LETTERS TO THE EDITOR

To The Editor:

Jacob and Weimer [33(10), p. 1698, Oct., 1987] present experimental data for the effect of pressure, up to 120 bar, on the minimum bubbling point, ϵ_{mB}, for gas fluidized fine powdered carbon: values of ϵ_{mB} of up to 0.8 were reported. They show these results to be in good agreement with our hydrodynamic stability criterion for ϵ_{mB} (Foscolo and Gibilaro, 1984, 1987) which had previously been tested to only some 20 bar pressure.

Our reason for writing concerns the steady-state expansion characteristics, $u_o(\epsilon)$, for the initial nonbubbling expansion region which, together with the four basic fluid and particle properties (ρ_p, d_p, ρ_g, μ_g), close the criterion. These expansion characteristics enter the analysis via the well established theoretical relationship for the continuity wave velocity, u_ϵ (Wallis, 1969):

$$u_\epsilon = (1-\epsilon)\frac{du_o}{d\epsilon} \tag{1}$$

Jacob and Weimer calculated ϵ_{mB} from our criterion using three different evaluations of $u_o(\epsilon)$ all in terms of the linear log/log relationship that leads to the form:

$$u_o = u_t' \epsilon^n \tag{2}$$

and hence:

$$u_\epsilon = u_t'(1-\epsilon)n\epsilon^{n-1} \tag{3}$$

The first evaluation used the true, experimentally determined, values of the parameters, u_t' and n. We were relieved to learn that it was these parameter values that led to the good predictions of the onset of bubbling behavior referred to above. Had good predictions of ϵ_{mB} resulted from values of u_t' and n that did not match up to reality (as was the case for the other evaluations employed), it only could have been fortuitous; this point would not perhaps be appreciated by a reader unaware of the theoretical background.

A further point worth noting is that the linear log/log relationship for $u_o(\epsilon)$, Eq. 2, needs apply only in the vicinity of ϵ_{mB} for Eq. 3 to represent a valid form for use in the criterion. However, for nonspherical particle systems, it is certainly unsafe to equate the extrapolated value, u_t' at $\epsilon = 1$, with the unhindered particle settling velocity, u_t, obtained from standard spherical particle correlations, or indeed to rely on spherical particle system correlations for n.

For near-spherical fine powder gas fluidized beds (many catalyst powder systems meet this requirement), there is substantial evidence to indicate that the standard correlations for u_t and n adequately describe the expansion characteristics (Foscolo et al., 1987) thereby yielding predictions for ϵ_{mB} from solely ρ_p, d_p, ρ_g and μ_g.

Notation

d_p = particle diameter, m
n = parameter in Eq. 2
u_o = superficial gas velocity, m · s^{-1}
u_t = unhindered single particle settling velocity, m · s^{-1}
u_t' = extrapolated value of u_o, Eq. 2, at $\epsilon = 1$, m · s^{-1}
u_ϵ = continuity wave velocity, m · s^{-1}
ϵ = void fraction
ϵ_{mB} = void fraction at minimum bubbling
μ = gas viscosity, Ns · m^{-2}
ρ_g = gas density, kg · m^{-3}
ρ_p = particle density, kg · m^{-3}

Literature cited

Foscolo, P. U., and L. G. Gibilaro, "A Fully Predictive Criterion for the Transition Between Particulate and Aggregate Fluidization," *Chem. Eng. Sic.*, **39**, 1667 (1984).

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L. G. Gibilaro
Dept. of Chemical and Biochemical Engineering
University College London
London WC1E 7JE, U.K.

P. U. Foscolo
Dipartimento di Chimica
Ingegneria Chimica e Materiale
Universita di L'Aquila
67100 L'Aquila, Italy

Reply:

Indeed, as Professors Gibilaro and Foscolo note, calculations of minimum bubbling voidage from their criterion (Foscolo and Gibilaro, 1984) were validated experimentally at the high pressure conditions of our experiments (Jacob and Weimer, 1987). The deviation of the experimental expansion indices, n, from those suggested by Richardson and Zaki (1954) has no bearing on the validity of their criterion.

Professors Gibilaro and Foscolo note that there is substantial evidence to indicate that the standard correlations for n adequately describe the expansion characteristics (Foscolo et al., 1987) for near-spherical fine powders, thereby yielding predictions for minimum bubbling voidage using their criterion *a priori*.

It should be noted that there is also substantial evidence that such is not the case, particularly in high pressure systems. Both Godard and Richardson (1968) and Crowther and Whitehead (1978) have reported significant deviations between n suggested by Richardson and Zaki (1954) and those determined experimentally for high pressure systems of spherical powders. The reason for these deviations needs to be understood and is an area for fruitful research.

Notation

n = expansion index

Literature cited

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A. W. Weimer
Engineering Research Laboratory
The Dow Chemical Company
Midland, MI 48674