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ENTRAINMENT-FLOTATION ACTIVITY OF QUARTZ IN THE PRESENCE OF SELECTED FROTHERS

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Flotation is used for separating mineral particles. Flotation is accompanied by entrainment of hydrophilic particles which is an undesirable process. Flotation and entrainment depend on numerous parameters, among them the presence and concentration of frother. This work was devoted to investigate the borderline between entrainment and flotation of quartz particles in the so-called monobubble Hallimond tube in the presence of varying concentrations of selected frothers. The following frothers were used: octyl alcohol, isoamyl alcohol, α-terpineol, tricosene-ethyleneglycol 1-hexadecanoic ether and corflot (a mixture of butyl ethers of di-, tri- and tetraethylene glycols). Entrainment of the quartz particles in pure water has also been conducted as a reference test. The work has confirmed that entrainment depends on particle size. It also confirmed the role of the frother used. Two of the frothers: tricosene-ethylene glycol 1-hexadecanoic ether and octyl alcohol have exhibited both frothing and collecting properties.

key word: mechanical recovery, frother, entrapment, surface phenomena, quartz, flotation

INTRODUCTION

Flotation is accompanied by undesirable phenomena, such as particle aggregation and entrainment, taking place usually during fine particles flotation. Entrainment has been investigated by numerous researchers including Ross (1991), Drzymała (1994), Łukaszewska (1998), Hrycyna (1999), Konopacka (2005) and Szyszka (2007), with the use of flotation machines or the so-called Hallimond tubes. In spite of extensive research on the subject, the phenomenon is not yet well understood, especially the

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issue when a frother becomes collector in flotation. The purpose of this work was to study this aspect of flotation.

EXPERIMENTAL

Microlaboratory tests were performed with quartz obtained from Osiecznica (Poland) using five frothers: octyl alcohol, isoamyl alcohol, α-terpineol, tricosene-ethyleneglycol 1-hexadecanoic ether and corflot (a mixture of butyl ethers of di-, tri- and tetraethylene glycols). In order to obtain the desired quartz particles it was crushed in a laboratory rock disintegrator and separated by wet screening into size fraction using 0.5, 0.2, 0.1 and 0.0071 mm screens. The square-shaped screens were provided by Metallweberei (Germany). After screening, the quartz samples were dried and individual particle size fractions were use for flotation-entrainment tests.

The stock aqueous solution of frothers were 1% by weight. The amount of frother for each concentration was established on the basis of its molecular weight.

The flotation experiments were conducted in a Hallimond tube shown in Fig. 1. Prior to each experiment, 0.35 g of quartz had been added to 120 cm^3 of aqueous frother solution in a glass beaker. Then, the mixture was agitated for 1.5 min, poured into the Hallimond tube and subjected to flotation with an air flow of 0.625 cm^3/s. The air flow was measured with the use of a Brooks Rotametr Co. (US). The air bubbles in pure water were 3.1 mm in diameter.

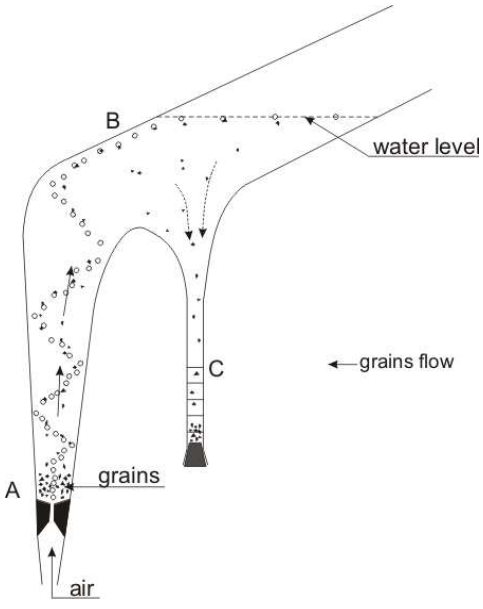

Fig. 1. Hallimond tube used in the experiments

The tested material was placed in part B of the Hallimond tube. The air bubbles and some mineral particles were moving to the water surface (C) where the particles were falling to the calibrated glass tube D. This enabled a continuous measurement of the percentage of the material floating and entrained as a function of time. The recovery of particles were read every 3 minutes throughout the whole flotation time of 15 minutes.

RESULTS AND DISCUSSION

As a result of the tests, conducted for all quartz size fractions, it was possible to determine the amount of particles entrained with air bubbles with time. On the basis of the results, kinetics of flotation-entrainment were plotted for different frothers and for pure water. Next, an average particle size was calculated for each size fraction as an arithmetic mean of the largest and the smallest particles in a given fraction. Having such data, it was possible to draw curves to show a relationship between the maximum recovery and average particle size. The way frothers affect flotation has been presented in Tables 1-5.

Table 1. The results obtained for air bubbles passing through the Hallimond tube filled with 0.5-0.2 mm quartz particles

Time t, min	Cumulative recovery, Σε, %					
	water	α-terpineol	isoamyl alcohol	octyl alcohol	Ether $C_{16}E_{23}$	corflot
0	0	0	0	0	0	0
3	0.3	0.5	0.5	0.5	2	0.5
6	0.5	0.5	0.5	0.5	4	0.5
9	0.5	0.8	1	1	8	0.5
12	0.5	0.8	1	1	9	0.5
15	0.5	0.8	1	1	9	0.5

Table 2. The results obtained for air bubbles passing through the Hallimond tube filled with 0.2-0.1 mm quartz particles

Time t, min	Cumulative recovery, Σε, %					
	water	α-terpineol	isoamyl alcohol	octyl alcohol	Ether $C_{16}E_{23}$	corflot
0	0	0	0	0	0	0
3	1	2	2.5	5	17	1
6	1.5	3	3.5	8	32	1.5
9	2	4	4.5	9	40	2
12	2.5	4.5	5	10	43	3
15	3	4.5	5.5	10	44	4

Table 3. The results obtained for air bubbles passing through the Hallimond tube filled with 0.1-0.071 mm quartz particles

Time t, min	Cumulative recovery, Σε, %					
	water	α-terpineol	isoamyl alcohol	octyl alcohol	Ether $C_{16}E_{23}$	corflot
0	0	0	0	0	0	0
3	9	7	8	15	48	5
6	16	10	11	28	70	12
9	19	15	16	40	78	20
12	23	19	20	49	80	26
15	28	21	25	52	81	30

Table 4. The results obtained for air bubbles passing through the Hallimond tube filled with <0.071 mm quartz particles

Time t, min	Cumulative recovery, Σε, %					
	water	α-terpineol	isoamyl alcohol	octyl alcohol	Ether $C_{16}E_{23}$	corflot
0	0	0	0	0	0	0
3	10	12	10	19	25	10
6	22	23	16	33	40	20
9	31	30	26	41	48	28
12	36	34	30	47	54	34
15	38	38	32	51	59	39

Table 5. Cumulative quartz recovery $\Sigma\varepsilon_{max}$ for each size fraction

Average-sized particles, $d_{śr}$	Cumulative recovery, Σε, %					
	water	α-terpineol	isoamyl alcohol	octyl alcohol	Ether $C_{16}E_{23}$	corflot
0.35	0.5	0.8	1	1	1	0.5
0.15	3	4.5	5.5	10	10	4
0.086	28	21	25	52	52	30
0.036	38	38	32	51	51	39

The work was focused on investigating frothing and collecting properties of frothers. During the experiments, pure water was used as the reference. The research results indicate that the collecting properties towards hydrophilic quartz particles depends on the frother type.

A comparison of the results obtained (Fig. 2.) has led to an observation that tricosene-ethylene glycol 1-hexadecanoic ether and to a lesser extent octyl alcohol show collective properties towards quartz. The remaining frothers were responsible merely for the quartz particle entrainment, since the amount of entrained particles was

comparable with the amount obtained when the flotation cell was filled only with water.

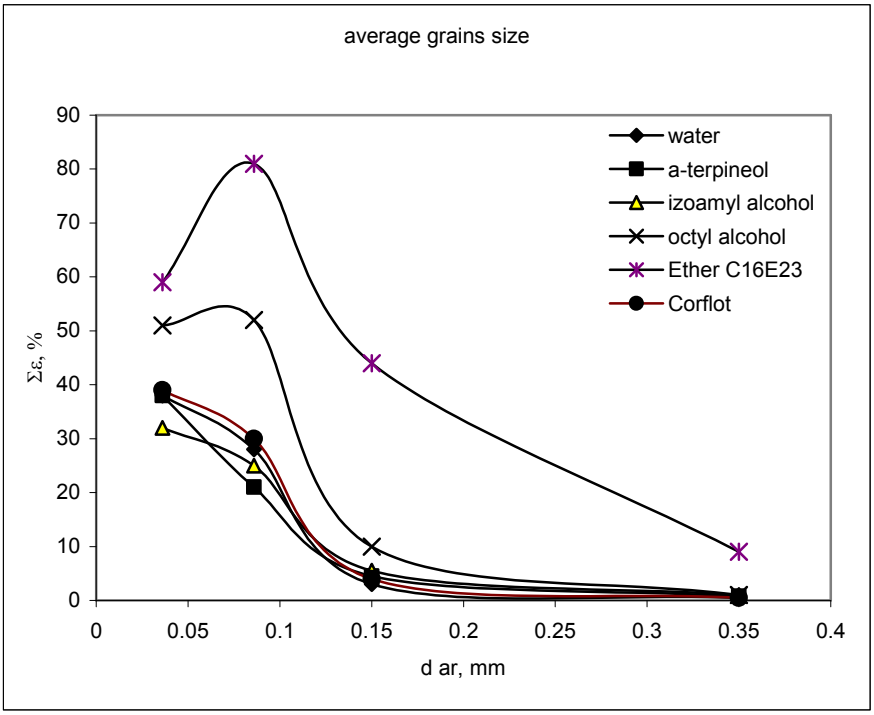

Fig. 6. Quartz cumulative recovery (Σε) after 15 minutes of flotation (plateau) vs. size of quartz particles

CONCLUSIONS

Among the five frothers used tricosene-ethyleneglycol 1-hexadecanoic ether, and to a lesser extent octyl alcohol, produced quartz flotation, with the particle recovery greater than the entrainment. The remaining frothers (isoamyl alcohol, α-terpineol and corflot) acted as proper frothers, with entrainment being equal to that observed in water containing no frother. Thus, such a simple Hallimond tube experiment can be used for testing frothers to establish whether they are pure entraining non-collecting frothers or they have tendency to float the particles. The frothers which partially collect (float) particles may significantly contribute to reduced flotation selectivity.

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Flotacja jest stosowana do rozdziału drobnych ziarn mineralnych. Każdej flotacji towarzyszy zjawisko niepożądane pogarszające jakość końcowego produktu, którym jest wyniesienie mechaniczne ziarn (flotacja mechaniczna). Na flotacje właściwą i mechaniczną wpływa wiele parametrów, które nie zostały całkowicie poznane. W pracy badano flotację mechaniczną ziarn kwarcu w monopęcherzykowym flotowniku Hallimonda w zależności od rodzaju stosowanych spieniaczy. W testach zastosowano takie spieniacze jak: alkohol oktylowy, alkohol izoamylowy, α-terpineol, eter jednoheksadekanowy trikozanoetylenowy oraz corflot (mieszanina eterów butylowych glikoli di, tri i tetraetylenowych). Przeprowadzono także badania dla czystej wody, które obrano jako punkt odniesienia w stosunku do pozostałych wyników testów. W pracy stwierdzono, że eter jednoheksadekanowy trikozanoetylenowy ($C_{16}E_{23}$) oraz alkohol oktylowy wykazały nie tylko właściwości spieniające, ale również zbierające.

słowa kluczowe: wyniesienie mechaniczne, spieniacze, właściwości powierzchniowe, kwarc, flotacja