An Experimental Study on the Flotation of a Magnesite Ore in Liaoning

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Abstract —**In this paper, the mineral properties of the magnesite in Haicheng mine corporation is studied, and a novel mixed amines collector with high selectivity and efficiency is devised. On the basis of this work, the analysis of the mineral properties, grinding fineness test, PH value condition test of the pulp, regulator dosage test, and collector dosage test were carried out. The optimum technological parameters were obtained through experimentation, and a new method of removing impurities from magnesite was taken in the flotation of the actual ore. The results showed that if a suitable mineral processing flowsheet is adopted, indices are improved: i) concentrate grade of MgO 47.15%, ii) SiO2 0.16%, and iii) CaO 0.73%. The results not only realize the purpose of desiliconization and decalcification, but also have guiding significance for the full utilization of this type of magnesite.**

Keywords - Magnesite, Flotation, Collector, Sodium hexa-meta phosphate, Sodium silicate

I. INTRODUCTION

Magnesite is one kind of carbonate minerals which has significant commercial value, it is also one of superiority mining resources of china, and the yield and export volume of magnesite's products of china ranks first in the world [1]. The production of magnesite is usually used for metallurgy, building materials, chemical industry, light industry, faming and graziers and the refining of magnesium due to its fire resistance, agglutinating value and the other excellent physicochemical properties[2].

The main application of magnesite ore is used for refractory, but the impurities in it will break the fire resistance property of its product, so there is a rigid criterion of magnesite's impurities if it will be used for fireproofing[3]. Although the magnesite ore has the property of high MgO grade and less impurity in china, there are few mineral reserves of high grade magnesite ore due to years of exploitation. The problem of the utilization of low grade magnesite ore is becoming more and more serious, although it is difficult to beneficiate magnesium ores because the associate minerals are also other magnesium containing ores with similar characteristics and reciprocal influences in the beneficiation process[3,4]. It is very important that comprehensive research should be done such as the physicochemical properties, mechanism of magnesite's manufacture and application, optimization of magnesite's processing technology and conditions, thus can reduce the waste of resources, provide technical support and guarantee for the development and utilization of magnesite ore resource [5,6].

Therefore, it has obvious economical benefits, environmental benefits and social benefits to explore reasonable mineral processing technology of low-grade ore to produce high quality magnesite ore concentrate, make full use of magnesite ore resources and promote the quality of magnesium products.

II. EXPERIMENTAL MATERIALS AND METHODS

A. *Experimental materials*

The experimental materials were got from Haicheng mine corporation . Raw magnetite ore were crushed to -2mm particle size, after mixing and dividing for test sample. The samples were selected before and after treatment to do the rock and mineral identification.

B. *Properties of test ore sample*

The mineral composition was relatively complex in Haicheng magnesite, , The main magnesium mineral was magnesite, then the talc, brucite and dolomite, others were all impurities like quartz (opal), clinochlore and apatite etc, small amounts of iron mineral was also included. The main chemical component analysis are shown in Table 1, X-ray diffraction spectrum of magnesite ore are shown in Fig. 1.

TABLE 1. CHEMICAL COMPOSITION OF MAGNESITE ORE (%)

chemical component	MgO	CaO	SiO_2	Al_2O_3	Fe_2O_3	LOI
content	46.34	1.02	0.76	0.20	0.40	51.28

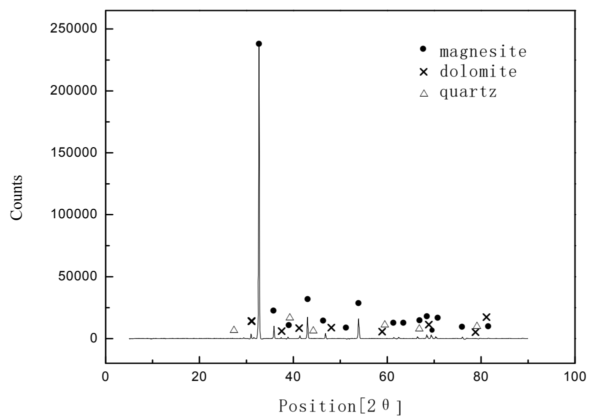

Fig. 1 X-ray diffraction spectrum of magnesite ore.

Through the analysis of the chemical composition and X-ray diffraction spectrum, we can deduced that the main components of the ore is magnetite, and the main gangue were talc, quartz, dolomite and clinochlore, etc. The content of calcium and iron were low and relatively stable, the main impurity affecting the quality of concentrate was SiO_2 and $(Ca,Mg)CO_3$, small amounts of them was closely associated with the magnesite, they are required to be removed as the primary impurities. The content of magnesium and calcium in the concentrate is the focus of our test to meet the market requirement.

C. Disseminated Grain Size of Magnesite

Disseminated grain size of magnesite in crude was mainly coarse, inhomogeneous distribution, rarely fine grains. The distribution rate for +1mm, 1-0.5mm, 0.5-0.15mm, 0.15-0.1mm, 0.1-0.075mm, 0.075-0.053mm, 0.053-0.037mm and -0.037mm were 23.95%, 23.95%, 42.56%, 1.61%, 2.49%, 2.44%, 2.44% and 0.28% respectively. The cumulative distribution rate for +0.075mm fraction was 96.82%, and 3.18% for -0.075mm fraction, besides, the distribution rate of -0.037mm fraction was 0.28%. From the above data , conclusion can be made that the liberation of the valuable minerals from the associated gangue minerals at the coarsest possible particle is very easy. Therefore, subsequent separation stages become easier and cheaper to operate, this is also a great advantage of magnesite beneficiation.

D. Mineralogy characteristics

Magnesite outputs as granular, irregular shape and its aggregate in ore was closely contact with brucite and talc. Between the particles and fractures of magnesite, there was al ways brucite filling and cementing, and has metasomatism to magnesite. Quartz and dolomite were also occurred between the fractures of magnesite in most cases.

E. Experimental methods

Crushing is the first mechanical stage in the process, after this process the particle size reached -2mm or so. Before the flotation test, the sample was grinding to the particle size of -0.075mm.XFD tank-suspending flotation machine was used, the tank volume is 1 L. In every test, 400g ore sample were used with the pulp density about 33.33%, impeller spindle speed about 1800r/min. Distilled water was used in the whole process, and the test temperature was room temperature .After the flotation process, flotation products were filtrated, dried and weighed respectively, then the grades were tested and the recoveries were calculated[6]. The test flowsheet is shown in Fig2.

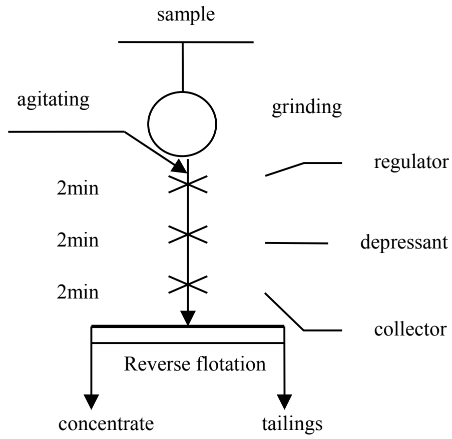

Fig. 2. The flowsheet used for mineral flotation.

III. FLOTATION TEST

A. Grinding fineness test

The full disintegration of the metal and gangue minerals is an important factor that affects the flotation indexes. The mesh of grinding determines the degree of dissociation between different minerals. An appropriate mesh of grinding is necessary for it may help remove more gangue, make the metal minerals enrichment in full and avoid the metal minerals argillization and waste energy.

The mesh of grinding test was conducted in one-stage flotation flowsheet by such condition: PH value 5.5, collector dosage 150g/t, sodium hexa-meta phosphate 150g/t , sodium silicate dosage 1500g/t. The results were shown in Fig. 3.

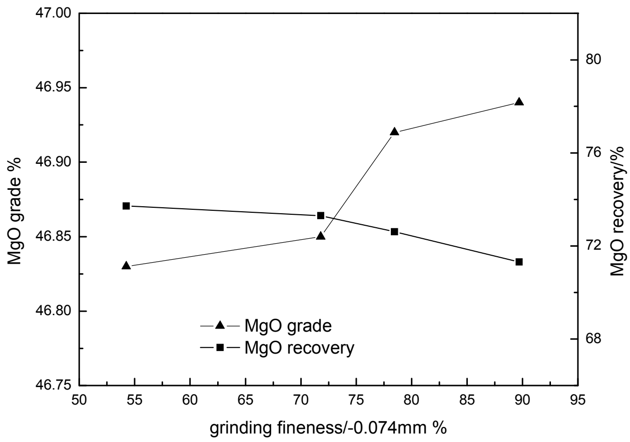

Fig. 3. The results of grinding fineness.

Figure 3 shows that the with the increase of the grinding size, the concentrate grade increased while the recovery rate decreased. A mesh of grinding fineness of -0.074 mm 71.8% was used in the succeeding test based on the consideration of grade recovery and energy consumption.

B. PH Value Test

In the test process ,the pH value is an important factor affecting the flotation effect, the pH level of pulp will usually cause the minerals particles to change their surface nature[7,8] ,thus affect the action of flotation reagents. So it is very important to investigate the relations between pH value and flotation results. Test results are shown in Fig . 4.

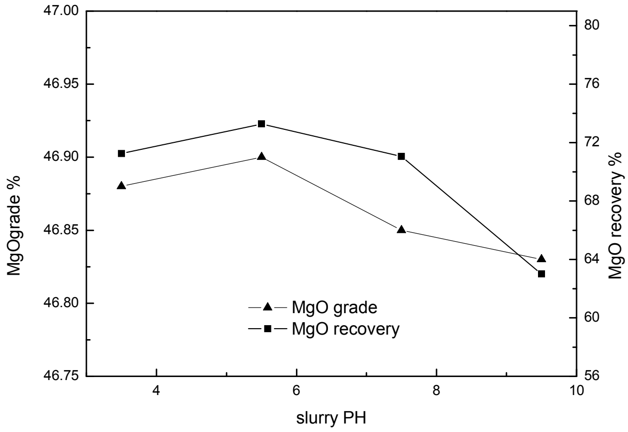

Fig . 4 The test results of pH value.

As can be seen from figure 4 , with the decrease of pH value of the pulp, recovery and grade of MgO increased first and then decreased. When the pH is 5.5 or so, MgO recovery is 73.28%、grade is 46.88%, At this time the recovery rate, the concentrate grade achieve the best value, based on the above considerations, the best pH value of the pulp is identified as 5.5.

C. Sodium Hexa-meta Phosphate Dosage Test

In the process of flotation, sodium hexa-meta phosphate has depressing effect both on magnesite and dolomite, At low density pulp ,the effect is always between the sodium hexa-meta phosphate and the surface of dolomite, yet at high density pulp the effect occurred both on the surface dolomite and magnesite[9] . On the condition of pH 5.5, collector dosage 150g/t, sodium silicate dosage 1500g/t, the test were made through changing the dosage of sodium hexa-meta phosphate. Test results are shown in Fig. 5.

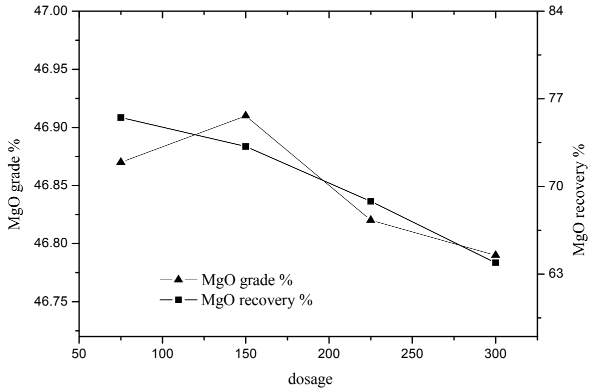

Fig. 5 Dosage of sodium hexametaphosphate test results

From figure 5, we can see that with the increase of the amount of sodium hexametaphosphate, the recovery rate decreased while concentrate grade increased at firs and then decreased. Finally the dosage of sodium hexametaphosphate is determined as $150g \cdot t^{-1}$ by analysis and comparison,

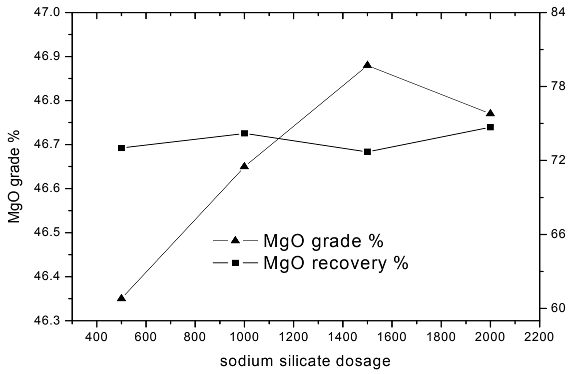

Fig. 6 Dosage of sodium silicate test results.

D. Sodium silicate dosage test

Sodium silicate has a dispersing effect on fine particles, meanwhile has a certain depressing effect on magnesite. It is often used with sodium hexametaphosphate in the flotation of magnesite. On the condition of pH 5.5, collector dosage 150 g/t, sodium hexametaphosphate dosage150 g/t, the test were made through changing the dosage of sodium silicate. Test results are shown in Fig. 6.

As shown in figure 6, recovery rate change is not obvious with the increase of the amount of sodium silicate , concentrate yield increased after slightly decreased. In the amount of sodium silicate 1500 g/t, the grade of concentrate MgO reached the peak. Finally the dosage of sodium silicate is determined as 1500 g/t by analysis and comparison,

E. Collector Dosage Test

A new type of collector were developed which is mixed amines , It has the characteristic of high selectivity and frothing .The collector dosage test were made under the condition that pH 5.5,sodium silicate dosage 1500 g/t, sodium hexa-meta phosphate dosage150 g/t in order to achieve best collector volume. The results are shown as Fig. 7.

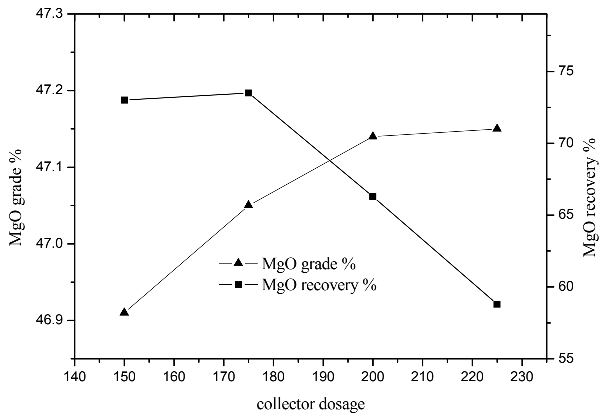

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Fig. 7 Dosage of collector test results.

Figure 7 showed that, with the increase of the amount of collector, the recovery rate is decreased, and the content of MgO in the concentrate is increased. In test A, when collector dosage is 175g/t,recovery is 73.89%、MgO content is 47.05%; In test B , when collector dosage is 200g/t, recovery is 66.24%、MgO content is 47.15%.A conclusion could be made after comparison of the results of test A and B that, recovery decreased sharply while grade increase is slowly , so multiple flotation can be used to ensure high recovery rate based on improving the quality of concentrate grade, thus the collector dosage is determined as 175g/t.

IV. FLOWSHEET EXPERIMENT

The suitable flotation process and determined by the comprehensive flotation experiment[10]. The flowsheet experiment was done according to Fig. 8, the experiment results were shown in Table 2.

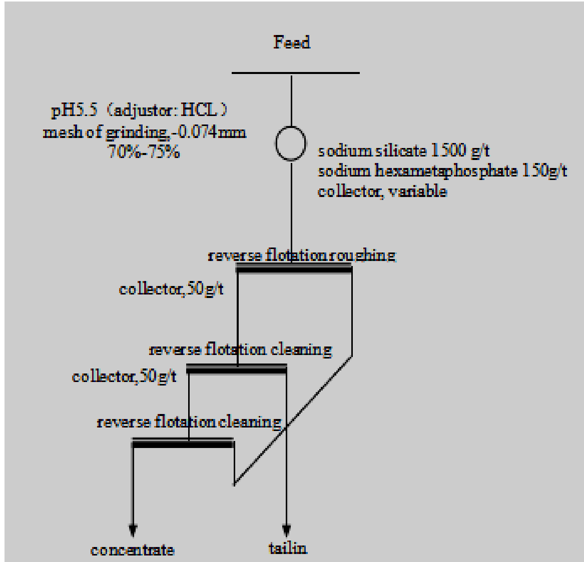

Fig. 8 The flowsheet experiment

TABLE 2 RESULTS OF THE FLOWSHEET EXPERIMENT (%)

name	yield	grade /%				
		CaO	Fe_2O_3	Al_2O_3	SiO_2	MgO
ore	100	1.02	0.40	0.20	0.76	46.34
concentrate	63.04	0.73	0.47	0.02	0.16	47.15

The results of close-circuit experiment showed: with HCL to adjust pH value and decrease the side effects of dissolution ions, sodium silicate and sodium hexametaphosphate to disperse and reduce the adsorption effect, the closed-circuit three-step flotation flowsheet could obtain magnesite concentrate with MgO 47.15%, SiO_2 0.16%, CaO 0.73%,which met the industrial requirements.

V. ANALYSIS AND DISCUSSION

Both the sodium hexametaphosphate and the sodium silicate are often used together in the magnetite flotation process, they all have the effect of decrease the Zeta potential of the magnetite and quarts, whiles the collector has the effect of increase the Zeta potential of the magnetite and quarts. So to make the flotation process being carried out smoothly, the best environmental conditions should be rigidly controlled.

It is difficult to beneficiate magnesium ores because the associate minerals are also other magnesium containing ores with similar characteristics and reciprocal influences in the beneficiation process. The reciprocal influences in flotation are defined as the influences caused by the dissolution and

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adsorption of minerals, which leading to the activating or depressing effects on other minerals. Much work should be done such as investigating the reciprocal influences among magnesium-containing minerals, studying the existence form and the mode of action of active principle in the system of reverse flotation of magnesite ore from micro-perspective, and inspecting the existence form and the trending of MgO in the separation process of magnesite ore from macro-perspective.

VI. CONCLUSIONS

Through the research of this topic, we can draw some conclusions as follows:

Both sodium hexametaphosphate and sodium silicate all have the effect of reducing the Zeta potential of the magnisite and quarts, the more the amount of regulators, the Zeta potential decreased more sharply, the action of sodium hexametaphosphate was more obvious.

Low density collector can slightly decrease the isoelectric point of magnesite , but the Zeta potential of magnesite will increase with the amount of collector and gradually increase ,The magnesite isoelectric point moves to the basic direction.

Magnesite and quartz floating rate difference maximum appears in the range of 4~8 pH. When pH=5~6, the highest floating rate of quartz appears. Amine as collectors, sodium hexametaphosphate and sodium silicate both has the depressing effect on magnesite .

The best grinding fineness is -0.074 mm 71.8%in the process of reverse flotation of magnesite ore, the best pH value is about 5.5 or so. In the flotation system, sodium hexametaphosphate and sodium silicate can be used together as an effective depressant, thus can make them cooperate with each other, strengthen the regulating functions. However, in the best dosage, the sodium silicate is about 10 times the sodium hexametaphosphate.

Both sodium hexametaphosphate and sodium silicate adsorbed on the surface of magnesite by chemical adsorption form, so as to depressing magnesite and collecting silicon by reverse flotation. Amine collector is adsorbed on the quartz surface for collecting by electrostatic adsorption form.

Mixed amine is an effective collector in of magnesite flotation process. In the flotation system, magnesite, dolomite and quartz, have obvious surface differences , so we can choose the mixed amine as collector, through reverse flotation method to collecting dolomite and quartz . In the flotation process , magnesite and dolomite have close flotation behavior , so we can adapt the method of adding regulator to increase the difference , good results can also be achieved.

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