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Original Research Paper

Improvement of dry float–sink separation of smaller sized spheres by reducing the fluidized bed height

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ABSTRACT

In this study, the influence of the fluidized bed height on the float–sink of different sized spheres in a gas–solid fluidized bed was investigated. Fluidized beds with heights h = 200, 150, 100 and 50 mm were prepared using a cylindrical column of inner diameter = 290 mm and a mixture of zircon sand and iron powder as the fluidized medium. Float–sink experiments were carried out using density adjusted spheres of diameter D_{sp} = 40, 30, 20 and 10 mm. It was found that the float–sink performance at $D_{sp} \geqslant 20$ mm is not affected by the height of the bed, and the sharpness of separation (the density range where spheres neither float nor sink completely) is less than or equal to 200 kg/m^3. In the case of D_{sp} = 10 mm, the sharpness of separation is a larger value (1100 kg/m^3 at h = 200 mm), whereas it decreases with decreasing h and is 400 kg/m^3 at h = 50 mm. The fluctuation of the surface height of the fluidized bed was visually recorded. The fluctuation is reduced by reducing h. The fluctuation vs. h correlates with the sharpness of separation at D_{sp} = 10 mm vs. h. These results indicate that the dry float–sink separation of smaller sized spheres is improved as the fluctuation of fluidized bed surface is decreased by reducing the fluidized bed height.

1. Introduction

Separation by density of an object is an indispensable unit operation for industry, in particular, for mineral processing. Generally, wet float–sink separation in a dense suspension of fine particles in a liquid is utilized [1]. However, the wet separation has disadvantages; (1) waste water treatment is necessary, (2) the workshop deteriorates due to water leakage from separators, (3) fine particles (usually magnetite) for density adjustment of the dense liquid are costly, (4) drying after separation consumes a large amount of energy, and (5) the wet separation is not convenient in cold or dry districts because large quantities of water are used for the wet separation. Therefore, development of dry separations to replace the conventional wet separation is in great demand.

The gas–solid fluidized bed has the potential to replace the wet separation. The fluidized bed has liquid-like properties such as density and viscosity [2]. When an object is placed onto the fluidized bed surface, the object floats or sinks in the fluidized bed based on the density difference. So the fluidized bed can be utilized for the dry separation. Several studies of the fundamentals and practical uses for waste treatment and mineral processing have been performed so far [3–18]. Recently, the present authors applied the dry float–sink separation to iron ore treatment [19,20]. The lump iron ore particles with size greater than 17.6 mm were successfully separated, whereas ore particles smaller than 17.6 mm were not separated with high efficiency because the float–sink of particles was unstable [19]. For the practical use of the dry separation, separation of the smaller sized ore particles should be improved. In our previous study [21], the separation of 6-nylon and teflon spheres of diameter = 5 mm was improved with lowering the fluidized bed height. However, in the previous study [21], the sphere's size and density were fixed, so the relationship between the sphere's size and density and the fluidized bed height was not clarified. By using a mixture of zircon sand and iron powder as the fluidized medium, the separation density of the fluidized bed was adjusted from 2750 to 3150 kg/m^3 [20] as used for the wet float–sink separation [22]. So here we also used the mixture as the fluidized medium focusing on iron ore particles separation.

2. Experimental

Zircon sand with bulk density equal to 2900 kg/m^3 and +90–355 μm in size (RASA CORPORATION) and iron powder with bulk density equal to 4400 kg/m^3 and +90–125 μm in size (SINTOKOGIO, Ltd.) were mixed at the bulk volume fraction of each = 50% to be used as the fluidized medium. We found that the mixture does not segregate when the mixture is fluidized at $u_0/u_{mf} \geqslant 1.5$

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