem., 51, 1449 (1959).

comparison with pneumatic conveyance as chosen by Gopichand et. al., worked out satisfactorily for the lean bed fluidization, it was felt that in the case of dense bed region, comparison with batch fluidization conditions will form a more rational basis. This was achieved through extensive experimental work for which rational dimensional analyses were developed.

In the generalized phase diagram suggested by Zenz [3] for explaining the different phenomena of gas-solid moving systems, no definite region was earmarked for continuous fluidization. This was taken together with pneumatic region. The data of Gopichand et. al., for silica gel - II, when plotted according to the method of Zenz (Fig. 1)*, clearly indicates that continuous fluidization is a transition between batch fluidization and pneumatic conveyance. Thus it can be seen that continuous fluidization condition can be achieved from the pneumatic conveyance zone in the lean bed region and from batch fluidization in the dense bed region.

Data on heat transfer in continuous fluidized beds appear to have not been reported so far in literature and hence experiments were carried to find out the film coefficient of heat transfer from metal wall to bed in a fluidizer with cylindrical baffle. The dimensionless groups

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3. Ind. Eng. Chem., 41, 2801 (1949).

* Enclosed in the back cover pocket of the thesis.

which form the basis of correlation in momentum transfer mechanism, are made use of here also to correlate the heat transfer data in continuous fluidized beds as compared to that of batch fluidized bed. The work is being continued to cover the dense bed zones and higher bed temperature levels.

All the above researches are planned and being carried out with a primary objective to develop a continuity between various aspects of two phase flow relating to gas-solid systems and predict ~~data~~ conditions for the zones for which meagre data is available, from well established correlations in the other zones. The second objective is to apply these techniques to the coking and gasification of run-of-mine coal dust.

The thesis is presented in four chapters and an appendix.

In the first chapter a sincere attempt is made to present the scope of the subject relevant to the present investigation, in momentum transfer studies, in dense bed regions. The references given include momentum transfer studies in batch fluidization and mechanisms and phase diagrams which explain, or schematically indicate different phenomena in gas-solid moving systems. They further help understanding and correlating the momentum transfer in various zones. This scheme of introduction chapter was developed to lead to the work in the thesis, which partly covers the area of momentum transfer studies in

dense bed continuous fluidization. A useful scheme of continuity concept is developed and presented.

Chapter II presents the description of the several pieces of apparatus constructed and used in the present investigations.

Chapter III presents the experimental data and new correlations of momentum transfer studies in continuous fluidizers with and without cylindrical baffles, in three parts A, B & C.

Part - A is practically an extension of continuous fluidization work with coal powder - air system, started earlier. In addition to the lean bed data, distinct dense bed data are obtained. The equation proposed and extended for lean bed data is :

$$\epsilon_s = \phi_L \left[\lambda \frac{D_p g_c}{U_g^2} \frac{\rho_p}{\rho_g} \right]^{1.2} \left[L/D_T \right]^{-2} \quad \ldots\ldots\ldots (1).$$

where

ϵ_s Percentage volume occupied by the solids in the bed

λ solid loading ratio lbs of solid/lbs of gas

D_p Particle diameter

g_c Acceleration due to gravity

U_g Velocity of gas

ρ_p Density of particle

ρ_g Density of gas

L Length of the fluidizer

D_T Diameter of tube (fluidizer)

ϕ_L . 2500.

1) Fluidizers without baffles

$$\lambda_p = \varphi \left[\pi\right]^{0.45} \left[\frac{D_p g_c}{u_g^2}\right]^{0.45} \left[\frac{D_p G}{\mu_f}\right]^3 \qquad (5)$$

where $\varphi = 35 \times 10^{-6}$ for $L/D_T = 35.40$

$\varphi = 6.5 \times 10^{-5}$ " $= 19.81$

G = Mass flow rate of gas

μ_f = Viscosity of gas

2) Fluidizers with cylindrical baffles

$$\lambda_p = \psi \left[\pi\right]^{0.275} \left[\frac{D_p g_c}{u_g^2}\right]^{0.275} \left[\frac{D_p G}{\mu_f}\right]^5 \qquad (6)$$

where $\psi = 0.7 \times 10^{-9}$ for $L/De = 37.82$

$\psi = 1.2 \times 10^{-9}$ " $= 59.50$

In Chapter - IV the data on heat transfer in continuous fluidized beds of coal powder by air are reported. Correlations analogus to momentum transfer are developed and presented; The equation can be expressed as :

$$\lambda_h = 6.75 \left\{ \left[\pi\right]^{0.275} \left[\frac{D_p g_c}{u_g^2}\right]^{0.275} \left[\frac{D_p G}{\mu_f}\right]^5 \left[\frac{D_p}{De}\right]^{1.65} \right\}^{-0.09} \qquad (7)$$

The appendix contains published papers by the author in collaboration with other researchers :

1. Continuous Fluidization of solids by gases
   - J. Sci., Ind. Res., Vol 15B, No. 6, p-323, 1956.
2. Quality Studies in Continuous Fluidization
   - J. Sci., Ind. Res. Vol. 16B, No. 2, p-97, 1957.

3. Flow Properties of solid powders
- Trans.I.I.Ch.E., Vol. IX, 1956-57, Part-I.

4. Pneumatic conveyance and continuous fluidization of solids - Ind. Eng. Chem., Vol. 51, p-1449, 1954.

5. Studies in Vapour Liquid Equilibria at High Pressures - J.Sci. Ind. Res., Vol. 16B, No.1, p-4 (1957).

Note :- Nomenclature and references are given at the end of each Chapter. Equations, Tables and figures are numbered separately for each Chapter.