The slip velocity between particulate solids and an interstitial fluid

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SYNOPSIS

An empirical dimensionless correlation is presented that relates system variables to the superficial slip velocity between solid mineral products and an interstitial fluid. The correlation is valid within engineering accuracy for all solids and fluids at all concentrations. The particular usefulness of the correlation is that it provides explicit equations for both slip velocity and voidage.

SAMEVATTING

'n Empiriese dimensielose verwantskap wat sisteem veranderlikes met die glipsnelheid tussen minerale vastestowwe en 'n omringende vloeistof verbind, word gegee. Die verwantskap het voldoende akkuraatheid vir ingenieursdoeleindes vir alle vastestowwe en vloeistowwe teen alle konsentrasies. Die besondere nut van die verwantskap lê in die explisiete oplossings wat dit bied vir beide glipsnelheid en vloeistof volume fraksie.

Introduction

The superficial slip velocity, U_c, between solids and interstitial fluid is a quantity needed for calculations in a wide range of applications in solid and fluid technology such as fluidization, vertical transport of solids, sizing of discharge orifices and downcomers, classification, sedimentation, thickening, and continuous crystallization.

Relationship between Design Quantities and Superficial Slip Velocity

The mean suspension velocity, U_m, of a slurry in upflow is related to U_c as follows:

$$U_m = U_c (1 - E)/(E_d - E),$$

where

E = the *in situ* liquid fraction in the pulp, and

E_d = the volume fraction of the input and discharge liquid of the slurry.

For a fluidized bed in which the solids flux is zero, U_c equals the superficial flowrate of liquid, i.e. the upflow rate of liquid above the interface of the fluidized bed. For sedimenting systems, the solids flux is $U_c\ (1 - E)$. For a discharge orifice or a downcomer feeding a closed receiver, this equals the displaced-liquid flux.

A General Explicit Correlation for Superficial Slip Velocity

Above the fluidizing limit (typically above $E = 0{,}4$), the superficial Reynolds number of particles being fluidized, $R_e = U_c\, d/v$, can be related to their Archimedes number, $A_r = gd^3\ (S - 1)/v^2$, as follows:

$$R_e = a((1 + bE^c A_r)^{\frac{1}{2}} - 1).$$

The term E^c is an empirical correction to account for the effect of increased effective drag due to the momentum transfer between particles and the decreased cross-sectional area of fluid flow as the concentrations of particles increase.

For most mineral products that are much smaller than the spacings on the equipment, this equation is valid within an engineering accuracy that is acceptable, in view of the usual ignorance concerning corrections for variations in particle shapes, over the entire range of flow regimes if the constants $a = 8{,}4$, $b = 0{,}10$, and $c = 4{,}7$ are chosen. This is demonstrated in Figs. 1 and 2. For greater precision, the constants should be determined

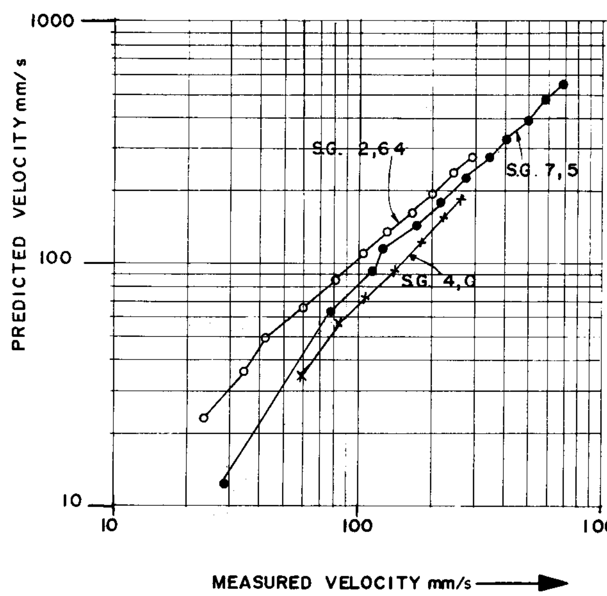

Fig. 1—Free settling velocities in water (measured velocities from Taggart[1]). SG = specific gravity or relative density.

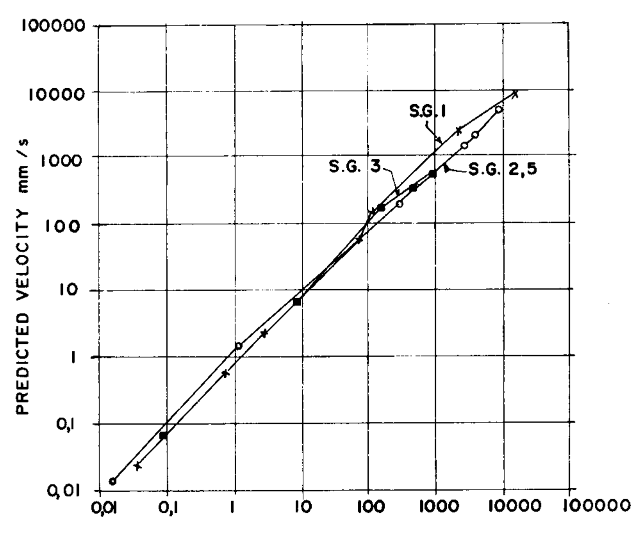

Fig. 2—Free settling velocities in air (measured velocities from Taggart[2]). SG = specific gravity or relative density.

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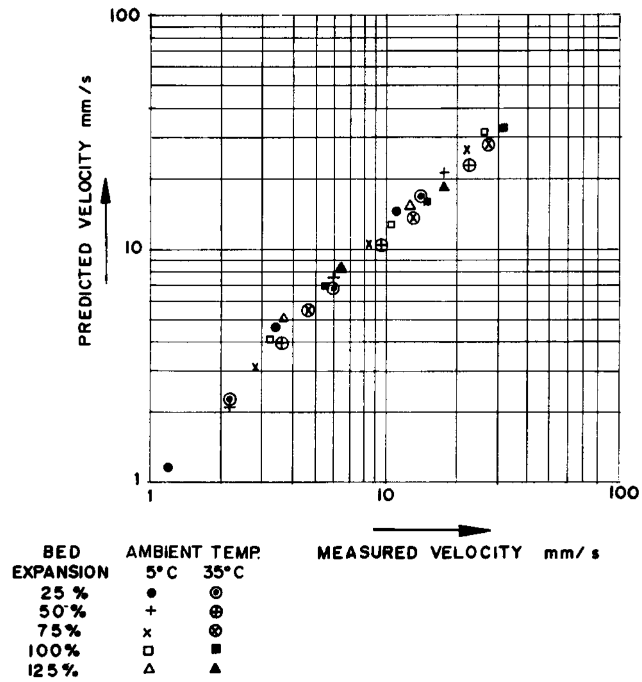

Fig. 3—Hindered settling velocities of wetted activated carbon (relative density 1,28) in water (measured velocities from Edward L. Bateman).

by experiment for specific applications. An example is the fluidization of activated carbon for the recovery of gold, for which the constants $A = 5{,}47$, $B = 0{,}0335$, and $C = 4{,}7$ give a good fit (see Fig. 3).

The particular usefulness of the above equation is that U_c or E can be solved explicitly. This gives direct solutions for systems with essentially uniform particle-size distributions such as typical sedimenting coagulates or 'flocs'. Fluidized beds can be considered to consist of layers containing uniform particles if size ranges under 1,414 : 1 are considered.

Symbols Used

A_r = Archimedes number (ratio of particle buoyancy to drag forces) $= (gd^3(S - 1)/v^2)$
d = Particle diameter
E = Fraction of *in situ* fluid volume
E_d = Fraction of inlet and discharge fluid volume
g = Gravitational constant = 9,81 m/s
R_e = Reynolds number (ratio of particle inertial to viscous forces) $= U_c d/v$
S = Relative density of particle relative to the density of the *in situ* suspension
U_c = Superficial slip velocity between solids and the interstitial fluid
U_m = Mean upflow velocity of a suspension (solids plus fluid)
v = Kinematic viscosity of fluid

References

1. TAGGART, ARTHUR F. *Handbook of mineral dressing.* John Wiley & Sons, Inc. 1945. p. 8 – 04.
2. TAGGART, ARTHUR F. *Ibid.*, p. 9 – 03.

Precious Metals

Mr Robert P. Paise, AMTEC Corporation, Gilroy, California, Chairman of the IPMI International Conference on Precious Metals, released highlights of the 7th Conference, to be held in San Francisco, California, from 13th to 16th June, 1983.

For the first time IPMI will conduct a mini-exhibit of literature and equipment of its member companies. Exhibit hours are scheduled on Tuesday, Wednesday, and Thursday during the conference.

The technical programme organized by David Reese, Micro Metallics Corp., consists of ten sessions for a total of 40 papers over the three-day period. The sessions planned are Economics and Trading, Recovery of Precious Metals from Mining Operations, Unique Properties of Precious Metals, New Technology, Recovery and Refining, Precious Metal Applications, Analytical Methods, Mining and Metal Extraction, and Chemistry of Precious Metals.

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