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FROTH FLOTATION OF OXIDE IRON ORE

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This invention relates to the art of froth-floating oxidic iron particles from aqueous pulps thereof containing also silicious gangue particles. The process of the present invention is particularly concerned with the pre-treatment and conditioning of such pulps when using fatty acids, fatty acids soaps, talloel, talloel soaps or resinates as anionically acting collectors.

In essence, the process of the present invention comprises the following combination of procedural features and operative steps: The pulp is deslimed and given an acid wash (1) to clean the surfaces of the oxidic iron particles whereby to enhance their floatability and simultaneously (2) to remove iron slimes from the surface of the silicate minerals whereby to depress the floatability of the latter. To effect the acid wash, the pulp is thoroughly admixed with a suitable acid, usually a mineral acid, in an amount equivalent to more than 1 but not more than about 3 pounds of concentrated sulphuric acid per ton of the pulp, dry basis. The acid-washed pulp is then repulped with fresh water, and then thickened to a solids content of at least 65% and desirably between 65% and 80%. The pulp, at high pulp density, is made mildly yet definitely alkaline by the incorporation thereinto of a suitable alkali, e. g., caustic soda or soda ash, in an amount sufficient to give the pulp a pH of from 8.0 to 8.5, e. g., about 8.2, depending to some extent upon the identity of the collector. Thereupon, the mildly alkaline pulp is conditioned with an emulsion of the selected anionically acting agent, e. g., a materially alkaline and quite soluble sodium resinate soap or a talloel soap, and a suitable oil, e. g., fuel oil. The so-conditioned pulp is ready to be diluted with water to 20–25% solids and subjected to froth flotation in conventional manner.

In the cases of certain ores it is advantageous to first deslime and then acid wash. With other ores it is simpler to acid wash first and then deslime. These two operations are interchangeable and the choice depends on the character of the ore, the type of mill water being used, the soluble salts encountered, etc.

I have found that the degree of alkalinity conferred upon the deslimed and acid-washed pulp prior to conditioning with the aforesaid agents is of great importance to the subsequent conditioning and flotation. The above referred to "mild alkalinity" is essential to good flotation results when using the above-named anionically acting collectors with the silicious oxidic iron pulps with which the present invention is concerned. Thus, I have found, in working with alkali resinate collectors, that if the pH of the circuit be dropped below 8.2 through addition thereto of an acid, the resinate collector tends to break down to free resin and an alkali metal salt of the added acid (e. g., sodium sulphate): in such case, the resin continues to function as an anionically acting collector but in a manner much less effective than the soluble resinate. When working with alkali metal soaps of talloel (which latter consists essentially of fatty acids and resin acids in approximately equal amounts) much the same result attends lowering the pH of the pulp circuit as in the case of the soluble resinates.

The petroleum hydrocarbon sulphonates, such for example as the well known mahogany soaps, behave just oppositely; they are quite soluble in acidic solutions, but break down to flotatively ineffective compounds when the pulp circuit is made alkaline.

The above experimentally derived facts pertain to the effect of too low a pH value when working with the above named anionically acting collectors. I have found, on the other hand, that too great an alkalinity of the pulp circuit is equally as disadvantageous as too low a value. Thus, numerous experiments have established that as the alkalinity is increased above pH 8.5 the grade of the resulting concentrate depreciates and at a pH of approximately 9.5 the separation tends to be reversed—i. e., tends so to operate as to float the silicious particles in preference to the oxidic iron particles.

Table No. 1 immediately following shows the effect of varying the pH on the anionic flotation of oxidic iron particles from a silicious washing plant tailing product from the Danube mine, located near Bovey, in St. Louis County, Minnesota.

Table #1.—Effect of varying pH on iron ore flotation using sodium resinate-fuel oil emulsion as collector

Test	pH Flotation Pulp	Product	Per Cent Wt.	Assay, Per Cent		Per Cent Total Iron
				Iron	Silica	
#209	3.15	Concentrate	10.97	65.20	3.44	49.89
		Middling	1.64	47.05		5.37
		Tailing	87.39	7.33		44.74
		Composite	100.00	14.33		100.00
#213	7.0	Concentrate	15.31	63.58	5.76	65.12
		Middling	2.14	33.36		4.76
		Tailing	82.55	5.45		30.12
		Composite	100.00	14.94		100.00
#197	8.0	Concentrate	19.09	61.97	6.66	83.31
		Middling	5.14	19.68		7.11
		Tailing	75.77	1.79		9.58
		Composite	100.00	14.20		100.00
#206	8.3	Concentrate	20.84	53.57	18.94	79.21
		Middling	20.71	6.83		10.00
		Tailing	58.45	2.60		10.79
		Composite	100.00	14.09		100.00
#207	9.5	Concentrate	61.13	14.71	72.45	61.96
		Middling	13.20	11.27		10.27
		Tailing	25.67	15.69		27.77
		Composite	100.00	14.51		100.00
		Deslimed Head Sample		14.53		

Test conditions.—Ore given acid wash using 3 lbs. H_2SO_4/ton ore and deslimed. Ore repulped with fresh water. Conditioned at high solids with acid or caustic to give an arbitrarily selected pH and then added collector. Collector in each test was an emulsion made up of 10% sodium resinate collector, 10% fuel oil and 80% water. Amount used in each test equivalent to 2 lbs. sodium resinate and 2 lbs. fuel oil per ton of ore.

It will be noticed that optimum results were secured at a pH of 8.0—test #197. With a lower pH, as in tests #209 and #213, while a good concentrate was produced the tailings undesirably increased in grade—apparently because the sodium resinate collector broke down to a resin under the acidic conditions maintained. It will be observed, on the other hand, that as the alkalinity is increased beyond pH 8.0 or 8.2—as in tests #206 and #207—the grade of concentrates drops off until at pH 9.5 the separation is reversed and more silica than iron is floated.

The beneficial effects of using a mildly alkaline circuit are not limited to the resinates but apply also to alkali metal soaps of talloel.

Table #2 shows the results using talloel as a collector. In an acid pulp the results were so poor that not enough concentrate was floated to warrant having the products analyzed. At a pH of 9.2 the selectivity was poor, as it was with the other two collectors in circuits as alkaline as pH 9.0.

Table #2.—Effect of varying pH on iron ore flotation using talloel-fuel oil as collector

Test	pH Flotation Pulp	Product	Per Cent Wt.	Assay, Per Cent		Per Cent Total Iron
				Iron	Silica	
#208	3.55	Concentrate	0.42	No Analysis		
		Middling	1.71			
		Tailing	97.87			
		Composite	100.00			
#204	8.0	Concentrate	20.77	60.40	8.50	86.61
		Middling	5.02	14.79		5.11
		Tailing	74.21	1.62		8.28
		Composite	100.00	14.49		100.00
#212	9.2	Concentrate	38.57	34.92	45.00	93.86
		Middling	16.82	3.09		3.63
		Tailing	44.61	0.81		2.51
		Composite	100.00	14.34		100.00
		Deslimed Head Sample		14.53		

Test conditions.—Ore prepared as described in Table #1. Talloel and fuel oil added as such, separately, and conditioned at high solids. In each of above tests 2 lbs. talloel and 2 lbs. fuel oil per ton of deslimed ore used as collector.

The conditions of test #204 gave optimum separation results.

It was found that alkali metal soap of talloel could be substituted for the talloel of the above experiments with comparable results.

In Table #3, following, are assembled data pertaining to the flotation of oxidic iron from a deslimed, acid-washed and then alkalized pulp of an oxidized taconite ore material, using an aqueous emulsion of sodium resinate collector and fuel oil.

Table #3 on flotation tests using oxidized Taconite, pool mine sodium resinate-fuel oil emulsion as collector

Product	Per Cent Wt.	Per Cent Iron	Per Cent Silica	Per Cent Total Iron
Concentrates	37.00	61.78	8.20	71.59
Middlings	22.37	29.31		20.55
Tailings	40.63	6.19		7.86
Composite	100.00	31.93		100.00

Test conditions.—Sample of oxidized Taconite crushed and wet ground to 100 mesh. Deslimed. Conditioned with 3 lbs. H_2SO_4/ton deslimed ore. Repulped with fresh water. Conditioned at 75% solids with 0.3 lb. sodium hydroxide per ton feed and an emulsion made up of 10% sodium resinate, 10% fuel oil and 80% water. Amount of collector used was equivalent to 2 lbs. of resinate and 2 lbs. of fuel oil per ton of deslimed feed.

From a series of experiments I have found that best results follow holding the pH at from 8.0 to 9.0 at the point where the collector is added to the thickened pulp, the upper limit being carefully controlled to eliminate activation of the silica, while in the rougher cells the pH preferably is maintained at 7.8–8.5 and in the cleaner cells at 7.0–8.5. The data indicate that it is helpful to make the pulp nearly neutral during the cleaning step, as the silica particles then sink from the rougher froth better and a cleaner concentrate is secured.

An advantage of the present method is that by controlling the pH one can effect an excellent separation by the use of relatively small amounts of resinates and talloel soaps, which are cheaper than sulfonates. By keeping the circuit alkaline one secures full use of the collector (resinate, or talloel soap) and requires only half as much as in an acid circuit. The flotation separation is carried on in alkaline circuit which is not corrosive to iron and steel equipment as an acid circuit would be.

I claim:

1. Process of concentrating by anionic froth floatation the oxide iron of pulps of oxidic iron-bearing ores and ore-like materials including taconites containing silicious gangue, which comprises treating the pulp with a mineral acid of a strength and in an amount sufficient to clean the sulfaces of the pulp particles, desliming the pulp, treating the deslimed acid-treated pulp at a pulp density at least equivalent to 65% solids with an alkaline-acting alkali metal compound in an amount sufficient to raise the pH of the pulp to from 8.0 to 9.0, conditioning the alkalized pulp with a reagent charge consisting essentially of an aqueous dispersion of an anionically acting agent of the group consisting of alkali metal soaps of talloel and alkali metal resinates and an oily carrier, diluting the so-conditioned pulp with water, and subjecting the diluted conditioned pulp to froth flotation.

2. Process of concentrating by anionic froth flotation the oxidic iron of pulps of oxidic iron-bearing ores and ore-like materials including taconites containing silicious gangue, which comprises treating the pulp with a mineral acid of a strength and in an amount equivalent to from 1 pound to 3 pounds of concentrated sulphuric acid per ton of the pulp solids and sufficient to clean the surfaces of the pulp particles, desliming the pulp and repulping in fresh water, treating the deslimed acid-treated pulp at a pulp density at least equivalent to 65% solids with an alkaline-acting metal compound in an amount sufficient to raise the pH of the pulp to from

reagent charge consisting essentially of an aqueous emulsion of an anionically acting agent of the group consisting of alkali metal soaps of talloel and alkali metal resinates and an oily carrier, diluting the so-conditioned pulp with water, and subjecting the diluted conditioned pulp to froth flotation.

3. Process of concentrating by anionic froth flotation the oxidic iron of pulps of oxidic iron-bearing ores and ore-like materials including taconites containing silicious gangue, which comprises treating the pulp with a mineral acid of a strength and in an amount sufficient to clean the surfaces of the pulp particles, desliming the pulp, treating the deslimed acid-treated pulp at a pulp density at least equivalent to 65% solids with an alkaline-acting alkali metal compound in an amount sufficient to raise the pH of the pulp to from 8.0 to 8.5, conditioning the alkalized pulp with a reagent charge consisting essentially of an aqueous emulsion of an anionically acting alkali metal resinate and an oily carrier, diluting the so-conditioned pulp with water, and subjecting the diluted conditioned pulp to froth flotation.

4. Process of concentrating by anionic froth flotation the oxidic iron of pulps of oxidic iron-bearing ores and ore-like materials including taconites containing silicious gangue, which comprises treating the pulp with a mineral acid of a strength and in an amount sufficient to clean the surfaces of the pulp particles, desliming the pulp, treating the deslimed acid-treated pulp at a pulp density at least equivalent to 65% solids with an alkaline-acting alkali metal compound in an amount sufficient to raise the pH of the pulp to from 8.0 to 8.5, conditioning the alkalized pulp with a reagent charge consisting essentially of an aqueous emulsion of an anionically acting sodium resinate and an oily carrier, diluting the so-conditioned pulp with water, and subjecting the diluted conditioned pulp to froth flotation.

5. Process of concentrating by anionic froth flotation the oxidic iron of pulps of oxidic iron-bearing ores and ore-like materials including taconites containing silicious gangue, which comprises treating the pulp with a mineral acid of a strength and in an amount sufficient to clean the surfaces of the pulp particles, desliming the pulp, treating the deslimed acid-treated pulp at a pulp density at least equivalent to 65% solids with an alkaline-acting alkali metal compound in an amount sufficient to raise the pH of the pulp to from 8.0 to 9.0, conditioning the alkalized pulp with a reagent charge consisting essentially of an aqueous emulsion of an anionically acting sodium soap of talloel and an oily carrier, diluting the so-conditioned pulp with water, and subjecting the diluted conditioned pulp to froth flotation.

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