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Numerical Study of Bubbling Fluidized Beds Operating at Sub-atmospheric Conditions

Authors : Lanka Dinushke Weerasiri, Subrat Das, Daniel Fabijanic, William Yang

Abstract : Fluidization at vacuum pressure has been a topic that is of growing research interest. Several industrial applications (such as drying, extractive metallurgy, and chemical vapor deposition (CVD)) can potentially take advantage of vacuum pressure fluidization. Particularly, the fine chemical industry requires processing under safe conditions for thermolabile substances, and reduced pressure fluidized beds offer an alternative. Fluidized beds under vacuum conditions provide optimal conditions for treatment of granular materials where the reduced gas pressure maintains an operational environment outside of flammability conditions. The fluidization at low-pressure is markedly different from the usual gas flow patterns of atmospheric fluidization. The different flow regimes can be characterized by the dimensionless Knudsen number. Nevertheless, hydrodynamics of bubbling vacuum fluidized beds has not been investigated to author’s best knowledge. In this work, the two-fluid numerical method was used to determine the impact of reduced pressure on the fundamental properties of a fluidized bed. The slip flow model implemented by Ansys Fluent User Defined Functions (UDF) was used to determine the interphase momentum exchange coefficient. A wide range of operating pressures was investigated (1.01, 0.5, 0.25, 0.1 and 0.03 Bar). The gas was supplied by a uniform inlet at 1.5U_{mf} and 2U_{mf}. The predicted minimum fluidization velocity (U_{mf}) shows excellent agreement with the experimental data. The results show that the operating pressure has a notable impact on the bed properties and its hydrodynamics. Furthermore, it also shows that the existing Gorosko correlation that predicts bed expansion is not applicable under reduced pressure conditions.

Keywords : computational fluid dynamics, fluidized bed, gas-solid flow, vacuum pressure, slip flow, minimum fluidization velocity
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