Optically Tagging Individual Particles in a Bed

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Among certain operations involving large numbers of particles, such as fluidization or hindered settling, information regarding the movement of the particles can be of great value in understanding the operations themselves. For this reason the literature reports a number of theoretical and experimental investigations of this movement. In the latter category, optical methods applied to systems contained by glass or clear plastic have been used. However optical methods are by their nature limited to that which can be seen. This generally means limitation to the near vicinity of the bounding surfaces, since the particles naturally hide each other. To the present writers' knowledge, no optical scheme has been reported which allows the observer to peer from the outside into the interior of a swarm or bed of particles and freely follow the movement of one selected particle. Accordingly, a new experimental technique is suggested here for overcoming the problem of opacity for certain cases and allowing the observer to track a particle throughout its entire region of motion.

In essence, the principle is simple. It involves three steps.

1. Particles of a clear material are selected. As a trial, the authors selected 3-mm. glass spheres of the ordinary laboratory variety.

2. One particle is suitably marked for tracking by making it opaque. Depending on the objective of the prospective study, the particle selected for marking can be representative for a uniform bed, or it can be oversized, undersized, or differ from the average in some other way. By selectively marking only a portion of the particle, rotation as well as translation can be observed. If desired, several particles can be tracked simultaneously.

The marking process must be accomplished without changing any of the pertinent properties of the particle so that it will move among the other particles as though it were unmarked. For the present trial the bead was marked by exposing it to high intensity gamma radiation. This colored the bead dark brown but changed no other properties of consequence.

3. A working fluid is selected which is of the same optical index of refraction as the beads, or nearly so. This will make the bed of particles nearly transparent, with the opaque marked particle visible anywhere in their midst. The movement of the marked particle can then be followed visually, with motion pictures, or by stroboscopically illuminated still photography. Strategically mounted mirrors will allow simultaneous observation from two directions, thus locating the successive positions of the particle in three dimensions.

In the present trial, a liquid mixture consisting of 12% by volume of 1,1,2,2, tetrabromoethane in 1,1,2,2, tetrachloroethane was used. The indices of refraction of these two compounds straddle that of the glass beads, and the composition employed was obtained by titration to the closest approach to invisibility by daylight. Use of monochromatic light and beads of more uniform optical properties should make for more complete transparency.

The trial itself was simple. It involved observation of a 250-ml. beaker filled with glass beads, with a single opaque bead near the center of the bed. When the voids were filled with air or water, the marked bead was completely hidden from view.

However when the voids were filled with the aforementioned mixture of halogenated hydrocarbons, the marked bead was plainly visible from every direction. With the beads in motion, the movement of the marked bead could be easily followed.

Thus the method should offer a means for tracking and examining individual motion throughout a fluidized bed or other swarm of particles.

Ion Exchange Kinetics: A Comparison of Models

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The kinetics of liquid-solid ion exchange reactions has been widely studied in recent years. This aspect of ion exchange has been considered from both theoretical and experimental points of view, and several different rate equations have been proposed. The objective of this note is to present the results of an analysis based on the most recent and rigorous model yet proposed for the ion exchange process. The model is developed and compared with two earlier models in the literature for one case of interest. The fit of all three models to experimental rate data is also considered.

The problem to be considered is the exchange which takes place when resin particles of one ionic form are contacted with a solution of different ions in a nonflow stirred reactor. The in-

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