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Original Research Paper

Sizes influences of weighing bar and vessel in the buoyancy weighing-bar method on floating particle size distribution measurements

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ABSTRACT

To evaluate the influences of particle migration lengths as well as the sizes of the weighing bar and vessel on the particle size distribution measured by the buoyancy weighing-bar method, we experimentally measured the size distribution of hollow glass beads as floating particles. The buoyancy weighing-bar method, microscopy, and laser diffraction/scattering method give similar particle size distributions. The variation coefficient of the buoyancy weighing-bar method is close to the value determined by the laser diffraction/scattering method. Moreover, the accuracy of the buoyancy weighing-bar method is equal to that of the laser diffraction/scattering method. For vessels with identical sizes, the particle sizes measured by the buoyancy weighing-bar method increase when the weighing bar is too thick or too thin. Additionally, the influence of the weighing bar length on the particle size distribution is not confirmed in the case of the hollow glass beads. Thus, to effectively employ the buoyancy weighing-bar method, the sectional area ratio of the rod/vessel must be 0.02–0.2.

1. Introduction

Various approaches have been used to measure particle size distributions [1]. For solid–liquid systems, particle size distributions have been measured by the Stokes diameter. The Andreasen pipette method [2], sedimentation balance method [3], centrifugal sedimentation method [4], etc. have been used to measure the particle size distribution in suspensions. These methods measure the migration velocities of particles in solution, and then particle size is calculated using Stokes formula. However, all these methods are time consuming and require special skills. On the other hand, a different principle can be used to analyze the particle size distribution through microscopy [5], laser diffraction/scattering method [6], and a Coulter counter method [7]. These methods require numerous samples to accurately determine the particle size distribution. Although the laser diffraction/scattering and Coulter counter methods produce highly accurate results within a shorter time, they require extremely expensive equipment. Hence, a simple and cost effective method to determine the particle size distribution is highly demanded.

The sedimentation method, which uses gravity, can simply and economically measure the particle size distribution, but it is time consuming. Bardet and Young have reported that the buoyancy method can measure the particle size distribution [8]. The buoyancy method determines the particle size distribution by measuring the buoyancy of a weighing ball. The coauthors tried the buoyancy method, but we were unable to measure the particle size distribution because the particles accumulated on the weighing ball. To prevent particle accumulation, we used a weighing bar.

We have strived to develop a new method to measure the particle size distribution using the buoyancy weighing-bar method [9]. In our method, the change in suspension density due to particle migration is measured by weighing buoyancy against a weighing bar hung in a suspension. Although the buoyancy method uses incremental analysis, our method uses cumulative analysis. The principles of these two methods differ. In our method the particle size distribution is calculated using the length of the weighing bar and the change in the apparent mass of the weighing bar with time.

We have reported that the buoyancy weighing-bar method can measure particle size distributions of the settling particles using JIS Test Powders [9]. The accuracy of this method is similar to that of the sedimentation balance method or the Andreasen pipette method. Additionally, the material of the weighing bar does not affect the results, and a particle size of 5 μm in water can be measured in 2 h. Furthermore, the particle size distribution of large particles in a viscous liquid can be measured using the buoyancy weighing-bar method. We have reported size distribution measurements of the floating particles by the buoyancy weighing-bar method [10–12]. The ability to measure the particle size distributions of floating

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