Reprinted from Indian Chemical Engineer January-March 1977 Vol. XIX No. 1
Pages 33—35

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Short Communication

Prediction of Maximum Semi-Fluidization Velocity for Heterogeneous Mixtures in Liquid-Solid Systems

The necessity of a generalized correlation for the prediction of maximum semi-fluidization velocity is emphasized. Values of the maximum semi-fluidization velocity, obtained from experimental investigations, have been compared with those from a theoretical equation, developed earlier for single-sized particles; and the deviations have been critically examined.

VARIOUS ASPECTS OF LIQUID-SOLID semi-fluidization have been studied and reported by different authors. These include the prediction of minimum and maximum semi-fluidization velocities,[1-4] packed bed formation,[5-7] and pressure drop across a semi-fluidized bed.[8] So far as the liquid-solid system is concerned the literature relating to the behaviour of the mixed particles' system is very limited,[9,10] as compared to the information available for close-cut particles.

Here an atempt has been made to calculate the maximum semi-fluidization velocities, in the case of various heterogeneous mixtures, by the equation developed for single-sized particles incorporating suitable modifications and comparing the same with the experimental values.

Experimental Set-up

The details of the experimental set-up used in the present study have been given in an earlier paper.[9]

Results and Discussion

Altogether 32 sets of runs were taken using different combinations of 36/44 B.S.S.-size of dolomite, chromite, baryte and iron ore particles to study the effects of various system parameters on G_{msf} (maximum semi-fluidization velocity) values. The mixtures can, be called heterogeneous with respect to materials, as only one particular size of materials, i.e. 36/44 B.S.S. was used. The characteristics of solid mixtures and the ranges of variables studied are given in *Table I.*

One of the authors has given the following correlation for the prediction of maximum semi-fluidization velocities for pure components in a liquid-solid system,[10]

$$G_{msf}=\frac{1{\cdot}85\times10^4\ (d_p)^{0{\cdot}65}\ [\rho_f(\rho_s-\rho_f)]^{0{\cdot}55}}{(\mu^{0{\cdot}1})} \qquad (1)$$

The particle density in the above equation has been replaced by $(\rho_s)_{av}$ for the present case and this has been calculated as follows:

$$(\rho_s)_{av}=\frac{\Sigma W}{\Sigma \frac{W}{\rho_s}} \qquad (2)$$

With $(\rho_s)_{av}$ the values of G_{msf} have been calculated by equation (1)

TABLE I

CHARACTERISTICS OF MIXTURES AND RANGES OF VARIABLES STUDIED

Particle size: 36/44 BSS *Mixture ratio: 50:50 binary*

Sl. No.	Mixture Nomenclature	$(\rho_s)_{av}$ from eqn. (2) kg/m³	h_s cms.	R.
1.	Dolomite-chromite	$3{\cdot}21\times10^3$	6·0, 8·0 10·0, 12·0	2·0, 2·5, 3·0, 3·5
2.	Dolomite-baryte	$3{\cdot}45\times10^3$	6·0	-do-
3.	Dolomite—iron ore	$3{\cdot}67\times10^3$	6·0	-do-
4.	Iron ore-chromite	$4{\cdot}34\times10^3$	6·0	-do-
5.	Iron ore-baryte	$4{\cdot}80\times10^3$	6·0	-do-

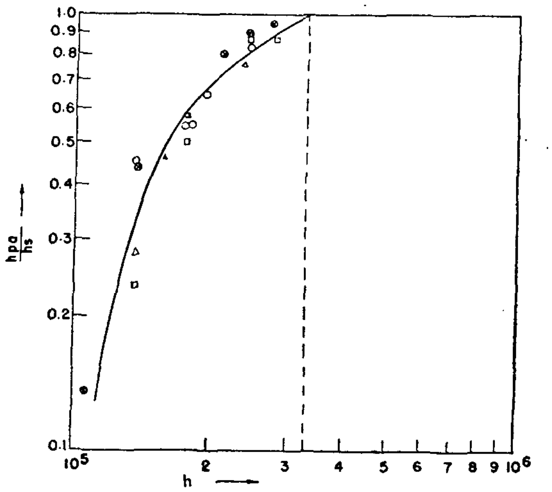

Fig. 1 Effect of static bed height on maximum semi-fluidization velocity.

Fluid mass velocity: G, Kg/Hr. M^2
System: dolomite—chromite—water
Mixture characteristics: 50:50
Size of the particles: $-36+44$ B.S.S.
Bed expansion ratio: R=2·5

hs_1= 6 cm — — — ○
hs_2= 8 cm — — — ⊗
hs_3=10 cm — — — △
hs_4=12 cm — — — □

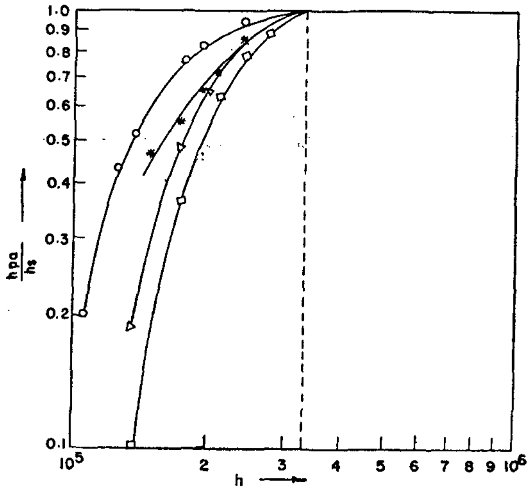

Fig. 2 Effect of bed expansion ratio on maximum semi-fluidization velocity.

Fluid mass velocity: G, Kg/Hr. M^2
System: dolomite—chromite—water
Static bed height: 6 cm.
Mixture characteristics: 50:50
Size of the particles: $-36+44$ B.S.S.

R=2·0 — — — ○
R=2·5 — — — ✳
R=3·0 — — — △
R=3·5 — — — □

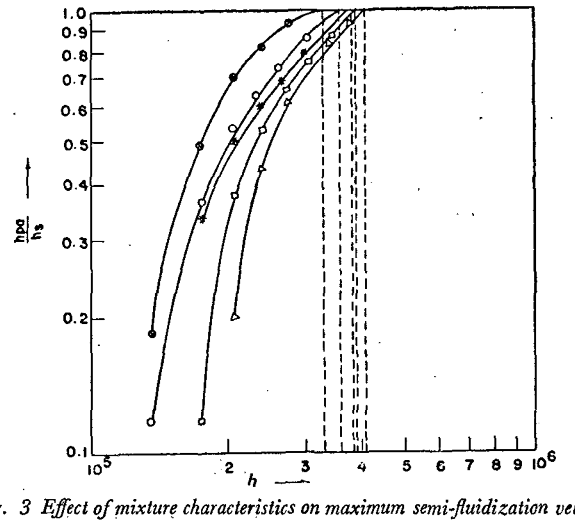

Fig. 3 Effect of mixture characteristics on maximum semi-fluidization velocity.

Fluid mass velocity: G, Kg/Hr. M^2
Static bed height: hs=6 cm
Bed expansion ratio: R=3·0
Mixture characteristics: 50:50
Size of the particles: $-36+44$ B.S.S.

Dolomite - chromite — — — ⊗
Dolomite - baryte — — — ○
Dolomite - iron Ore — — — ✳
Iron Ore - chromite — — — □
Iron Ore - baryte — — — △

TABLE II

COMPARISON OF THE MAXIMUM SEMI-FLUIDIZATION VELOCITIES

Sl. No.	Mixture characteristic (50:50)	G_{msf}, $\frac{kg}{hr.m^3}$ from experiment	G_{msf}, $\frac{Kg}{hr.m^2}$ from equation	Deviation of calculated values from the experimental value
1.	Dolomite-chromite	330000	309000	−6·37
2.	Dolomite-baryte	355000	327000	−7·90
3.	Dolomite-iron ore	375000	339000	−9·60
4.	Iron ore-chromite	385000	384000	−0·286
5.	Iron ore-baryte	405000	411000	+1·48

The experimental values of G_{msf} have been obtained from the packed bed formation vs. mass velocity plots, and it has been observed that the maximum semi-fluidization velocity is little affected by both static bed height and the bed expansion ratio *(Figures 1* and *2* respectively). However, the mixture characteristics have profound influence on the maximum semi-fluidization velocity *(Figure 3).*

The experimental values of G_{msf} have been compared in *Table II* with those obtained by equation (1). The deviations are found to lie within ±10%. Further, it is found that in all the cases except one the experimental values are higher than the calculated ones. This may be due to the fact that in the case of calculated values, the average values of density have been used for the mixtures, whereas in actual experiments, fluid velocities necessary to lift the denser particles will be higher than those calculated on the basis of the average (weighted) particle density of mixtures.

Paper received: 28-9-76 Accepted: 18-1-77

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

NOMENCLATURE

B.S.S.	British Standard Sieve
d_p	particle diameter, L
G_{msf}	maximum semi-fluidization velocity, $ML^{-2}\Theta^{-1}$
h	height of semi-fluidized bed, L
h_{pa}	height of packed bed in semi-fluidization, L
h_s	height of initial static bed, L
R	bed-expansion ratio in semi-fluidization, dimensionless, h/h_s
$(\rho_s)_{av}$	average (weighted) density of the mixture, ML^{-3}
ρ_f	density of fluid, ML^{-3}
ρ_s	density of solid, ML^{-3}
μ	viscosity of fluid, $ML^{-1}\Theta^{-1}$
W_1, W_2..	weights of components of the mixture

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