Study on separation of phosphate from phosphate ore by flotation

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Abstract. According to the properties of low grade phosphate rock, a positive-reverse flotation process is developed as a new way for making good use of phosphate rock and a good quantity of the product is obtained. In this paper the optimum flotation conditions with depressant dosage and collector dosage have been demonstrated. Na2SiO3 as depressant 3.2 kg/t and fatty acid as collector 0.44kg/t in the positive flotation, H3PO4 as depressant 4.4 kg/t and sodium oleate as collector 0.24kg/t in the reverse flotation, under this condition, we finally got the phosphate concentrate about the grade of P2O5 is 31.29%, the recovery is 59.17% and gained a better indicator of dressing.

Introduction

China is abundant in phosphate resources. But the grade of phosphate ore is not high In addition, phosphate ore usually contains high amount of Mg and Ca, therefore it is hard to separate value minerals from gangue minerals. Recovering phosphate from phosphate ore have three main kinds of mineral processing methods: straight flotation, positive-reverse flotation and double reverse flotation. The most useful method is straight flotation in acidic conditions. Apatite is a valuable resource and 90% of them are used to produce phosphate fertilizer [1-5].

This article mainly studied about the flotation reagents on positive-reverse flotation of phosphate ore, which aim at increasing the utilization efficiency of phosphate resource.

Materials

The chemical composition of phosphate ore is shown in table 1 and the mineral analysis of phosphate ore is shown in table 2.

Table 1. The multi element analysis of ore %

P_2O_5	CaO	SiO_2	Al_2O_3	TFe	MgO	Na_2O	K_2O	TiO_2
15.21	34.39	18.28	1.02	1.31	1.13	0.059	0.96	0.15

Table 2. The mineral analysis of ore

Mineral	Apatite	Dolomite	Calcite	Quartz	Pyrite	Hematite	others
Wt/%	35-40	38-43	5	15	1-2	3	2

As observed from table 1 and table 2, apatite is the valuable mineral. The main gangue minerals are dolomite and quartz, which is difficult to separate. So positive-reversed flotation was used in the experiment. Positive flotation is used to separate apatite with quartz and reverse flotation is used to separate apatite with dolomite.

Positive flotation experiments

The flow chart of positive flotation is shown in Fig 1.

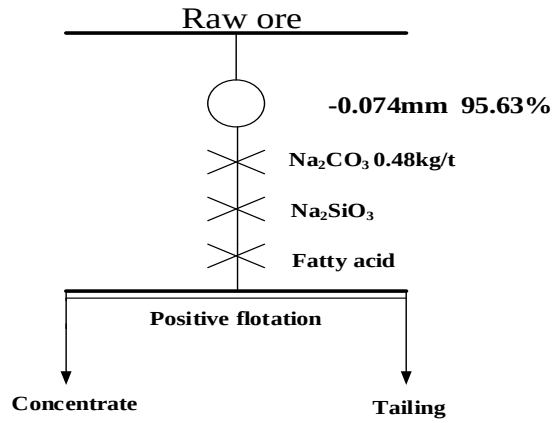

Fig. 1. The flow chart of positive flotation.

Na_2SiO_3 dosage

Na_2SiO_3 is the depressant used in the positive flotation. Na_2CO_3 is the pH regulator. pH of the solution is adjusted to about 9.5 and the dosage of Na_2CO_3 is 4.8 kg/t. Fatty acid is the collector of apatite and amount of fatty acid was fixed at 0.32kg/t. Separation Efficiency is defined as: E=Recovery(%) − Yield(%). The effect of Na_2SiO_3 dosage was researched and the result is shown in Table 3.

Table 3. The effect of Na2SiO3 dosage

Amount (kg/t)	Yield(%)	P_2O_5(%)	Recovery(%)	E
2.0	74.50	16.64	75.96	1.46
3.2	72.59	16.96	75.43	2.84
4.4	66.98	16.89	69.32	2.34
5.6	66.63	16.79	68.93	2.30

As observed from table 3, with the increasing of Na_2SiO_3 dosage, E increases first and then decreases. When the dosage of Na_2SiO_3 is 3.2 kg/t, separation efficiency reach to the best. When the dosage of Na_2SiO_3 is more than 3.2 kg/t, the content of P_2O_5 changes very little but recovery of P_2O_5 decreases. Comprehensive consideration, the optimal Na_2SiO_3 dosage is 3.2 kg/t.

Collector dosage

For the recovery of apatite from phosphate ore by positive flotation, fatty acid is the effective collector of apatite. Reasonable collector dosage can separate apatite from quartz effectively. Na_2CO_3 is the pH regulator. pH of the solution is adjusted to about 9.5 and the dosage of Na_2CO_3 is 4.8 kg/t. Na_2SiO_3 is the depressants of silicate minerals and amount of Na_2SiO_3 was fixed at 3.2 kg/t. The effect of fatty acid dosage was researched and the result is shown in table 4.

Table 4. The effect of fatty acid dosage

Amount (kg/t)	Yield(%)	P_2O_5(%)	Recovery(%)	E
0.20	52.68	16.79	54.20	1.52
0.32	72.59	16.96	75.43	2.84
0.44	80.17	17.20	86.48	6.31
0.56	78.75	17.22	84.50	5.75

As observed from table 4, E and recovery of P_2O_5 increase first and then decrease as the dosage of fatty acid is increasing. The content of P_2O_5 is increasing with the dosage of fatty acid increasing. Considering, the content of P_2O_5 is qualified and try to improve the recovery of P_2O_5, the optimal fatty acid dosage is 0.44 kg/t.

Reverse flotation experiments

The flow chart of reverse flotation is shown in Fig 2.

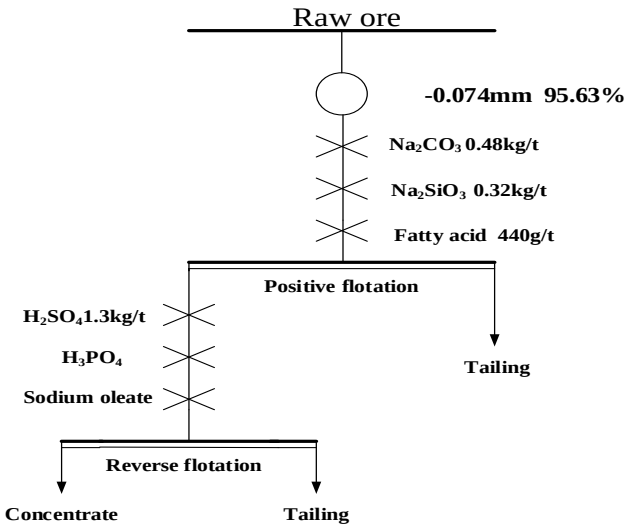

Fig. 2. The flow chart of reverse flotation.

H_3PO_4 dosage

Recovering apatite from phosphate ore by reverse flotation, H_3PO_4 is the depressants used in this experiment. H_2SO_4 is the pH regulator, pH of the solution is adjusted to about 5.4 and the dosage of H_2SO_4 is 1.3kg/t. Sodium oleate is the collector of Carbonate minerals in the concentration of flotation and amount of sodium oleate was fixed at 0.24kg/t. The effect of H_3PO_4 dosage was researched, the result is shown in Table 5.

Table 5. The effect of H3PO4 dosage

Amount (kg/t)	Yield(%)	P_2O_5(%)	Recovery(%)	E
2.0	24.07	28.77	41.74	17.67
3.2	27.59	29.20	48.67	21.08
4.4	28.22	31.41	53.51	25.29
5.6	27.90	31.18	52.50	24.60

As can be seen from table 5, when the dosage of H_3PO_4 is 4.4kg/t, the grade of P_2O_5, recovery of P_2O_5 and E are better than the others. The optimal H_3PO_4 dosage is 4.4 kg/t.

Collector dosage

Recovering apatite from phosphate ore by reverse flotation, sodium oleate is the effective collector of carbonate minerals in the concentration of flotation. Reasonable collector dosage can make apatite effectively separate with carbonate minerals. H_2SO_4 is the pH regulator, pH of the solution is adjusted to about 5.4 and the dosage of H_2SO_4 is 1.3kg/t. H_3PO_4 is the effective depressants and amount of H_3PO_4 was fixed at 4.4 kg/t. The effect of sodium oleate dosage was researched and the result is shown in table 6.

As observed from table 6, the P_2O_5 content increase as the dosage of sodium oleate increase from 0.08 to 0.40kg/t. E and the yield are decreasing with the dosage of sodium oleate increasing. Considering the reagent cost and mineral processing index, the optimal sodium oleate dosage is 0.24kg/t.

Table 6. The effect of sodium oleate dosage

Amount (kg/t)	Yield(%)	P_2O_5(%)	Recovery(%)	E
0.08	39.36	27.36	65.46	26.10
0.16	30.95	28.92	54.18	23.23
0.24	27.59	29.20	48.67	21.08
0.32	27.04	29.17	47.64	20.60
0.40	20.79	30.63	38.20	17.41

Optimal experiment

According to the above experimental study, Na_2CO_3 is the pH regulator, pH of the solution is adjusted to about 9.5 and the dosage of Na_2CO_3 is 4.8 kg/t. Na_2SiO_3 is the depressant of silicate minerals and amount of Na_2SiO_3 was fixed at 3.2 kg/t. Fatty acid is the effective collector of apatite and amount of fatty acid was fixed at 0.44kg/t. H_2SO_4 is the pH regulator, pH of the solution is adjusted to about 5.4 and the dosage of H_2SO_4 is 1.3kg/t. H_3PO_4 is the effective depressants in the concentration of flotation and amount of H_3PO_4 was fixed at 4.4 kg/t. Sodium oleate is the effective collector of carbonate minerals in the concentration of flotation and amount of sodium oleate was fixed at 0.24kg/t. The result of optimal experiment is shown in table 7.

Table 7. The result of optimal experiment

Yield(%)	P_2O_5(%)	Recovery(%)	E
29.87	31.29	59.17	29.3

Conclusion

Positive-reverse flotation was adapted to recovery phosphate from phosphate ore.Na_2SiO_3 as depressant 3.2 kg/t and fatty acid as collector 0.44kg/t in the positive flotation, H_3PO_4 as depressant 4.4 kg/t and sodium oleate as collector 0.24kg/t in the reverse flotation, in these conditions, a fine quality phosphate concentrate was obtained, the grade of P_2O_5 is 31.29%, the recovery of phosphate is 59.17% and the yield of phosphate is 29.87%.

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