Relation Between Maximum Semi-Fluidization and Minimum Fluidization Velocities in Gas-Solid Systems

DR. G. K. ROY and H. N. SHARAT CHANDRA

Department of Chemical Engg., Regional Engineering College, ROURKELA.

In this communication data on semi-fluidization characteristics of some gas-solid systems have been reported in form of a correlation relating the ratio of maximum semi-fluidization to minimum fluidization velocity to the various system parameters.

INTRODUCTION

Different aspects of gas-solid semi-fluidization which have been studied and reported earlier include the prediction of minimum and maximum semi-fluidization velocities, (1) packed bed formation (2) and pressure drop across a semi-fluidized bed (3). An attempt has been made here to develop a correlation which relates the ratio of maximum semi-fluidization to the minimum fluidization velocity with the various parameters of the system. A similar relationship was suggested for liquid-solid systems in an earlier communication by one of the authors (4).

EXPERIMENTAL SET-UP

The details of the experimental set-up and the method of investigation have been dealt with in an earlier paper (5).

RESULTS

The two extreme operations of the semi-fluidization phenomena are the on-set of fluidization and maximum semi-fluidization conditions. While the former corresponds to the initiation of particle movement in a fluid-solid bed, the latter indicates the fluid velocity at which all the solids are transferred to the packed section below the top restraint and there is no particle movement in the bed. Since there are a few correlations for the prediction of minimum fluidization velocity from a knowledge of the fluid and solid properties the ratio of maximum semi-fluidization to the minimum fluidization velocity can be related to the various parameters of the system.

The onset of fluidization velocity can be calculated from the equation suggested by Wen and Yu (6) which is as follows :

$$Re_{mf} = \left[(33.7)^2 + 0.0408\, G_a\right]^{\frac{1}{2}} - 33.7 \quad \ldots\ldots(1)$$

The values calculated by the above equation are presented in Table-1.

DEVELOPMENT OF CORRELATION

In both fluidization and semi-fluidization, various sequences of the phenomena are determined by properties of the fluid and the solid as well as the geometry of the system. Among the variables, important ones are :, h_s, D_{ef} d_p P_s P_f and R. During investigations, it was observed that neither the bed expansion ratio nor the initial static bed height had any influence on the maximum

TABLE — 1 COMPARISON OF MAXIMUM SEMI-FLUIDIZATION VELOCITY

System	$\frac{Dc}{dp}$	$\frac{\rho_s}{\rho_f}$	G_{mf} Kg/hr m^2	G_{msf} Kg/hr m^2		Percentage Deviation
				Cal.	Expt	
Dolomite-Air	18.10	1210.00	8230	36200	43000	— 15.80
Dolomite-Air	39.80	1210.00	4450	31200	28000	+ 11.40
Dolomite-Air	80.00	1210.00	1830	19750	17000	+ 16.20
Dolomite-Air	113.30	1210.00	1030	13700	14000	— 2.14
Chromite-Air	39.80	1590.00	5370	31800	32000	— 0.625
Baryte-Air	39.80	1900.00	5950	30600	36000	— 15.00
Iron Ore-Air	39.80	2244.00	6600	30000	40000	— 25.00

semi-fluidization velocity. The other variables expressed in the form of dimensionless groups will be :

$$\frac{G_{msf}}{G_{mf}} = \psi \left[\frac{D_c}{d_p}, \frac{\rho_s}{\rho_f} \right] \quad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Or $$\frac{G_{msf}}{G_{mf}} = A \left(\frac{D_c}{d_p}\right)^{a1} \left(\frac{\rho_s}{\rho_f}\right)^{a2} \quad \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Where A is a constant and al and a2 are the respective exponents of the system variables.

The effects of the individual parameters have been studied and the exponents evaluated. Substituting these exponents, equation (3) becomes

$$\frac{G_{msf}}{G_{mf}} = A \left[\left(\frac{D_c}{d_p}\right)^{0.60} \left(\frac{\rho_s}{\rho_f}\right)^{-0.72} \right]^{B} \quad \ldots\ldots\ldots (4)$$

Where A is the coefficient and B is the exponent of the overall product which is correlation factor for the exponents of the system variables.

The equation for the straight line (Fig. 1) is

$$\frac{G_{msf}}{G_{mf}} = 130 \left[\left(\frac{D_c}{d_p}\right)^{0.60} \left(\frac{\rho_s}{\rho_f}\right)^{-0.72} \right] \quad \ldots\ldots (5)$$

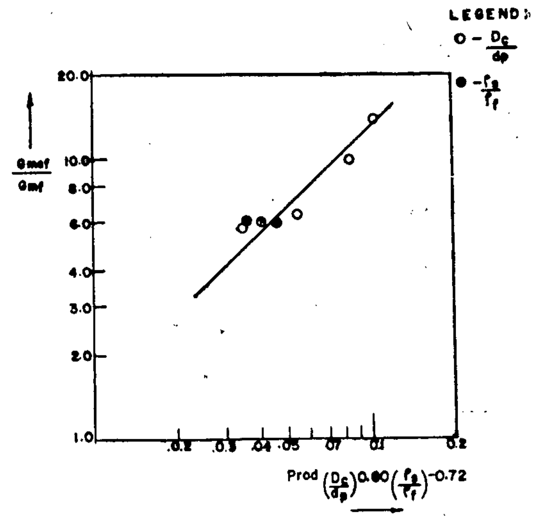

FIG.1 VARIATION OF Gmsf/Gmf WITH SYSTEM VARIABLES

The values of G_{msf} calculated from the above equation have been found to be in close agreement with the experimental data. The individual deviations are given in Table-1. It is found that, except for one case, the deviations lie within ± 18%.

NOMENCLATURE

A	=	Constant or co-efficient.
Dc	=	Diameter of column (semi-fluidizer)
dp	=	Particle diameter, L.
G	=	Mass velocity of fluid, $M\Theta^{-1}L^{-2}$
Ga	=	Galileo number, dimensionless group, $\frac{d_p^3 \rho_f (\rho_s - \rho_f) g}{\mu^2}$
G_{mf} G_{msf}	=	Mass velocity for minimum fluidization and maximum semi-fluidization conditions respectively, $M\Theta^{-1}L^{-2}$
h	=	Overall height of column (semi-fluidized bed), L
h_s	=	height of initial static bed, L
R	=	bed expansion ratio in semi-fluidization, h/h_s
Re_{mf}	=	Reynolds number corresponding to minimum fluidization condition, dimensionless group, $\frac{d_p G_{mf}}{\mu}$
ψ	=	Function.
μ	=	Viscosity of fluid, $M\Theta^{-1-1}$.
ρ_f, ρ_s	=	Density of fluid & solid respectively, ML^{-3}.

ACKNOWLEDGEMENT

The authors are thankful to the B.S. & I.R., Orissa for providing the necessary finance to carry out this work.

REFERENCES

1. Roy, G. K. and Sen Gupta, P. Processing, (U.K.), Jan, (1975.)
2. Roy, G. K. and Sen Gupta, P. **Ind.** Engg., Chem. Process Design Develop, Vol 13, No. 3 (1974).
3. Roy G. K. and Sen Gupta, P. The Chem. Engg. Jl., 5 (1973).
4. Roy, G. K. and Sarma, K. J. R., Jl. of Instn. of Engrs. **(India),** Vol. 54, Pt. CH. 2 (1974).
5. Roy, G. K. and Sarma, K. J. R., Paper Communicated to **Indian Jl. of** Technology for Publication.
6. Wen. C. Y. and Yu. Y. H.. **A.I.Ch.E.Jl.,** 12, 610 (1966).