Reprinted from the Journal of the Institution of Engineers (India) Vol. 54, pt CH 2, February 1974

UDC: 66.095.5

Relation Between Maximum Semi-Fluidization and Minimum Fluidization Velocity in Liquid-Solid Systems

G K Roy, *Associate Member*

Dr K J R Sarma, *Non-member*

In this paper data on semi-fluidization characteristics of some liquid-solid systems have been reported. Also, a correlation relating the maximum semi-fluidization with the minimum fluidization velocity in terms of various systems parameters has been developed and discussed.

NOTATIONS

A = constant or coefficient

D_c = diameter of column (semifluidizer), L

d_p = particle diameter, L

G = mass velocity of fluid, $M\theta^{-1}L^{-2}$

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 (semifluidized bed) L

h_s = height of initial static bed, L

R = bed expansion ratio in semi-fluidization, h/h_s

Ψ = function

μ = viscosity of fluid, $M\theta^{-1}L^{-1}$

ρ_f, ρ_s = density of fluid and solid respectively, ML^{-3}

INTRODUCTION

The various aspects of liquid-solid semi-fluidization which have been studied and reported earlier by the authors, include the prediction of minimum and maximum semi-fluidization velocities[2], packed bed formation. In a recent paper[3] the authors have given a correlation for the prediction of minimum semi-fluidization velocity from minimum fluidization velocity. An attempt has been made here to develop a correlation which relates the ratio of the maximum semi-fluidization velocity to the minimum fluidization velocity with the system parameters.

EXPERIMENTAL SET-UP

The experimental set-up used in the present study is given in Fig 1. The details of the set-up and the method of investigations are described in an earlier paper[2].

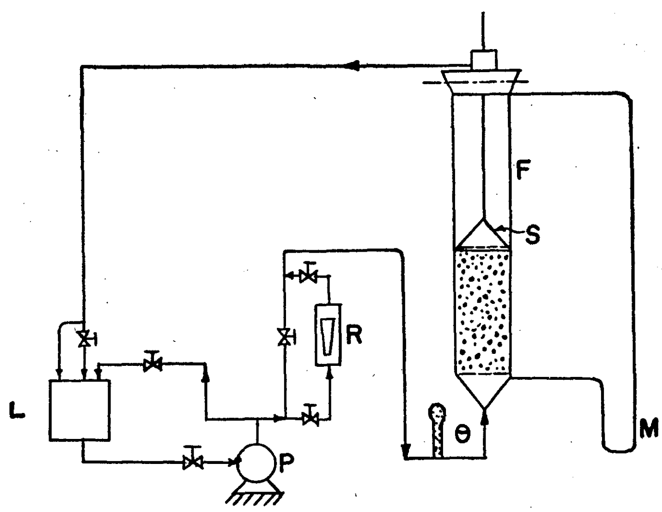

Fig 1 Liquid-solid semi-fluidization set-up
L = Liquid Reservoir
P = Pump
R = Rotameter
0 = Thermometer
F = Fluidization column
S = Adjustable Restraint (with screen)
M = Monometer

RESULTS

The onset of fluidization and maximum semi-fluidization conditions are the two extreme operations of the semi-fluidization phenomena. 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. There are a few correlations for the prediction of minimum fluidization velocity from a knowledge of the fluid and solid properties. Hence 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 Leva's simplified equation[1]. (FPS units)

$$G_{mf} = 688\, d_p^{\,1\cdot 82} \frac{[\rho_f\,(\rho_s - \rho_f)]^{0\cdot 94}}{\mu^{0\cdot 88}} \quad (1)$$

G K Roy and Dr K J R Sarma are with the Department of Chemical Engineering, Regional Engineering College, Rourkela.
This paper was received on July 19, 1973. Written comments on this paper will be received until April 30, 1974.

As equation (1) is valid for $Re_{mf} < 10$, for higher values correction factors were applied to obtain the accurate values of *Gmf*. The values calculated by the above equation are given in Table 1.

TABLE 1 COMPARISON OF MAXIMUM-FLUIDIZATION VELOCITY

System	$\frac{D_c}{d_p}$	$\frac{\rho_s}{\rho_f}$	G_{mf} $\frac{lbs}{hr\ ft^2}$	G_{msf} $\frac{lbs}{hr\ ft^2}$ Cal	Expt	Percentage Deviation
Dolomite-water	16.45	2.76	20 600	194 000	180 000	+ 7.57
Dolomite-water	36.40	2.76	9 440	124 000	115 000	+ 7.82
Stonechips-water	16.45	2.65	19 800	191 000	180 000	+ 6.11
Stonechips-water	36.40	2.65	9 100	123 000	110 000	+11.80
Iron ore-water	16.45	5.05	33 800	211 500	260 000	—18.65
Iron ore-water	36.40	5.05	17 200	151 500	175 000	—13.40
Coal water	36.40	1.58	3 970	75 500	84 000	—10.10

DEVELOPMENT OF CORRELATION

In fluidization as well as semi-fluidization, properties of the fluid and the solid as well as the geometry of the system will determine the various sequences of the phenomena. Among the variables, important ones are: h_8, D_c, dp, P_s, p_f and R. During investigations it was observed that the bed expansion ratio and the initial static bed height have no influence on the maximum semi-fluidization velocity. Writing the other variables in the form of dimensionless groups

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

or

$$\frac{G_{msf}}{G_{mf}} = A\left(\frac{D_c}{d_p}\right)^{a_1}\left(\frac{\rho_s}{\rho_f}\right)^{a_2} \quad (3)$$

where A is a constant and a_1 and a_2 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

$$\frac{G_{msf}}{G_{mf}} = A\left[\left(\frac{D_c}{d_p}\right)^{0.42}\left(\frac{\rho_s}{\rho_f}\right)^{-0.67}\right]^B$$

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

The equation for the straight line (Fig 2) is

$$\frac{G_{msf}}{G_{mf}} = 5{\cdot}71\left(\frac{D_c}{d_p}\right)^{0.42}\left(\frac{\rho_s}{\rho_f}\right)^{-0.67} \quad (5)$$

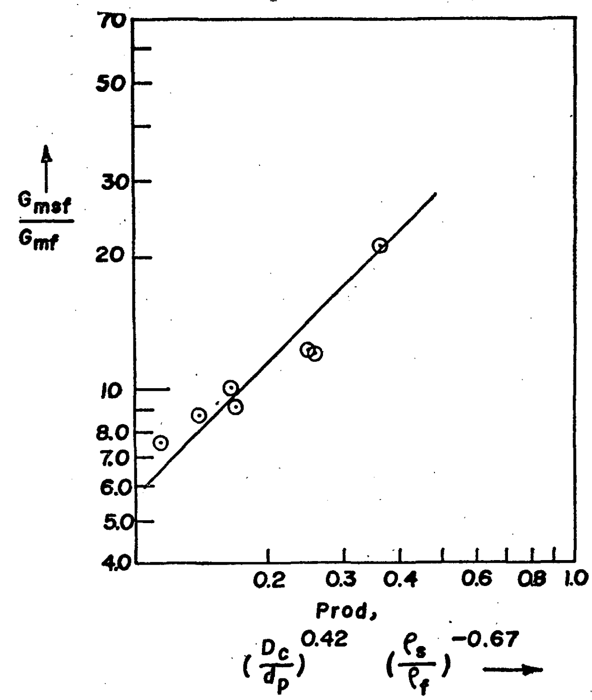

Fig 2 Gmsf/Gmf with system variation

The values of G_{msf} calculated from the above equation have been found to be in good 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 ±15%.

REFERENCES

1. M Leva. 'Fluidization'. *McGraw Hill Book Co Inc.* 1959.

2. G K Roy and K J R Sarma. 'Prediction of Onset of Semi-fluidization and Maxmum Semi-fluidization Velocities and the Packed Bed Height'. *Chemical Processing and Engineering*, vol 5, no 6, 1971, p 23.

3. G K Roy and K J R Sarma. 'Dynamics of Liquid-solid Semi-fluidization-III: Relation Between Onset of Fluidization and Minimum Fluidization Velocity'. *Chemical Engineering Journal*, vol 4, 1972, p 294.