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Stability of uniform fluidization revisited. (English summary)

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Despite significant attempts in the last two decades to derive a criterion of stability for uniform fluidization from the kinetic theory of a dense, collisional, fluid-particulate suspension, the issue still remains rather elusive and controversial. It has been known for some time that the earlier models, based on the kinetic theories developed for granular flow, predict instability of the uniform fluidized bed for any gas velocity exceeding that of minimum fluidization, u_{mf}. Such a conclusion contradicts experimental observations which show that, for fine (Geldart A) non-cohesive particles, a window of stability exists for fluidization velocities greater than u_{mf}. The marginal stability of uniform gas-fluidized beds is analyzed making use of "macroscopic" conservation equations based on a recent version of the theory of random particulate motion in dense, collisional suspensions. This version of the theory, developed by Buyevich and Kapbasov, combines the standard correlation theory of stationary random processes, applied to stochastic equations for fluctuations of the flow properties, and the generalization, to dense suspensions, of the classical Smoluchowski's theory of fluctuations of the particle concentration. It is shown that, within the framework of the adopted approach, the stability of uniform fluidization can be explained without reference to the hypothetical solid-like state of the particulate phase. The criterion of stability is derived in the form of the critical particle volume fraction as a function of the non-dimensional parameter controlling the dissipation, on interparticle collisions, of the kinetic energy of particle velocity fluctuations. The wavenumbers of "macroscopic" perturbations with the maximum growth rate in the unstable fluidized bed are analyzed. Such perturbations are usually associated with the initial sizes of emerging bubbles; these sizes are obtained as functions of the particle concentration and the above mentioned parameter of inelasticity of interparticle collisions. Recent theoretical studies led to the conclusion that the apparent stability of uniform fluidization cannot be explained without taking into account yield stress caused by direct interparticle contacts. The approach of this paper provides an explanation of the stability without invoking non-hydrodynamic phenomena (except for interparticle collisions).

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