Published in The Chemical Engineering Journal, 1972, Vol 4, Iss 3

Dynamics of liquid–solid semifluidization
III. Relation between onset of semifluidization and minimum fluidization velocity

G. K. ROY and K. J. R. SARMA

Department of Chemical Engineering, Regional Engineering College, Rourkela-8, Orissa (India)

(Received 10 January 1972; finally 6 October, 1972)

Data on semifluidization characteristics for a few liquid–solid systems have been reported. A correlation relating the onset of semifluidization with the minimum fluidization velocity has been developed in terms of various system parameters.

In our earlier work, correlations have been developed for the prediction of the onset and the maximum semifluidization velocities and the packed-bed formation for liquid-solid systems[1,2]. In the present paper, a correlation has been developed which relates the ratio of the minimum semifluidization velocity to the minimum fluidization velocity with the system parameter. The experimental setup used in the present study is described in detail in an earlier paper[1]. Altogether 104 sets of runs have been taken. Four non-spherical materials, viz. dolomite, stone chips, coal and iron ore of sizes 6/8 and 14/16 BSS, and one spherical material, viz. glass beads of size 0.0164 ft (0.5 cm dia), have been studied. The lowest and highest specific gravities of solids used are 1.58 and 5.05, respectively.

Prediction of minimum semifluidization velocity from minimum fluidization velocity

The onset of fluidization and semifluidization are two consecutive events in the sequence of operations of the semifluidization phenomenon. While the former corresponds to the initiation of particle movement in a fluid-solid bed, the latter indicates the fluid velocity at which the bed first touches the top restraint of the semifluidizer. There are many correlations for the prediction of minimum fluidization velocity from a knowledge of the fluid and solid properties. Hence the ratio of the minimum semifluidization to the minimum fluidization velocity can be related through the various parameters of the system.

Both in semifluidization and fluidization, the properties of the fluid and the solid as well as the geometry of the system will determine the onset conditions for the respective operations. Important among the variables are: $h_s, D_c, d_p, \rho_s, \rho_f$ and R. Writing in the form of dimensionless groups one may get,

$$\frac{G_{osf}}{G_{mf}} = \psi\left[\frac{h_s}{D_c}, \frac{D_c}{d_p}, \frac{\rho_s}{\rho_f}, R\right] \quad (1)$$

Since the column diameter has not been changed in the present study, the effect of the group h_s/D_c is not relevant. Consequently we consider an expression

$$\frac{G_{osf}}{G_{mf}} = A(D_c/d_p)^{a_1}(\rho_s/\rho_f)^{a_2}(R)^{a_3} \quad (2)$$

where a_1, a_2 and a_3 are exponents.

The effects of the individual parameters have been studied and the exponents evaluated. Substituting these exponents, eqn. (2) becomes,

$$\frac{G_{osf}}{G_{mf}} = A\left[(D_c/d_p)^{0.266}(\rho_s/\rho_f)^{-0.228}(R)^{0.585}\right]^B \quad (3)$$

Fig. 1 presents a log-log plot of G_{osf}/G_{mf} against $(D_c/d_p)^{0.266}(\rho_s/\rho_f)^{-0.228}(R)^{0.585}$. Two parallel straight lines, one for the spherical and the other for the non-spherical particles, have been obtained. The equations for these lines can be written, for non-spherical particles:

$$\frac{G_{osf}}{G_{mf}} = 1.625\,(D_c/d_p)^{0.266}(\rho_s/\rho_f)^{-0.228}(R)^{0.585} \quad (4a)$$

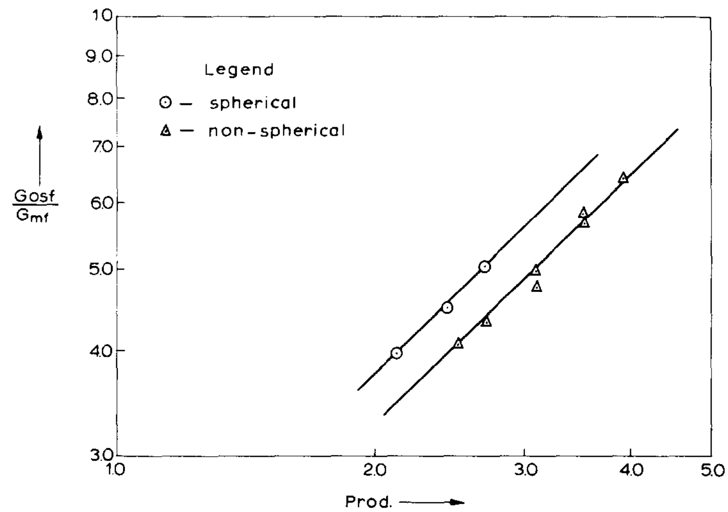
and for spherical particles:

$$\frac{G_{osf}}{G_{mf}} = 1.875\,(D_c/d_p)^{0.266}(\rho_s/\rho_f)^{-0.228}(R)^{0.585} \quad (4b)$$

The onset of fluidization velocity, G_{mf}, has been calculated from Leva's simplified equation[3]:

$$G_{mf} = 688\, d_p^{1.82}\, \frac{[\rho_f(\rho_s - \rho_f)]^{0.94}}{\mu^{0.88}} \quad (5)$$

The values of G_{osf} calculated from the above two equations have been found to be in good agreement with the experimental data. The individual deviations are given in Table 1. All the deviations lie within ±6%. However, it is felt that spherical particles need to be studied more exhaustively to make the correlation more generalized.



$\left(\frac{D_c}{d_p}\right)^{0.266} \left(\frac{\rho_s}{\rho_f}\right)^{-0.228} (R)^{0.585}$

Fig. 1. Relation of G_{osf}/G_{mf} with system variables.

TABLE 1

Comparison of minimum semifluidization velocity

Sl. No.	*System*	G_{mf} *(lb./h ft²)*	G_{osf} *(lb/h ft²)*		
			From Caln.	*From experiment*	*% deviation from expt. value*
	Non-spherical				
1.	Dolomite-water	20600	84000	84000	0.00
	(d_p = 0.0080 ft.)		95600	95900	−0.31
			105800	108000	−2.04
2.	Dolomite-water	9440	47500	47000	1.06
	(d_p = 0.0036 ft.)		54100	53600	0.93
			60100	60600	−0.82
3.	Stone chips-water	19800	81500	81000	0.62
	(d_p = 0.0080 ft.)		92600	92500	0.11
			103300	104000	−0.67
4.	Stone chips-water	9100	46100	43500	5.97
	(d_p = 0.0036 ft.)		52600	50200	4.79
			58500	56200	4.10
5.	Iron ore-water	33800	119800	115000	4.17
	(d_p = 0.0080 ft.)		136800	130500	4.83
			152000	152000	0.00
6.	Iron ore-water	17200	75500	74500	1.34
	(d_p = 0.0036 ft.)		86000	85500	0.59
			95500	96000	−0.52
7.	Coal-water	3970	22600	23100	−2.16
	(d_p = 0.0036 ft.)		25800	26700	−3.37
			28700	30200	−4.96
	Spherical				
8.	Glass beads-water	30500	122000	121000	0.83
	(d_p = 0.0164 ft.)		138500	137000	1.10
			154400	154000	0.26

Nomenclature

D_c	diameter of column (semifluidizer), [L]
d_p	particle diameter, [L]
G	mass velocity of fluid, $[M\Theta^{-1} L^{-2}]$
G_{mf}	minimum fluidization velocity, $[M\Theta^{-1} L^{-2}]$
G_{osf}	minimum semifluidization velocity, $[M\Theta^{-1} L^{-2}]$
h_s	height of initial static bed, [L]
R	bed expansion ratio in semifluidization, dimensionless

Greek letters

ψ	function
μ	viscosity, $[M\Theta^{-1} L^{-1}]$
ρ	density, $[ML^{-3}]$

Subscripts

c	column
f	fluid
mf	minimum fluidization conditions
osf	minimum semifluidization conditions
s	solid.

References

1 G. K. Roy and K. J. R. Sarma, *Chem. Proc. Eng.*, 5 (6) (1971) 23.
2 G. K. Roy and K. J. R. Sarma, submitted to *Indian Journal of Technology*.
3 M. Leva, *Fluidization*, McGraw-Hill, New York, 1959.