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# Study on influence of residual magnetite in Panzhihua ilmenite flotation

Zhang Xiaolin[a] Liu Dianwen[a] Fang Jianjun[a] Xu Jin[b, a*]

[a]Faculty of Land Resource Engineer, Kunming University of science and technology, Kunming, Yunnan province, 650093,China
[b]Faculty of Law, Kunming University of science and technology, Kunming, Yunnan province, 650093,China

**Abstract**

The main utilization mode of titano-magnetite was firstly separating titano-magnetite by low intensity magnetic separation, then concentrating ilmenite from magnetic separation tailings. Magnetic separation tailings mainly contained ilmenite, but there was still a small quantity of titano-magnetite. Magnetic agglomeration of titano-magnetite occured because of existentence of remanence and pre-flotation grinding. It was found that titano-magnetite presented more optimal floatability than ilmenite. Therefore some gangues wrapped by titano-magnetite went into the floatation concentrate. In a word, titano-magnetite had negative effect on ilmenite floatation by decreasing grade and recovery of concentrate and increasing reagent consumption. The pre-removal of residual titano-magnetite before cleaning ilmenite from magnetic separation tailings by floatation was essential.



*Keywords*：titano-magnetite；ilmenite；flotation；magnetic agglomeration

## 1 Introduction

The current gravity separation and electrostatic separation could only gain ilmenite, which size range was greater than 45 micros in Panzhihua titanium Corporation, and majority micro-fine particles of less than 45 microns was lost with thickener overflow. For comprehensive recycling of valuable titanium resources, the author carried out study on full flowsheet ilmenite flotation. The collectors of ilmenite flotation included mainly: oleic acid and its salts, tall oil, paraffin oxide soap, styrene phosphonic acid, diphosphonic acid, hydroxamic acid, and salicylic hydroxamic acid etc. However, selectivity and collecting performance of these reagents was poor, which caused to low

*Zhang Xiaolin. Tel.: 15887203570; fax: (0871)5187068.
*E-mail address*: xiaolin6001@sina.com


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concentrate index. To solve these issues, the author synthesized a good effective ilmenite collector BS-1 by adding auxiliary additives to hydroxamic acid. The test results showed: collector BS-1 was a new ilmenite flotation collector which had strong collecting characteristic and good selectivity.

## 2 Test samples

Test samples got from magnetic tailings of Panzhihua Titanium Corporation. The content of $TiO_2$ was 11.81%, S was 1.01% in samples, main metal minerals were ilmenite, little titanium magnetite, hematite, gangue minerals dominated by titanium pyroxene, minor plagioclase, chlorite. Form of sulfides mainly was pyrite. The content of less than 74 microns accounted for 39.87%. Main chemical component analysis results of run-of-mine ore was showed in Table 1, and phase analysis results of run-of-mine ore was showed in Table 2.

Table 1 Chemical analysis results of run-of-mine ore

| Chemical composition | $TiO_2$ | CaO | MgO | $SiO_2$ | $Al_2O_3$ | TFe | S | Co | Ni | P |
|---|---|---|---|---|---|---|---|---|---|---|
| Quality content/% | 11.81 | 10.71 | 11.68 | 31.99 | 9.86 | 15.10 | 1.01 | 0.02 | 0.01 | 0.03 |

Table 2 Phase analysis results of run-of-mine ore

| Mineral name | Ilmenite | Titanomagnetite | Hematite | Titanaugite | Plagioclase | Chlorite | Sulfide | Total |
|---|---|---|---|---|---|---|---|---|
| Content/% | 15.0 | 2.8 | 1.5 | 31.4 | 30.5 | 16.9 | 1.9 | 100.0 |

Metallic mineral was mainly ilmenite, followed by titanium magnetite, sulfide, and gangue minerals. About 90% ilmenite existed with form of monomers, and others formed combination with magnetite. The existing form of sulfide was mainly monomer, a little sulfide was symbiotic with gangue minerals and ilmenite.

## 3 Test results

Due to high-sulfur samples, de-sulfide was considered before floating titanium to ensure the quality of titanium concentrate. Because of stable de-sulfide process in the scene, followed test conditions was used in laboratory: dosage of butyl xanthate was 300g / t; $2^{\#}$ oil was 50g/t; floating time of sulfide was 4min. Titanium once roughing was processing after de-sulfide, floating time of sulfide was 5min.

### *3.1 pH regulator test*

Under the condition of BS-1 as collector, changing rule of flotation test index with different pH value was studied. It proved by labor test, the pH value of slurry was very important to floating ilmenite, test results were showed in figure 1.

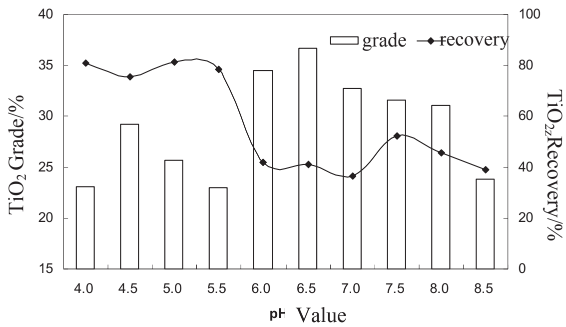


Fig.1 Changing diagram of flotation test index with different pH value

It could be seen from Fig.1, floating characteristics of ilmenite was different with different conditions pH value of slurry. With increasing pH value, the $TiO_2$ grade of concentrate showed tendency of first increasing then reducing, but recovery was almost shown declining trend. Peak value of grade and recovery was appearing at pH=5.25, grade was significantly increased when pH value was over 5.25, and recovery was greatly decreased, converse condition was shown when pH value was less than 5.25. We could see it was best state between ilmenite surface and collector reacting. The reason was mainly followed: under acidic conditions, active $H^+$ adsorbed to ilmenite surface, made ξ potential of ilmenite increase rapidly, and made double electrical layer of ilmenite and water alter, so flotability of ilmenite was changed. In addition, electro-negativity of ilmenite was increased due to specific adsorption of $SO_4^{2-}$, $HSO_4^-$, which was adverse to make anionic collectors absorb to ilmenite surface, but trend of absorbing collector to ilmenite surface was very strong when low iron was oxidized to high iron by dilute $H_2SO_4$. Thus, function of $H_2SO_4$ was not only pH value regulator, but also activator of ilmenite flotation

### *3.2 Collector test*

Based on condition test, pulp pH value was 5.5, dosage of CMC was 500g/t, test results of different amount of collector was shown in table 3.

Table 3 Collector BS-1 dosage test results

| Sample Name | BS-1dosage /g/t | Yield /% | $TiO_2$ grade /% | $TiO_2$ recovery /% |
|---|---|---|---|---|
| concentrate | 800 | 13.90 | 34.15 | 37.96 |
| middlings | | 52.80 | 11.24 | 47.45 |
| tailings | | 33.30 | 5.48 | 14.59 |
| total | | 100.00 | 12.51 | 100.00 |
| concentrate | 1200 | 35.70 | 22.69 | 66.34 |
| middlings | | 43.83 | 7.15 | 25.67 |
| tailings | | 20.47 | 4.77 | 8.00 |
| total | | 100.00 | 12.21 | 100.00 |
| concentrate | 1600 | 46.07 | 19.09 | 73.17 |
| middlings | | 40.33 | 6.51 | 21.85 |
| tailings | | 13.60 | 4.40 | 4.98 |
| total | | 100.00 | 12.02 | 100.00 |

It was shown from table above, concentrate grade was decreased step by step, and recovery was increased with the increasing collector dosage under condition of inhibitor certain dosage. The main reason was collector BS-1fixing on ilmenite surface by chemical reaction happened between collector BS-1 and metal ions of ilmenite surface, which made collector BS-1 have strong adsorbing effect. At the same time, pulp viscosity increased consequently with the dosage increasing, this made most no-disintegrate minerals and gangue minerals float by mechanical entrainment, thus, low concentrate grade was obtained. Therefore, role of depression could not be ignored in the process of ilmenite flotation.

### *3.3 Depressor tests*

The main minerals depressed were titanium pyroxene and plagioclase in the process of ilmenite flotation. According to feature of gangue minerals, main depressors included: natural macromolecular organism and synthetic polymer flocculants. We could draw followed conclusions by mass test: reagents of $Na_2SiO_3$,CMC, $H_2C_2O_3$, $Na_2SiF_6$, SHMP and sodium humate had certain depressing characteristic, but they had different selectivity to gangue minerals, CMC was made sure that it was best depressor for ilmenite flotation, influence of depressor dosage to ilmenite flotation index was shown in figure 2.

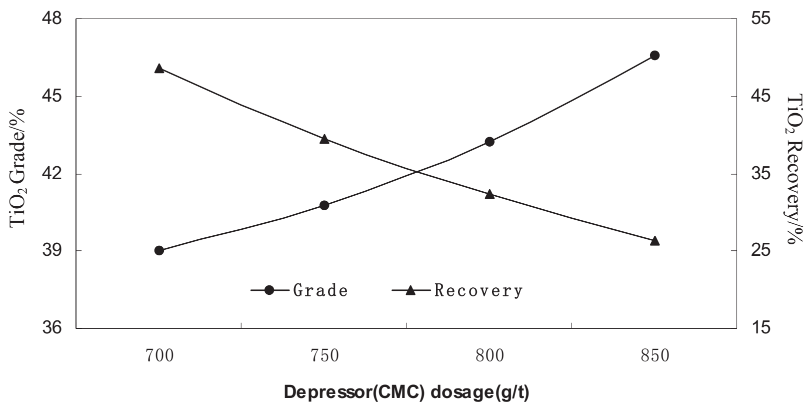


Fig.2 Relationship diagram between depressor dosage and concentrate index
(pH=5.5; BS-1=800g/t;flotation time:3min； flotation flow sheet: once coarse)

It could be seen from Fig.2, $TiO_2$ grade of concentrate was enhanced and recovery was decreased with increasing of depressor dosage. When dosage of depressor was 850g/t, $TiO_2$ grade of concentrate was 46.59%, but $TiO_2$ recovery was only 26.29%. The main reason was lots of mineral contains alkaline metal elements, such as $Ca^{2+}$, $Mg^{2+}$, which caused to interact between carboxyl of CMC and $Ca^{2+}$, $Mg^{2+}$,thus, CMC was fixed to mineral surface, and other 2−hydroxy was combined with water by hydroxy to make mineral hydrophilic. Having concluded optimum depressor dosage for roughing was 800g/t by contrasting concentrate index and reagent cost.

### *3.4 Flowsheet structure test*

Concentrate flotation index had been enhanced greatly by appropriate reagent type and dosage, but $TiO_2$ grade and recovery in concentrate had not achieved ideal test index by comparing with test results of reagent types and dosage. Therefore, in order to improve concentrate index, flowsheet structure must be made better. Because there had a little magnetite in raw ore and their influence in flotation could not be ignored. Tests confirmed: influence of magnetite dissociated to flotation index was very enormous. Thus, key point of flowsheet structure was focused on sequence of magnetite removed. Contrasting test flowsheets included mainly: once grinding- magnetic separation -flotation desulfide-once ilmenite roughing-once ilmenite cleaning and once grinding-flotation desulfide-once ilmenite roughing-once ilmenite cleaning- magnetic separation, test results were shown in table 4.

Table 4 Comparative test reuslts

| Test condition | Sample name | Yeild /% | $TiO_2$ grade /% | $TiO_2$ recovery /% |
|---|---|---|---|---|
| First flotation ilmenite, then separation magnetic | ilmenite | 10.60 | 46.50 | 42.70 |
| | magnetite | 1.04 | 18.50 | 1.67 |
| | sulfide | 3.70 | 6.90 | 2.21 |
| | tailings | 84.66 | 15.24 | 53.42 |
| | feed | 100.00 | 11.54 | 100.00 |
| First separation magnetic, then flotation ilmenite, | ilmenite | 11.08 | 48.55 | 47.59 |
| | magnetite | 2.80 | 6.61 | 1.64 |
| | sulfide | 8.80 | 12.75 | 9.93 |
| | tailings | 77.32 | 5.97 | 40.84 |
| | feed | 100.00 | 11.30 | 100.00 |

Test results showed from table 4: flotation recovery of ilmenite was increased significantly without magnetite influence, and compared with the process of removing magnetite after flotation, not only concentrate grade was improved two percent, but also recovery was increased five percent. The main reason was that bonding force of $Fe^{3+}$ was stronger than $Fe^{2+}$ with collectors, so adsorption chance of $Fe^{2+}$ was increased greatly without existence of $Fe^{3+}$. Thus, removing magnetite was an important measure of improving ilmenite concentrate indexes.

## 4 Disscussion

It was seen by EDS analysis and statistic (shown in table 5), it contained element of Mg and Mn in ilmenite concentrate, and the existing form of Mg and Mn in ilmenite was isomorphism (content of Mg was 3.05%, Mn was 0.27%, and Ti was 29.11%)(results were shown in Fig.3 and Fig.4), main reason of low concentrate grade was existence of Mg element and Mn element in ilmenite, and the problem was not been dissolved by traditional mechanical processing methods. In theoretical analysis, if we wanted to improve grade of ilmenite concentrate, effectual method was further removing of minerals containing Mg and Mn, but highest concentrate grade containing Ti was 29.11% (content of $TiO_2$ was 48.55%), even if minerals containing Mg and Mn in ilmenite was removed completely, it could not reach to theory of ilmenite (content of $TiO_2$ was 52.6%).

Table5 Ilmenite micro- composition EDS analysis /%

| NO. \ Name | O | Mg | Ti | Mn | Fe |
|---|---|---|---|---|---|
| 1 | 37.68 | 2.41 | 29.13 | 0.53 | 30.26 |
| 2 | 38.21 | 3.03 | 30.04 | / | 28.72 |
| 3 | 38.96 | 1.22 | 28.91 | / | 30.91 |
| 4 | 38.3 | 4.43 | 30.55 | 0.46 | 26.26 |
| 5 | 42.59 | 4.15 | 26.93 | 0.38 | 25.95 |
| Average | 39.15 | 3.05 | 29.11 | 0.27 | 28.42 |

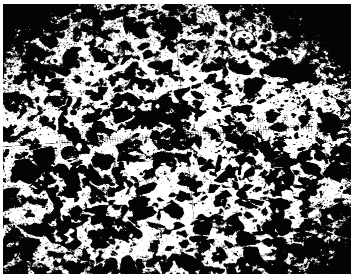

Fig.3 Orthogonal polarization, 0.02mm every length unit

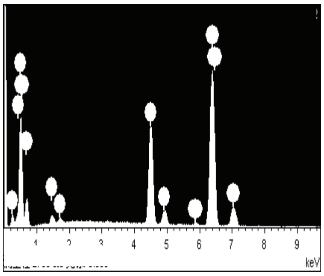


Fig.4 Ilmenite micro-composition EDS analysis

## 5 Conclusions

1）Good test index could be obtained through flowsheet of "once grinding – removing magnetite by weak magnetic separation–de-sulfide by flotation-once ilmenite roughing-once ilmenite cleaning". Its final concentrate index was: $TiO_2$ grade was 52.64%, and recovery was 47.4% in ilmenite concentrate.

2）There existed Mg element and Mn element in ilmenite(content was 3.05%) by EDS analysis, it had huge influence on grade of ilmenite concentrate, and their contents were, Mg was 3.05%, Mn was 0.27%, Ti was 29.11%($TiO_2$ was 48.55%).

3）It was found by ilmenite concentrates analysis, main reason of low concentrate grade was existence of Mg element and Mn element in ilmenite, and the problem was not been dissolved by traditional mechanical processing methods.

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