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SIZE BAND FLOTATION OF SILICA

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1 Claim. (Cl. 209—166)

This invention relates to a process of floating silica away from other minerals and more particularly to the beneficiation of Florida pebble phosphate ore by froth flotation.

Beneficiation of phosphate ore has been effected in general by two processes. The first is a froth flotation process in which the phosphate is preferentially floated, leaving the silica in the tail. Reagents employed in this process are primarily anionic collectors which may be used with various oils or, in certain recent processes, without other oleaginous material. The second method of beneficiation of phosphate ore is a froth flotation process in the presence of a cationic collector in which the silica is preferentially floated, leaving the phosphate as a tail. It is to this latter type of flotation process that the present invenion belongs.

Beneficiation of phosphate rock presents in accentuated form the problem which is inherent in the beneficiation of non-metallic materials, namely that the final material is relatively low in cost and hence economy in the flotation procedure is of primary importance. The beneficiation of phosphate presents the further problem of grade, because a considerable premium is paid for higher grade phosphate material. In a sense the phosphate and silica flotation have complementary advantages and disadvantages. Relatively cheap reagents but somewhat inferior grade is encountered in the ordinary anionic flotation whereas the flotation of silica while involving more expensive reagent has the advantage of somewhat higher grade, provided it is carried out properly.

The froth flotation of silica presents to an extreme degree a slime problem. Minute amounts of slime which in ordinary flotation procedures would have no adverse effect are capable of rendering a silica flotation entirely impractical. This problem has become so acute in silica flotation that it is not sufficient to deslime thoroughly the feed, sufficient secondary slime being formed in the flotation operation itself so that results are in many cases not commercial. This has led to a procedure in which the phosphate ore is deslimed, then subjected to a polishing operation and finally again deslimed to remove a secondary slime generated in the polishing operation. This process is described and claimed in our Patent No. 2,216,040 dated September 24, 1940. The present invention constitutes an improvement on this general procedure and is based on a sizing operation which is carried out on the feed at a particular point, followed by froth flotation under separately selected conditions of the different size bands. The sizing according to the present invention must be effected prior to polishing as otherwise it is not fully effective.

The flotation of phosphate ore by anionic means in a plurality of size bands is a known procedure used as standard in some of the largest phosphate operations in Florida. This is described and claimed in the patent to Mead and Weaver, No. 2,156,245 dated April 25, 1939. In general the flotation in a plurality of size bands results in a saving in reagent and improvement in grade or recovery or both.

When it is attempted to apply size band flotation to the removal of silica from phosphate ore in the same manner as it is applied to the feed for anionic flotation as described in the Mead and Weaver patent referred to above, namely before introducing into the strings of the flotation cells, the desired results are not obtained, or rather the full improvement is not obtained. We have found according to the present invention that when dealing with size band flotation of silica, the sizing must precede polishing and desliming because the polishing conditions vary with the particle size range, a phenomenon which would not be ordinarily expected as it has no relation to the reagent economy which is the normal result from size band flotation. It is not known fully why it is essential to effect sizing before polishing and to use different polishing times for the different size bands, in general much longer times of polishing for the fine sizes. One factor which may be of importance is the effect of fine mud balls or clay which tend to segregate with the fines when the sizing is effected, as it should be for economical operation, by hydraulic classification, for example in a hindered settling classifier. It is probable that the presence of these clay aggregates may affect polishing time and results because according to the present invention a much longer polishing time is necessary with the fines than with the coarse material which is economically no serious draw-back because of the relatively minor volume of fines in ordinary feed. This factor may be the principle one or it is possible that other factors

may contribute or may even be of greater importance, and it is not desired to limit the invention to any theory of action. In general the coarser size bands which form the vast majority by weight of the ordinary feed can be effectively polished by employing a polishing time of from ½ to ⅒ the time used with the fines.

The degree of slime removal when sizing is effected prior to polishing and particularly when hydraulic sizing is employed which tends to segregate light mud balls with fines will vary with the coarse and fine material even when the fines are subjected to a relatively longer polishing time. The slimes however, are a much greater detriment in the flotation of coarser size bands and when an unsized ore is polished and deslimed it is difficult to effect a sufficient polishing and slime removal to permit froth flotation of all of the coarse silica.

The present invention overcomes the difficulty in polishing encountered when unsized feed is employed and at the same time this advantage is obtained without any compromise with metallurgical efficiency of the froth flotation operation or with reagent cost. In fact, the present process not only improves the polishing and desliming operation greatly but it also permits obtaining the advantages in saving of reagent and improvement in metallurgical results which are noted in size band flotation of unpolished feed with anionic collectors described in the Mead and Weaver patent.

It is an advantage of the present invention that the sizing operation when carried out at a particular point in the feed preparation, namely just before polishing, should combine all of the improvements normally associated with size band flotation and at the same time solve the slime problem which in its nature is entirely different from that solved by the size band flotation of phosphate described in the Mead and Weaver patent.

The present invention is particularly important in the beneficiation of phosphate ore, but is also of use in other flotation processes in which silica is removed from other similar non-metallic ores.

The invention will be described in greater detail in conjunction with the following specific examples.

Example 1

A typical example of Florida pebble phosphate ore having a B. P. L. content of about 42% was divided into two portions. One portion was deslimed, polished, again thoroughly deslimed and floated with the appropriate amount of a salt of a condensation product of coconut oil fatty acids with polyethylene polyamine using a small amount of kerosene. The other portion was deslimed, sized in a hindered settling classifier into three bands, −25 +48 mesh, −48+65 mesh and −65 mesh.

A screen analysis of the original feed and size bands is as follows:

	+28	+35	+48	+65	+100	+150	+200	−200	Percent
−28 +48 mesh feed	22.2	30.2	32.0	11.4	3.7	.5	-----	-----	65.5
−48 +65 mesh feed	----	----	----	73.5	23.8	2.7	-----	-----	23.9
−65 mesh feed	----	----	----	----	78.0	19.7	2.1	.2	10.6
−20 mesh feed	16.0	20.6	21.7	18.4	17.6	5.1	.5	.1	100.0

The different sizes were then separately highly polished using 3–4 minutes for the coarser bands and 10–12 minutes for the −65 mesh material. Following polishing all the size ranges were very thoroughly deslimed. The three size bands were then separately floated using varying amounts of the same cationic collector and in the case of the coarse bands also using some kerosene. The metallurgical results appear in the following table, the lime marked −20 mesh relating to the first test in which the feed was unsized.

Table I

Size Band	Feed		Concentrates			Middlings		Tailings		Midds. loss		Midds. rec.		Lbs./ton conc.	
	B. P. L.	Percent	B. P. L.	Insol.	Percent	B. P. L.	Percent	B. P. L.	Percent	Ratio	Rec.	Ratio	Rec.	Collector	Kerosene
−20 +48 mesh	43.12	65.5	78.51	2.45	70.0	52.11	51.1	3.39	62.0	1.95	93.4	1.89	96.3	1.75	.16
−48 +65 mesh	30.88	23.9	78.72	1.50	18.5	22.52	33.3	.81	28.5	2.68	95.1	2.59	98.4	1.21	-------
−65 mesh	42.23	10.6	77.70	1.75	11.5	32.69	15.6	1.14	9.5	1.94	94.8	1.86	98.9	.89	-------
Composite	40.10	100.0	78.46	2.19	100.0	39.23	100.0	2.44	100.0	2.08	94.1	2.02	96.9	1.55	.11
−20 mesh	42.31	100.0	78.95	2.20	100.0	58.25	100.0	7.63	100.0	2.17	86.0	2.06	90.6	2.34	.18

It will be apparent that a very marked improvement in recovery is obtained with some improvement in grade and with materially lower reagent consumption. In fact, with regard to this particular reagent the reagent cost per ton of floating the three bands is approximately ⅔ of that required when the whole size range is floated.

Example 2

A slightly higher grade pebble phosphate ore of +20 mesh was deslimed and classified in a hindered settling classifier and resulted in the following screen analysis:

	+28	+35	+48	+65	+100	+150	+200	−200
Coarse band	7.9	22.0	42.2	22.8	4.7	.4	-----	-----
Intermediate band	------	3.4	38.6	46.5	10.9	.6	-----	-----
Fine band	------	------	.4	15.9	46.5	24.8	11.1	1.1

Each size band was divided into a plurality of samples which were polished for varying lengths of time and the polished material thoroughly deslimed. Thereafter each sample was conditioned with a cationic promoter consisting of a salt of a condensation product of coconut oil fatty acid with polyethylene polyamines and subjected to froth flotation in a Fagergren flotation machine including a rougher float and a cleaner

float. The metallurgical results and polishing time are shown in the following table:

Table II

COARSE BAND

Feed B. P. L.	Phosphate tails		Middling B. P. L.	Silica concentr. B. P. L.	Ratio	Recovery	Collector lbs./ton feed	Polishing time, minutes
	B. P. L.	Insol.						
50.08	76.46	6.65	7.43	.90	1.54	99.1	.73	0
50.39	77.98	4.80	31.80	1.77	1.57	98.6	.73	2
49.47	78.75	4.40	48.64	.58	1.60	99.5	.73	4
49.86	78.31	4.10	39.31	2.32	1.60	98.2	.73	6
				INTERMEDIATE BAND				
46.12	76.20	7.00	10.52	2.01	1.68	98.2	.73	0
43.61	79.42	2.55	27.06	1.79	1.86	97.9	.73	2
44.09	80.95	1.90	49.27	2.12	1.88	97.7	.73	4
43.15	80.08	2.00	48.07	2.01	1.90	97.7	.73	6
				FINE BAND				
36.79	36.79	----	No float	----	----	----	.77	0
36.79	59.87	23.60	----	2.12	1.67	97.4	.77	2
37.25	76.78	3.60	11.30	.90	2.09	98.6	.77	4
36.76	78.22	2.80	12.17	1.01	2.16	98.5	.77	6
36.18	78.95	2.60	16.82	1.14	2.22	98.3	.77	8
35.25	79.48	2.50	9.42	.68	2.28	98.9	.58	12

From the above results it is apparent that a much longer polishing time is necessary with the fines band, improvements including a saving in the amount of collector required being noted even up to 12 minutes. But little improvement results in polishing the coarser band beyond 2 minutes or the intermediate band beyond 4 minutes. With a powerful collector for coarse silica such as the polyethylene polyamine coconut oil acid condensation product, good results are obtained even in the coarse band.

EXAMPLE 3

Samples from the band sizes of phosphate ore used in Example 2 were polished for various times, completely deslimed and conditioned with a different type of cationic collector, namely octadecylamine emulsified in pine oil. They were then subjected to flotation in Fagergren flotation machines as described in Example 1, employing a single cleaning to produce one middling product. The metallurgical results are shown in the following table:

Table III

COARSE BAND

Feed B. P. L.	Phosphate tails		Middling B. P. L.	Silica concentr. B. P. L.	Ratio	Recovery	Amine lbs./ton feed	Pine oil lbs./ton feed	Polishing time, minutes
	B. P. L.	Insol.							
50.15	69.90	14.50	15.71	7.76	1.47	94.9	.46	.46	0
50.22	75.16	9.50	61.72	5.46	1.56	95.9	.46	.49	2
49.72	75.27	8.40	66.97	5.03	1.57	96.4	.46	.46	4
50.00	75.16	9.15	63.47	3.63	1.54	97.6	.46	.46	6
				MEDIUM BAND					
44.27	59.10	27.80	----	10.94	1.45	92.1	.45	.45	0
44.45	76.46	7.00	23.98	2.21	1.76	97.7	.45	.45	2
43.93	78.75	4.60	54.84	4.50	1.88	95.4	.45	.45	4
				FINE BAND					
38.45	38.45	----	No float	----	----	----	.58	.58	0
38.45	61.29	23.35	----	4.33	1.67	95.5	.58	.58	2
37.65	62.82	20.70	----	5.09	1.77	94.3	.58	.58	4
38.08	74.95	7.15	17.23	1.55	2.01	97.9	.58	.58	6
37.00	79.00	3.00	40.51	2.45	2.22	96.2	.58	.58	8
37.96	79.10	2.80	26.55	1.44	2.13	97.8	.46	.46	12

It will be noted that the polishing time variations are substantially the same as in Example 2, but the grade of the phosphate tails in the coarse band were poor. This is due to the fact that octadecylamine is not normally considered capable of floating +28 mesh silica effectively. When such coarse material as this is to be floated more powerful silica promotors such as the polyethylene polyamine fatty acid condensation products should be employed. The coarse band, is however, included in the table so as to show that even with a reagent which is not commercially suitable for floating such coarse material, effects of the present invention are to be noted.

In the examples three size bands have been shown. This number is a desirable compromise

in the case of Florida pebble phosphate feed as it gives optimum results without undue complication. Markedly improved results over unsized feed is obtained when the sizing is such that two size bands only are produced and sizing may be carried beyond three size bands, but the further sizing in such cases usually does not sufficiently improve the results to warrant the additional equipment and complication of the process. Other non-metallic ores will in general require a comparable number of size bands, although the best sizes and the optimum number of bands will vary with each ore.

We claim:

A method of beneficiating phosphate ore by froth flotation of silica therefrom in the presence of a cationic collector which comprises desliming and sizing the ore into a plurality of size bands, separately polishing each size band until substantially all of the secondary slime is formed, the polishing time for the fines size band being several times that of the coarser size bands thoroughly desliming each size band and floating the silica from each band in a separate flotation operation in the presence of an optimum quantity of cationic collector.

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