Application of Magnetization Treatment in Flotation

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Abstract. With the decrease of mineral resources reserves, the characteristics of "poor, fine and miscellaneous" of mineral resources are becoming more and more obvious. People pay more and more attention to the environmental protection. A simple, green and efficient separation process magnetization flotation has been paid more and more attention by mineral processing workers. Based on the analysis and summary of the development process and advantages of magnetic flotation, the application status of magnetic flotation at home and abroad in the processing of ferrous metal ore, non-ferrous metal ore, rare metal ore, precious metal ore, non-metallic ore, coal, etc. Compared with conventional flotation, it is found that the cost of magnetic flotation is lower than that of conventional flotation. Combining theoretical analysis, computer simulation, experiment and advanced detection methods, the mechanism, influencing factors, process and equipment of magnetic flotation are the development trend in the future.

1. Introduction

China is the world's largest producer and trading country of mineral products, with a complete range of minerals and rich in total mineral resources, which plays an important role in the global mining industry. However, there are less rich ore and more lean ore, less single ore and more associated ore, less free-milling ore and more refractory ore. And since 19th CPC National Congress, under the guidance of Xi Jinping thought on ecological advancement, green mines have been increasingly valued by people. Therefore, the mine needs more environmental friendly and efficient mineral processing technology and equipment.

Any substance has magnetism and will be affected by magnetic force in magnetic field. Magnetization treatment technology refers to the technology of magnetizing a substance in a magnetic field in order to change its physical and chemical properties. Magnetization treatment has an impact on flotation, gravity separation and chemical leaching. The combination of magnetization treatment technology and flotation is called magnetization flotation[1,2]. Compared with conventional flotation and other beneficiation processes, magnetic flotation has better separation index, simpler operation and less investment.

2. Development and advantages of magnetic flotation

2.1. Development of magnetic flotation
Magnetization treatment technology was first used in medicine. Later, it was gradually used in chemical industry, metallurgy, agriculture, environmental protection and other fields. In 1945, Belgian engineer T. Vermeriven found that magnetization treatment of water can reduce the generation of boiler scale. This method is easy to operate and does not produce chemical pollution, so it is quickly applied to...
practice, but it has not attracted much attention. Until the early 1960s, researchers in the former Soviet Union proposed that the magnetization treatment technology may change the physical and chemical properties of the water system, and the change of the physical and chemical properties of the water system can have an impact on many industries, such as agriculture, construction, metallurgy, etc. Therefore, the magnetization treatment technology has attracted widespread attention and developed rapidly. In the 1990s, the magnetization treatment technology was widely used in the petroleum industry with good results. Since the 21st century, magnetization treatment technology has been paid more and more attention in the field of mineral processing, and the research on magnetization treatment has gradually developed to how to effectively use magnetic energy and how to strengthen the mineral processing mechanism[3].

2.2. Advantages of magnetic flotation
Magnetization treatment is different from conventional magnetic separation. Magnetization flotation still follows the basic principle of flotation. Only external magnetic system is needed, no additional reagents are needed, and there is no pollution. Some studies show that magnetization treatment technology can effectively treat the heavy metal ions in mineral processing wastewater and make the waste water clean. Magnetic flotation only needs to add a magnetic field and no power. For the transformation of the existing plant, there is no need to change the original configuration on a large scale. The operation is simple and the cost is low. Further research on magnetic flotation can simplify the separation process, speed up the separation speed, reduce reagent consumption, enhance the selectivity and action of reagents, and improve the quality and quantity of concentrate. Magnetization flotation is the application of magnetization treatment technology to flotation, which helps to integrate magnetization treatment technology and mineral processing technology, learn from each other, develop advantages and avoid disadvantages, and give full play to the advantages of interdisciplinary. Magnetic flotation is conducive to the comprehensive utilization and effective recovery of mineral resources in China, with a good prospect.

3. Application of magnetization flotation

3.1. Application in metal ore dressing

3.1.1. Application of ferrous metal ore dressing
Ran Hongxiang etc used magnetic flotation method to separate magnetite. It was found that the magnetic field in the magnetic flotation device can inhibit the magnetic minerals from entering the tailings and effectively improve the recovery rate of iron concentrate; at the same time, it can reduce the magnetic agglomeration, reduce the non-magnetic gangue inclusion in the concentrate, and improve the grade of iron concentrate. Magnetic flotation is not only beneficial to the improvement of concentrate quality, but also to the increase of quantity. T. Yalsin etc used magnetic flotation instead of conventional magnetic flotation combined beneficiation process, and found that the indexes that can be achieved by four stage separation in the original process can be achieved by one stage magnetic flotation, greatly simplifying the beneficiation process flow and reducing the beneficiation cost. Xia Jianqin found that after one roughing, two cleaning and two scavenging, the concentrate grade and recovery of a magnetite mine conventional flotation method are 64.70% and 71.77%, respectively. For the same separation times, the grade and recovery of conventional magnetic separation method are 59.30% and 90.49% respectively. The magnetite concentrate with grade of 71.31% and recovery of 96.63% can be obtained by one stage magnetic flotation. Magnetic flotation shortens the separation process and improves the separation index obviously. Liao Yinfei etc[4] studied the effect of magnetization treatment on reverse flotation of magnetite flotation column. The experimental results show that magnetization flotation index is better than conventional flotation index, and the flotation index of pulsed magnetic field is better than that of constant magnetic field. The recovery rate and grade of iron concentrate are increased by 1.12% and 4.22% respectively by pulsed magnetic field. S. Avar etc[5] found that magnetic field can...
effectively reduce the loss of fine magnetite. Mustafa Birinci etc[6] used magnetic micro flotation column to study the effect of external magnetic field on quartz cation flotation in magnetite. Because of the advantage of external magnetic field, the selectivity of magnetite inhibition is strong. The high selectivity is due to the fact that magnetic field only affects magnetite particles, while quartz particles are not affected by magnetic field. In the presence of magnetic field, flotation efficiency increased from 0% without magnetic field to 88%, and the separation efficiency was significantly improved. A. López-Valdivieso etc [7] found that in the absence of starch, dextrin, CMC and other organic inhibitors, the use of amine collectors to flotation of iron concentrate (mainly magnetite) with 65.1% TFe grade can be significantly inhibited by uniformly applying a weak magnetic field. Under the action of magnetic field, magnetite particles aggregate into large chain and column shape, and rapidly settle to the bottom of sedimentation tank. Magnetite adsorbs amines and becomes hydrophobic, which causes bubbles to adhere to magnetite aggregates. The bubbles in magnetite aggregates can not float because of the large mass of magnetite aggregates, so they are discharged as tailings. It is possible to produce iron concentrate by flotation without depressant. Because these depressants inhibit the flotation of quartz and silica bearing minerals, the flotation recovery of these minerals will be improved if the depressants are not used in the reverse flotation process. This will result in higher quality iron concentrate. Li Aiqiang etc[8] studied how magnetization affects hematite flocculation, and found that magnetization treatment can strengthen flocculation among hematite particles. If magnetization treatment can strengthen the flocculation of hematite, it will be beneficial to the separation of fine hematite. Lu Yiping etc found that magnetization treatment can increase the apparent particle size of weakly magnetic pyrolusite, which is conducive to the flotation of fine-grained pyrolusite.

3.1.2. Application of nonferrous metal ore dressing.

The recovery rate of copper is increased about 3% by magnetization treatment of flotation water in Tangdan concentrator of China. Fang Xihui etc studied the effect of magnetization on the flotation of copper sulfide ore. The results show that magnetization treatment increases the dissolved oxygen content of pulp, makes more hydrophobic substances on the surface of minerals, increases the dissociation degree and dispersion degree of flotation reagents, and improves the recovery rate of copper. The recovery rate of porphyry primary copper sulfide copper ore increases by 5% ~ 6%, and that of high sulfur secondary copper sulfide copper increases by 2% ~ 3%. The magnetic field intensity has a great influence on the recovery. Corachev found that magnetization treatment of flotation water can improve the flotation recovery of copper. It is found that proper magnetization treatment can increase the hydrophobicity of mineral surface and optimize the flotation process. Compared with conventional flotation, the recovery of copper in magnetic flotation is 7% higher[9]. Qiu Tingsheng etc found that magnetization treatment of flotation water or magnetization of butyl xanthate solution can improve the flotation recovery rate of chalcopyrite. Compared with conventional flotation, the recovery of chalcopyrite increased by 3.45% when magnetizing flotation water and 3.54% when butyl xanthate was magnetized. Qiu Tingsheng etc also found that the water magnetization treatment can improve the recovery rate of copper in the waste residue. Qiu Tingsheng etc carried out magnetization flotation of chalcopyrite and pyrite. The test results show that magnetization treatment increases the surface tension of solution and the wettability of minerals, and magnetization treatment enhances the effect of inhibitors on pyrite and reduces the effect of xanthate on pyrite, so as to expand the hydrophobic difference between brass ore and pyrite and achieve better flotation effect. Wang Qiufeng etc magnetized xanthate and found that in the flotation of ZnS, PbS and FeS2, the flotation recovery rate of magnetized xanthate as collector is higher than that of ordinary xanthate, which proves that magnetized flotation reagent is beneficial to the flotation of lead-zinc sulfide ore. Fu Lizhu etc magnetized flotation Fankou Lead-Zinc ore. The experimental results show that magnetizing treatment can change the composition of the agent and the mineral surface, significantly increase the adsorption capacity of the ore surface agent, thereby promoting the interaction between the agents and minerals, and promoting the transformation of hydrophobic components. In addition, it can also improve the foam characteristics of flotation, reduce the viscosity, reduce entrainment, increase the flotation rate of target minerals, thereby improving the
recovery rate and concentrate. Quality. T. Yalsin etc magnetized flotation a nickel mine. Magnetization treatment reduced the pyrrhotite inclusions in the foam. Most of them remained in the pulp, the grade of nickel concentrate increased, the flotation index became better, and the technological process became shorter.

3.1.3. Application of rare metal ore dressing.
Qiu Tingsheng etc carried out magnetic flotation of scheelite and found that magnetization treatment can change the dynamic potential of mineral surface and enhance the adsorption of reagents on the mineral surface. Magnetization treatment improves the flotation rate of scheelite and reduces the separation process. The research of Deng Xiangxiang etc shows that in scheelite separation, compared with conventional flotation, the effect of reagent and mineral is enhanced, the dosage of reagent can be reduced, the cost can be saved, and the magnetic flotation can also improve the separation index. Zhang Chunju etc magnetization treatment scheelite ore dressing wastewater, the effect is good. The application of magnetization treatment in mineral processing is not only beneficial to separation, but also beneficial to subsequent wastewater treatment. Chen Xiang etc[10] magnetized a tungsten ore containing a large amount of wolframite slime in Jiangxi Province, and found that compared with conventional flotation, the dosage of reagent was less, and the grade of wolframite concentrate was increased by 6.87%, and the recovery rate was increased by 7.19%. He Tingshu etc used magnetized kerosene in molybdenum flotation, and the concentrate grade increased by 0.5%, and the molybdenum recovery increased by 2.53%. Chen Xiang etc[11] magnetized flotation a fine-grained tantalum niobium tailings gravity separation coarse concentrate in Jiangxi Province. The test results show that compared with conventional flotation, the magnetic flotation reagent consumption is less, and the grade of Ta2O5 concentrate is increased by 1.88%, the recovery rate is increased by 2.75%; the grade of Nb2O5 concentrate is increased by 1.58%, and the recovery rate is increased by 2.96%. As we all know, China is a big country of rare earth, and flotation is the main method of rare earth separation. Fang Xihui etc applied magnetization treatment to the precipitation of rare earth mother liquor with ammonium bicarbonate. It was found that the purity of rare earth can be increased by 3% ~ 4% under appropriate magnetization conditions, and crystalline rare earth carbonate can be obtained. It also provides a reference for rare earth magnetic flotation.

3.1.4. Application of precious metals in mineral processing.
Liu Kongda etc studied the effect of magnetization treatment on gold flotation of Zhuji gold company. The results show that compared with conventional flotation, the grade of gold concentrate is increased by 10.24 g/t, the recovery rate is increased by 7.92%, and the grade of tailings is reduced by 0.76 g/t. In order to verify whether the test results are caused by errors, they also studied the effect of magnetization on cyanide leaching gold concentrate to determine the accuracy of the test. It is found that under the optimum experimental conditions, the leaching rate of gold concentrate is increased by 12.26% compared with conventional leaching. It is also verified that magnetization treatment is really beneficial to the separation of gold ore, which is not caused by experimental error. Although the principle is not clear, the practical application can obtain good indicators. Qiu Tingsheng etc[3] conducted a comparative test between magnetization flotation and conventional flotation for a certain gold and silver bearing polymetallic oxide ore. It was found that under the condition that the grade of gold and silver concentrate remained basically unchanged, the recovery rate of gold and silver in magnetic flotation could be increased by 5% and 2%, respectively.

3.2. Application in mineral processing of nonmetallic ore.
Qiu Tingsheng etc magnetized flotation fluorite. The research results show that magnetization treatment can simplify the separation process of fluorite and quartz, enhance the inhibition of quartz, improve the recovery rate of fluorite, and have the effect of increasing iron and reducing silicon. Zhou Wenbo etc[12] compared the conventional flotation and magnetic flotation of calcite and fluorite, the recovery of calcite and fluorite increased by 19.77% and 12.81% respectively. Liao Dehua etc conducted a comparative
test of magnetization flotation and conventional flotation for a skarn type tungsten ore tailings in Hunan Province. The experimental results show that magnetization treatment of flotation water can enhance the effect of flotation reagents on minerals, improve the grade and recovery of fluorite concentrate, and reduce the dosage of reagents. Zhou Wenbo etc[13] also found that magnetization treatment can improve the recovery rate of fluorite. The results obtained by Liu Kongda etc are also gratifying. Li Qingqing[14] studied the magnetization flotation of fluorite, and found that the magnetization treatment technology significantly improved the recovery rate of fluorite, and found that the effect of magnetization treatment agent was the best, followed by magnetization treatment water and magnetization treatment pulp. Zhu Jujian etc magnetized flotation silica. The experimental results show that magnetization treatment can reduce the flotation rate of quartz and the activation ability of Ca2+ on quartz, which is conducive to the separation of hematite and quartz.

3.3. Application in coal preparation

Li Haipeng[9] magnetized the slime collector, and found that magnetization treatment can reduce the viscosity and surface tension of the agent, increase the dispersion, accelerate the diffusion speed, so as to improve the yield of clean coal and the recovery rate of combustible body, and enhance the collection effect. The floatability of low rank coal is poor due to the existence of a large number of hydrophilic functional groups on the surface. Zheng Changlong etc studied the effect of magnetization treatment of 2-octanol on the flotation performance of low rank coal under different magnetization time and magnetic field intensity. It is found that the yield of clean coal can be increased by 3.91% by using magnetized 2-octanol as foaming agent, while the ash content of clean coal has little change. It is found that with the increase of magnetization time and magnetic field intensity, the interfacial tension of coal slurry decreases, and the decrease of interfacial tension of coal slurry is conducive to coal flotation, so magnetization treatment of 2-octanol is conducive to coal flotation. Wu Shuming[15] magnetization treatment flotation water increases the contact angle of coal, improves the surface hydrophobicity of coal, and is conducive to the adsorption of reagents on the coal surface. The yield of clean coal is increased from 33.5% to 34.6%, and the flotation effect of coal is enhanced. Liu Jia magnetized flotation coal slurry and found that magnetization treatment can improve the yield of clean coal. Under the appropriate magnetic field strength, the yield of clean coal can be increased by 2.80%. Song Zhiwei etc magnetized flotation coal slurry and found that magnetization treatment was beneficial to desulfurization and ash reduction of high sulfur coal, and desulfurization rate was increased by 7% compared with conventional flotation method. Bian Bingxin etc magnetized flotation coal slurry and found that magnetization treatment can improve the floatability of coal, which is conducive to desulfurization and ash reduction of slime. Xiong Yanquan etc also reached this conclusion, and also found that magnetization treatment can improve the filtration performance of materials, and Li Jianjun etc also found that magnetization treatment can make the settling effect of coal slime better. The magnetization flotation of coal is not only beneficial to the separation effect, but also has reference significance for the development of dewatering equipment.

4. Conclusion

Magnetic flotation is different from the combined process of magnetic flotation. Magnetic flotation follows the basic principle of flotation. The object of magnetization treatment is water system (including water for magnetic flotation, reagent for magnetic flotation and magnetized pulp). Magnetization treatment changes the physical and chemical properties of water system, thus affecting the flotation speed, reagent dosage, treatment capacity, concentrate quality and recovery rate, etc. Magnetization can be carried out before and during flotation. The magnetized magnetic system can be permanent magnetic system or electromagnetic magnetic system, each has its own advantages and disadvantages. And the magnetic field of magnetization treatment can be uneven magnetic field or even magnetic field, and magnetic separation method requires that it must be uneven magnetic field. A. López-Valdivieso etc Used uniform magnetic field.
Compared with conventional flotation and conventional magnetic separation, magnetic flotation has better separation effect, higher product quality and quantity, and saves reagents. In addition, the application of magnetization treatment in flotation only needs additional magnetic system, no reagent addition, no chemical pollution and no power. The modification of the current plant is small and the cost is low. Therefore, magnetic flotation has strong vitality and broad application prospect in the situation that the quantity and quality of mineral resources are decreasing day by day. However, magnetization treatment may have no effect on flotation, or even inhibit it. The mechanism of magnetization treatment is not clear and opinions vary. Therefore, in the future development, theoretical analysis, computer simulation, experiment and advanced detection methods will be combined to develop advantages and avoid disadvantages. The research trend of magnetization flotation is to study the mechanism of magnetic flotation, the influencing factors and law of magnetization flotation, the technology research of magnetic flotation and the equipment research of magnetic flotation.

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