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Influence of air bubble size on float–sink of spheres in a gas–solid fluidized bed

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ABSTRACT

The float–sink of density adjusted spheres of different diameter (10–40 mm) in a gas–solid fluidized bed was investigated at various bed heights (50–200 mm). The maximum density of floating spheres (ρ_{float}) and the minimum density of sinking spheres (ρ_{sink}) were determined by the float–sink experiments. The fluidized bed density (ρ_{fb}) was measured using the height and cross section of the fluidized bed and total weight of the fluidized media. The diameter of air bubbles at the bed surface was measured at each bed height, and was normalized by the sphere diameter. It was found that the value of ρ_{fb}–ρ_{float} approaches zero as the normalized bubble diameter decreases from 4 to 0.5 regardless of the sphere diameter. The value of ρ_{sink}–ρ_{fb} for sphere diameter = 10 mm approaches zero as the normalized bubble diameter decreases from 4 to 1.5, whereas the value for sphere diameter = 20–40 mm rises from zero as the normalized bubble diameter decreases from 1.5 to 0.5. The float and sink of spheres basically tend to follow the fluidized bed density with decreasing the normalized bubble diameter. However, relatively larger spheres do not sink based on the density difference as the normalized bubble diameter decreases, which may be due to that the fluidized bed viscosity becomes larger as the normalized bed diameter decreases.

1. Introduction

Development of dry separation techniques is strongly demanded as the substitution for the general wet separations using large quantities of water, because drought due to global warming is a critical issue and frugal water usage is unavoidable. The gas–solid fluidized bed, which has liquid-like properties such as density and viscosity [1], is one of the possibilities to replace the wet separations [2–7]. The float–sink of objects in the fluidized bed can be applied as the dry separation based on the density difference. We performed fundamental and practical studies on the dry separation using the fluidized bed [8–17], and continuous separators based on our results are commercialized. We reported that the float–sink of lump iron ore particles smaller than 17.6 mm is unstable, although those with size greater than 17.6 mm are sharply separated [18]. Recently, we also reported that when the bed height is lowered, the float–sink of the smaller sized ones is stabilized [19]. The fluctuation of the surface height of the fluidized bed was focused as the determinant factor for the stabilization; however, decisive conclusion was not obtained. In this study, we focused on the size of air bubbles at the fluidized bed surface. The float–sink experiments using density adjusted different sized spheres and the measurement of the fluidized bed density were performed by changing the bed height. We measured the size of the air bubbles, and investigated the correlation between the spheres' float–sink and the size of air bubble. In the previous study [19], a mixture of zircon sand and iron powder was used as the fluidized medium with the aim of lump iron ore particles separation. Here we used not the mixture but only the zircon sand as the fluidized medium.

2. Experimental

Zircon sand (bulk density = 2900 kg/m^3 and size = +90–355 μm) (RASA CORPORATION) was used as the fluidized medium. The apparatus used previously [18,19] was used in this study; the apparatus consisted of a cylindrical column (inner diameter = 290 mm and height = 530 mm) and an air distributor with a textile felt held between two perforated metal plates. The zircon sand was put into the column as the bed height h = 50–200 mm, and was fluidized by compressed air at u_0/u_{mf} = 1.7; u_0 and u_{mf} were 5.6 and 3.3 cm/s, respectively. The fluidized bed density ρ_{fb} was determined using the fluidized bed height recorded visually, the cross section of the column and total weight of the fluidized medium. Movies of the fluidized bed surface were recorded, and were played back at slow speed on a monitor. The size of air bubble just before bursting was regarded as the air bubble diameter. One hundred bubbles were randomly picked up for the diameter measurement, and the mean value was taken as D_b.

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