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Flotation behaviour of fine particles with respect to contact angle

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ABSTRACT

The flotation behaviour of methylated quartz particles of different size, but within the size range from 0.2 to 50 μm, and varying contact angle, was probed in a mechanical flotation cell. Results suggest that particles of a given size need to possess a minimum critical contact angle (θ_{crit}) for flotation to occur. This behaviour is shown not to be solely dependent on fine particles having lower collision efficiency with bubbles, but rather due to a combination of low collision efficiency and particles not having enough kinetic energy at collision with bubbles to form the three phase line of contact and initiate the attachment process. In the particle size range investigated, the critical contact angle increases with a decrease in particle size.

Keywords: Flotation; Critical contact angle; Fine particles

1. Introduction

It has long been established that fine particles (particle diameter <10 μm) exhibit low flotation rate and recovery (Trahar and Warren, 1976), with the best flotation rate and recovery occurring in the 10–100 μm particle size range (Sutherland and Wark, 1955). The low recovery of fine particles is often attributed to their low mass and inertia that leads to low probability of particle colliding with bubbles (Schulze et al., 1989; Weber and Paddock, 1983) as fine particles follow bubble fluid streamlines instead of colliding with the bubble.

The other, but less explored and discussed reason for the low floatability of fine particles is that they possess insufficient kinetic energy (due to low mass) to displace the thin water film between the colliding particle and bubble and form the three phase line of contact. This school of thought assumes that for bubble and particle to attach, the particle must possess minimum kinetic energy to be able to cause the thinning of the liquid film to critical rupture thickness and subsequent formation and expansion of the three phase line of contact (TPLC) (Hewitt et al., 1993). The foregoing suggests that the problems of fine particles flotation are both kinetic and thermodynamic in nature.

Scheludko et al. (1976) derived the only theoretical model for attachment of fine particles to bubbles. In deriving this model, Scheludko et al. (1976) assumed that after collision, bubble-particle attachment can only proceed when particle kinetic energy is equal to, or more than, the energy required to thin, form and expand the three phase line of contact. At equilibrium, the kinetic energy balances the forces that resist the thinning and formation of the three phase line of contact. By balancing these forces, a minimum particle diameter for flotation was calculated as a function of particle contact angle. The lower the contact angle, the higher is the minimum particle size for attachment to occur (Scheludko et al., 1976), which also implies that the flotation of particles of a given size can only occur if the particles attain a certain minimum critical contact angle.

Validation of the Scheludko model with experimental data has been hampered by lack of flotation data for fine particles (Drelich and Miller, 1992). The model is strictly valid for particles 1–2 μm in size, and is premised on the accuracy and validity of the magnitude of the line tension value (Crawford and Ralston, 1988; Drelich and Miller, 1992). The value of the line tension is largely debatable and difficult to determine, hence the introduction of pseudo line ten-

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