Study on separation of phosphate from phosphate ore by flotation

Fengxiang Jiang a, Yanhai Shao b, * Shuan Xu c and Mingming Li d
Kunming University of Science and Technology, Kunming 650093, China
a chengzhang1025@163.com, b csusyh@126.com, c lanhualishi@163.com d Lmingming0318@163.com

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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 0.44 kg/t in the positive flotation, H3PO4 as depressant 4.4 kg/t and sodium oleate as collector 0.24 kg/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.

|        | P2O5 | CaO  | SiO2 | Al2O3 | TFe  | MgO  | Na2O | K2O | TiO2 |
|--------|------|------|------|-------|------|------|------|-----|------|
| wt/%   | 15.21| 34.39| 18.28| 1.02  | 1.31 | 1.13 | 0.059| 0.96| 0.15 |

| Mineral   | Wt/% |
|-----------|------|
| Apatite   | 35-40|
| Dolomite  | 38-43|
| Calcite   | 5    |
| Quartz    | 15   |
| Pyrite    | 1-2  |
| Hematite  | 3    |
| others    | 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.
Raw ore
-0.074mm 95.63%
Na₂CO₃ 0.48kg/t
Na₂SiO₃
Fatty acid

Positive flotation

Concentrate Tailing

Fig. 1. The flow chart of positive flotation.

**Na₂SiO₃ dosage**

Na₂SiO₃ is the depressant used in the positive flotation. Na₂CO₃ is the pH regulator. pH of the solution is adjusted to about 9.5 and the dosage of Na₂CO₃ 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:

\[ E = \text{Recovery(\%)} - \text{Yield(\%)} \]

The effect of Na₂SiO₃ dosage was researched and the result is shown in Table 3.

| Amount (kg/t) | Yield(\%) | P₂O₅(\%) | 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 Na₂SiO₃ dosage, E increases first and then decreases. When the dosage of Na₂SiO₃ is 3.2 kg/t, separation efficiency reach to the best. When the dosage of Na₂SiO₃ is more than 3.2 kg/t, the content of P₂O₅ changes very little but recovery of P₂O₅ decreases. Comprehensive consideration, the optimal Na₂SiO₃ 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. Na₂CO₃ is the pH regulator. pH of the solution is adjusted to about 9.5 and the dosage of Na₂CO₃ is 4.8 kg/t. Na₂SiO₃ is the depressants of silicate minerals and amount of Na₂SiO₃ was fixed at 3.2 kg/t. The effect of fatty acid dosage was researched and the result is shown in table 4.

| Amount (kg/t) | Yield(\%) | P₂O₅(\%) | 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 P₂O₅ increase first and then decrease as the dosage of fatty acid is increasing. The content of P₂O₅ is increasing with the dosage of fatty acid increasing. Considering, the content of P₂O₅ is qualified and try to improve the recovery of P₂O₅, the optimal fatty acid dosage is 0.44 kg/t.

**Reverse flotation experiments**

The flow chart of reverse flotation is shown in Fig 2.
**H₃PO₄ dosage**

Recovering apatite from phosphate ore by reverse flotation, H₃PO₄ is the depressants used in this experiment. H₂SO₄ is the pH regulator, pH of the solution is adjusted to about 5.4 and the dosage of H₂SO₄ 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 H₃PO₄ dosage was researched, the result is shown in Table 5.

| Amount (kg/t) | Yield(%) | P₂O₅(%) | 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 H₃PO₄ is 4.4kg/t, the grade of P₂O₅, recovery of P₂O₅ and E are better than the others. The optimal H₃PO₄ 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. H₂SO₄ is the pH regulator, pH of the solution is adjusted to about 5.4 and the dosage of H₂SO₄ is 1.3kg/t. H₃PO₄ is the effective depressants and amount of H₃PO₄ 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 P₂O₅ 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.

| Amount (kg/t) | Yield(%) | P₂O₅(%) | 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$_2$CO$_3$ is the pH regulator, pH of the solution is adjusted to about 9.5 and the dosage of Na$_2$CO$_3$ is 4.8 kg/t. Na$_2$SiO$_3$ is the depressant of silicate minerals and amount of Na$_2$SiO$_3$ 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$_2$SO$_4$ is the pH regulator, pH of the solution is adjusted to about 5.4 and the dosage of H$_2$SO$_4$ is 1.3kg/t. H$_3$PO$_4$ is the effective depressants in the concentration of flotation and amount of H$_3$PO$_4$ 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.

| Yield(%) | P$_2$O$_5$(%) | Recovery(%) | E |
|----------|---------------|-------------|---|
| 29.87    | 31.29         | 59.17       | 29.3 |

Conclusion

Positive-reverse flotation was adapted to recovery phosphate from phosphate ore. Na$_2$SiO$_3$ as depressant 3.2 kg/t and fatty acid as collector 0.44kg/t in the positive flotation, H$_3$PO$_4$ 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$_2$O$_5$ is 31.29%, the recovery of phosphate is 59.17% and the yield of phosphate is 29.87%.

Reference

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