

121c The Kinematic Theory of Fluidized Bed Expansion and Contraction

Stefano Brandani

Slis et al. (1959) were the first to use the kinematic theory to study the dynamics of the expansion and contraction of fluidized beds subject to a variation in the inlet fluid flow rate. The main conclusion that they reached was that expansion and contraction are not symmetrical and that contraction results in a shock transition in void fractions propagating along the bed. In the recent literature the same process has been analyzed by various authors and treated as if in both cases the bed responds with the propagation of a shock transition. In this contribution we show that all Eulerian-Eulerian models have as a limiting solution the kinematic theory when the dynamic wave velocity is significantly greater than the kinematic wave velocity. This corresponds to the state of homogeneous fluidization and in this case the momentum balance equations can be decoupled and solved assuming that the solid-fluid relative velocity is equal to the equilibrium value corresponding to the local void fraction. The mass balance equations can be rewritten as advection equations with nonlinear wave velocities. To understand the dynamic response of a bed subject to a variation in inlet flow rate one has to study the shape of the nonlinear wave velocity, in analogy with the equilibrium theory of adsorption. The results of the analysis show that the dynamics of bed expansion and contraction are not symmetrical, and that both expansion and contraction may or may not lead to shock transitions. Therefore, the case investigated by Slis et al. (1959) is shown to be only one particular possible outcome. A map of the possible expansion/contraction regimes is presented and discussed also with reference to Rayleigh-Taylor instabilities. Practical applications to expanded bed chromatography and the correct interpretation of the final stages of a bed collapse curve will be discussed.