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The Effect of Density and Particles Size of α-Quartz and Amorphous Silica on Flotation

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ABSTRACT

Density is one of the effective parameters in the particles flotation. For heavier particles, gravity force is more than bubble - particle cohesion force and it increase the probability of separation of particle from bubble. In this research the effect of particles density on flotation were investigated by using sample α-quartz and amorphous silica with density of 2.67 and 2.2 g/m^3 respectively. The result of flotation studies showed that in the size range of -250+212µm with increasing of density the recovery of flotation decreases from 97.74% to 93.42%, whereas in the size range of -150+125µm this decrease of recovery is not noticeable. In the size range of -75+53 µm with increasing of the density recovery increased from 88.49% to 92.42%. The probability of detachment increases with an increase in particle size and density.

KEYWORDS:

Density, Particles Size, Flotation.

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1- INTRODUCTION

The variety of approaches to powder processing depends largely on the purity, structure, density, and etc. of materials, volume properties, and morphological characteristics of materials (i.e. size, shape, texture, etc.) [1]. Among these properties, particle density is one of the most influential parameters affecting particle flotation. The overall probability of particle flotation (P_{total}) which is due to the probability of collision (P_c) between mineral particles and air bubbles, the probability of attachment (P_a) and the probability of separation ($1-P_d$) of particles from the air bubbles is described by equation 1. [3, 2]:

$$P_{total}=P_c \times P_a \times (1-P_d) \quad (1)$$

The interaction between the bubble and particle is controlled by forces such as hydrodynamic resistance, inertia forces, gravitational forces, short-range e

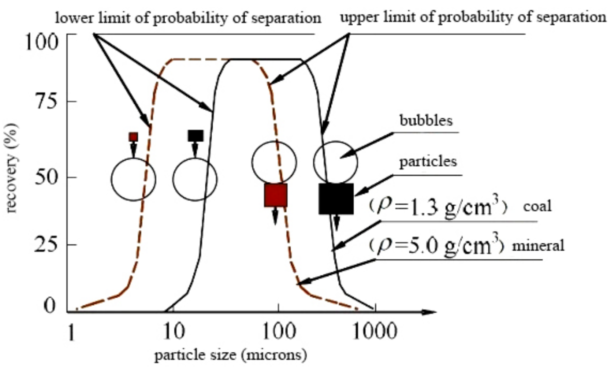

Figure 1. The effect of coal and mineral density on particle flotation

surface forces and capillary forces. The probability of collision between particles and air bubbles is defined by hydrodynamic conditions which are affected by the particle - bubble size and turbulence of systems [8, 9, 3, 4, 5, 6, 10, 7]. The probability of attachment depends mainly on surface forces in the system and induction time, and the probability of particle separation from air bubble depends on the particle density [11].

Density, particle size and surface hydrophobicity have an important role in the mineral flotation [12]. As it is shown in Figure 1, the effect of particle size fractions with different mineral density (ρ ~ 5.0 g/cm^3) and coal (ρ ~ 1.6-1.3 g/cm^3) on the flotation recovery has been studied. For instance, the fraction of effective particle size in the flotation for mineral particles (ρ ~ 5.0 g/cm^3) is from 10 to 100 microns, while the fraction of effective particle size for coal (ρ ~ 1.6-1.3g/cm^3) is from 50 to 500 microns. Mineral particles smaller than 10 microns (50 microns for coal) in comparison to the mineral particles in the range e of 10 to 100 microns (50-500 microns for coal) are less suitable for flotation as these particles enjoy less inertia, which enables them to follow hydrodynamic flows and to avoid being trapped in bubbles. Particles larger than 100 microns for minerals (500 microns for coal) floats hardly, because of the bubble - particle separation in turbulence flows of flotation channels and difficulty in moving the particle from the accumulation zone is the floor. The upper size limit depends mainly on probability of separation (P_d). The results of these studies showed that [13]:

1) With an increase in particle size and density, the probability of separation (Pd) increases.

2) The maximum size of particles that can float is a function of the degree of hydrophobicity.

2- METHODOLOGY

In this study, minerals of alpha-quartz and amorphous silica were crushed by jaw crusher, cone crusher and cylinder crusher, respectively. The size of feed for ball mill was - +2380- 841 microns and the weight of feed was 1000 g. Milling time in rod mill was 35 min. All the crushing experiments were carried out in dry conditions. After milling, both minerals were riddled by dry sieve for 15 minutes and they were classified for the next stages in sizes range of + 212 -250, + 125- 150 and +53 -75 microns.

Flotation tests were conducted in Denver D12 Laboratory Machine and the 1.5 liter cell was used. Sample weight for each test was 100 g. the sample together with about 1200 ml water were poured into 1. 5 liter cell and pH was adjusted at 9 using sodium hydroxide. For initial preparation, the sample is stirred with a speed of 1000 rpm for 2 min. The collector is added to the pulp at a rate of 1500 ppm. The type of collector was Armak C and the preparation period was 4 minutes. After measuring and re-adjusting the pH of the pulp at 9, the air valve was opened and froth removal was done for three minutes.

Both cases with the density of 2.67 and 2.2 g/cm^3, were crushed under the same conditions by a ball mill and were classified in size range es of -300+ 250, -250+ 212, - 180+150, - 150+125 , -106+75, -75 +53 microns. In order to investigate the flotation recovery, 100 grams of samples from each range e was used in flotation (under optimum conditions). As it is shown in the table (1) and (2), the results of flotation recovery for particles of quartz and amorphous silica

Table 1. The results of α-Quartz particle flotation

recovery (%)	particle size (microns)
90/23	-300+250
93/42	-250+212
98/01	-180+150
97/16	-150+125
94/96	-106+75
92/43	-75+53

Table 2. The results of Amorphous Silica particle flotation

recovery (%)	particle size (microns)
95/38	-300+250
97/74	-250+212
99/86	-180+150
98/65	-150+125
91/65	-106+75
88/49	-75+53

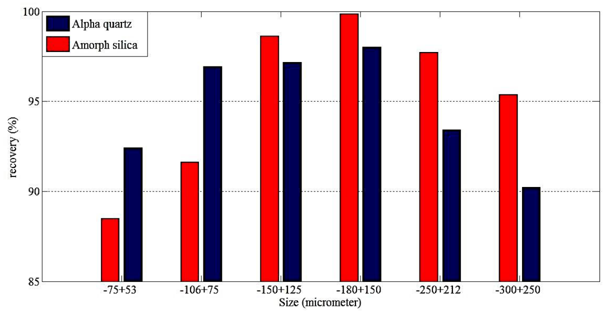

Figure 2. Flotation recovery of alpha-quartz and amorphous silica particles in the size range of -300+250, -250+212, -180+150, -150+125, -106+75, -75+53 microns.

in each of the six size are presented.

As it is shown in Figure 2, the flotation recovery in both upper size (-300+212 microns) for amorphous silica particles (2.2 g/cm³) is greater than alpha-quartz particles (2. 67 g/cm³). In other words, with the increase of density in sizes range es of -250+ 212 and -300+250 microns, the flotation recovery decreased from 97.74 to 93.42 percent and from 95.38 to 90.23 percent respectively, due to the increase of gravity force on the bubble which lead to the decrease of contact angle between the bubble – particle and also increase of the probability of particle separation.

With the simultaneous analysis of the effect of particle size and density on the flotation, it is observed that in general, the impact of particle size is greater than density and with an increase of the density, the optimum sizes for flotation decrease.

3- RESULTS

The results of flotation for both minerals in the classified size ranges indicated:

1. Flotation recovery of size range (+300-212 microns) for amorphous silica particles (with density of 2.2 g/cm³) in comparison with alpha-quartz particles (2.67 g/cm³) increased significantly. In other words, with an increase of density, flotation recovery decreases due to the increase in the gravitational force exerted on the bubble. Also, the separation force of these particles increases with air bubbles.
2. In medium size ranges (-180+125 microns) flotation recovery of amorphous silica particles increase less than alpha-quartz as particles with less density exert less the gravitational force on air bubbles and their contact angle with bubble increase.
3. But in the smaller size range (- 106+53 microns) flotation recovery of amorphous silica particles in comparison with alpha-quartz, declined. Amorphous silica particles in this size range due to the decrease of density in comparison with quartz alpha have lower inertia that enables them to follow the hydrodynamic flow and prevent them from trapping in bubbles.
4. The effect of interaction between size and density showed that with an increase of the size and density the probability of separation between the bubble and the particle increases. With increasing density, also, the optimum range of particle size for flotation changed and reduced.

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