Prediction of Semi-fluidization Velocity of Irregular Particles in Liquid-Solid System

— G. K. ROY & K. J. R. SARMA*

In an earlier paper (2), the authors have given two nomographs for the prediction of minimum and maximum semifluidization velocities. While it is necessary to know the velocity at which semi-fluidization begins (the first particle of the bed touches the top retraint) and also the velocity at which all the particles are transferred to the packed bed below the top screen, it is also necessary to know the variation of the height of the top packed bed with the change in velocity of the fluid, the two limits of the velocity being the onset of semi-fluidization velocity and the maximum semi-fluidization velocity. The values of fluid velocity in between the two extreme limits (the onset and the maximum) are termed as semi-fluidization velocities which, along with other system variables, also depend on the particle oncentrations in the two sections of the bed. A glance into literature reveals scanty informations in this aspect. Based on their experimental data, Roy and Sarma have given the following correlation for the prediction of semi-fluidization velocity of irregular particles in liquidsolid systems from a knowledge of the properties of the system and the solid and fluid properties (3). The proposed correlation is

$$\frac{G_s}{G_{msf}} = 0{\cdot}945 \left(\frac{D_c}{d_p}\right)^{-0\cdot15} \left(\frac{\rho_s}{\rho_f}\right)^{-0.11} (R)^{0\cdot57} \left(\frac{h_s}{D_c}\right)^{0.10} \left(\frac{h_{pa}}{h_s}\right)^{0.66} \quad .. \quad (1)$$

The correlation for the prediction of Gmsf, has been given in an earlier paper (1).

Based on equation (1), a nomograph has been prepared for the rapid estimation of the semi-fluidization velocity ratio and with the help of the maximum semi-fluidization velocity, obtained by an earlier nomograph. (Fig. 1, Ref. 2) the actual semi-fluidization velocity can be calculated for a definite fixed bed at the top.

Accuracy of the nomograph

The value found from nomograph, has been compared with the respective values obtained by the other two methods, viz. from the equation and the actual experiment. The percentage deviations have also been calculated.

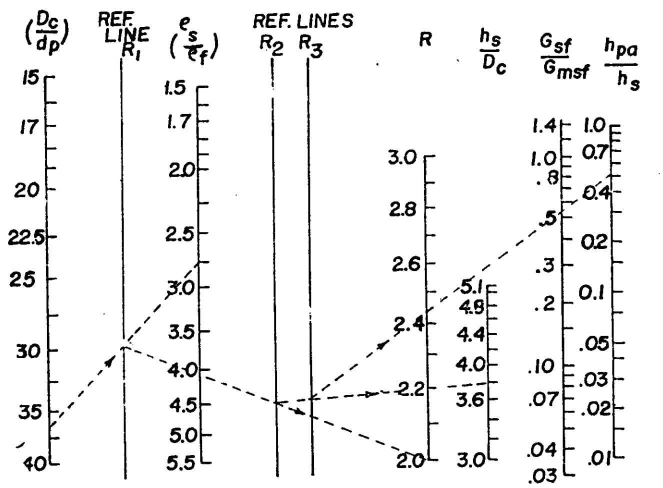

Fig. 1: Prediction of Semi-fluidization Velocity ratio

EXAMPLE :

System	—	Dolomite-water
Diameter of column (D_c)	—	1.58 inch.
Particle size (d_p)	—	0.0036 ft.
Particle density (ρ_s)	—	172.2 lb/ft.^{3}
Fluid density (ρ_f)	—	62.4 lb/ft.^{3}
Fluid viscosity (μ)	—	0.8 c. p
Bed expansion ratio (R)	—	2.0
Initial static bed height (h_s)	—	6.0 inch
Depth of top packed bed (h_{pa})	—	3.0 inch

Calculate and compare the value of semi-fluidization velocity for the above case

(i) From equation —

$$\frac{G_{sf}}{G_{msf}} = 0{\cdot}945 \left(\frac{D_c}{d_p}\right)^{-0\cdot15} \left(\frac{\rho_s}{\rho_f}\right)^{-0\cdot11} (R)^{0.57} \left(\frac{h_s}{D_c}\right)^{0\cdot10} \left(\frac{h_{pa}}{h_s}\right)^{0.66}$$

$D_c / d_p = 36.40$ $\quad h_s / D_c = 3{\cdot}80$

$\rho_s / \rho_f = 2.76$ $\quad h_{pa} / h_s = 0{\cdot}50$

$R = 2{\cdot}0$

* The authors are with the Dept. of Chemical Engg., Regioanal Engineering College, Rourkela-8 (Orissa).

$$\frac{G_{sf}}{G_{msf}} = 0.954\ (36.40)^{-0.15}\ (2.76)^{-0.11}\ (2.0)^{0.57} (3.80)^{0.10} (0.50)^{0.66} = 0.532$$

$$G_{msf} = 2{\cdot}675 \times 10^4\ (d_p)^{0{\cdot}74}\ [\ \rho_s\ (\rho_s - \rho_f)\ ]^{0{\cdot}58}$$
$$= 2{\cdot}675 \times 10^4\ (.0036)^{74}\ [\ 172.2\ (172-62{\cdot}4)\ ]^{0{\cdot}58}$$
$$= 1.27 \times 10^5 \text{ lbs/hr. ft}^2.$$

$$G_{sf} = 0.532 \times 1.27 \times 10^5 = 67500 \text{ lbs/hr.ft}^2.$$

(ii) From experiment —

G_{sf} = 61750 lbs/hr.ft^2.

(iii) From nomograph —

$$\frac{G_{sf}}{G_{msf}} = 0.53$$

G_{msf} = 1.28 x 10^5 lbs/hr.ft^2 (from fig. 1 of Ref. 2)

G_{sf} = 67800 lbs/hr. ft^2.

TABLE 1

Comparison of G_{sf} values

G_{sf}, lbs/hr. ft^2			Percentage deviation of nomograph values	
Nomo-graph	Experi-ment	Calcula-tion	From experimental values	From calculated value
67800	61750	67500	+9.80	+0.45

NOMENCLATURE

A_r = Archimedes number, $\frac{d^3p\, g_c\, \rho_s (\rho_s - \rho_f)}{\mu^2}$

D_c = Inside diameter of column (semifluidizer), L

d_p = Particle diameter, L

G_{msf} = Maximum semi-fluidization velocity, $ML^{-2}\theta^{-1}$

G_{sf} = Semi-fluidization velocity, $ML^{-2}\theta^{-1}$

h_{pa} = Height of packed section in semifluidized bed, L

h_s = Height of initial static bed, L

R = Bed expansion ratio, i.e. ratio of the top restraint height from the bottom restraint to the initial fixed bed height.

GREEK LETTERS :

ρ_s = Density of solid, ML^{-3}

ρ_f = Density of fluid, ML^{-3}

μ = Viscosity of fluid, $ML^{-1}\theta^{-1}$

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