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Current Situation and Prospect of Re-separation and Recovery Technology for Fine-grained Minerals

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Abstract: *Reseparation has an important position in mineral separation, but reseparation cannot effectively recover fine particles, this paper summarizes the development of reseparation recovery technology in recent years, expounds the research status of reseparation at home and abroad in three aspects: equipment, process, theory, etc., summarizes the current new process of reseparation technology, concludes that the new process of composite force field reseparation composed of a variety of force fields is the future development direction of fine grain reselection, and puts forward its own thinking on the way out and development direction of reselection.*

Keywords: *re-separation; fine particles; new process; composite force field*

1. Introduction

Resorting has a long history, especially its advantages of low energy consumption, low cost and low pollution, making it indispensable in mineral sorting. However, in recent years, with the continuous exploitation of mining resources, with the long-term exploitation and utilization of mineral resources, rich ore and coarse-grained embedded mineral resources have been gradually exhausted, and the selected minerals have shown the trend of fine particle size, low grade, high mud and high oxidation rate [1]. Modern mines have to face increasingly poor, fine, miscellaneous minerals and long-term accumulation of hundreds of millions of tons of tailings, and resorting is difficult to achieve an efficient sorting effect for poor, fine and miscellaneous minerals, so most people believe that resorting has come to an end [2]. Through the research status of reseparation technology at home and abroad this year, and from the three aspects of equipment, process and theory, this paper conducts a more in-depth discussion, and puts forward some development trends of fine mineral reseparation technology.

2. Development overview in recent years

The re-separation of mineral particles has a long history, starting from gold panning, and the emergence of new re-sorting processes in recent years has injected fresh blood into the mining industry. To a certain extent, the recovery accuracy of minerals is improved, and many low-grade concentrates and associated minerals embedded in fine particles can be effectively sorted, which brings a new look to the beneficiation, and the heavy separation method based on shaker selection, jigging and centrifugal separation is gradually widely used in the mineral processing industry because of its unique sorting process advantages. Gravity beneficiation technology mainly uses the difference in particle size, density and shape between mineral particles of different components to achieve sorting, especially for the treatment of coarse and medium-grained minerals [3].

In the past two decades, China and abroad have been committed to the research on the re-separation and recovery technology of fine minerals, and have also achieved certain results, such as the use of centrifugal force or mechanical shear force to strengthen the reseparation capacity of mineral sludge, can effectively reduce the lower limit of mineral recovery particle size, as an effective force of the composite force field, the application of centrifugal force is increasingly considered to be an important development path. Many mineral processing workers at home and abroad have developed various shapes of centrifugal force field flotation equipment, so that the flotation behavior occurs under the action of centrifugal force field. The mass effect and surface effect of fine-grained minerals are forcibly overcome by centrifugal force, thereby improving the fine-grained flotation efficiency. The centrifugal force field flotation machine is one of the fine particle flotation equipment that has been considered

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effective in recent years. The centrifugal concentrator is to provide a super-gravity centrifugal environment for the slurry, amplifying the density difference of the particles, so that more efficient sorting can be carried out. Among them, Nielsen concentrator as a typical representative of vertical centrifugal concentrator, has the advantages of good sorting effect, large processing capacity, wide application range and high concentrate grade. However, it also has some weaknesses, Nielsen and other centrifugal concentrators sorting inner cone structure is complex, the material under the strong force of centrifugal force, the particle group compaction phenomenon is serious, it is difficult to achieve continuous discharge, resulting in low efficiency of sorting operations, which has become a bottleneck affecting its development in the field of mineral processing. Therefore, the continuous sorting technology of centrifugal beneficiator is studied, the gravity beneficiation equipment is improved, and the reseparation of fine minerals is an urgent problem to be solved in the mineral processing industry.

3. Status of foreign research

In recent years, due to economic and environmental protection considerations, people have paid enough attention to the development of fine grain reseparation new equipment, fine grain reseparation equipment has been an important topic in the field of reseparation, in order to reduce the effective recovery of the lower limit of the equipment particle size, a variety of re-separation new equipment has also emerged. 1954 Bergnold R. A) The theory of shear is systematically proposed. 1961 Bucrh C· R) applied this theory to make a rocking spiral experimental equipment, and in 1975 Burt applied this theory to develop a cross-flow belt chute [4]. In 1977, the British sand mining company developed the Paradyne centrifugal jig, the water consumption is only 1/6 of the ordinary jig and the unit area processing capacity is 7 times that of the ordinary jig, the American International Development Corporation on the basis of the Paradyne centrifugal jig improved into the Indeco centrifugal jig, the lower limit of the recovery particle size of the equipment is 425 mesh, the processing capacity is 10 to 20 tons / hour. Richard and Maudsley combined the beneficiation principles of a centrifugal concentrator and a shaker to develop a high-capacity multi-force sorter that makes it possible to recover very fine ore grains compared to conventional shakers. In 1989, MGS conducted a successful experiment at the Kannon and Whirl-Jane tin mine in the United Kingdom, and achieved satisfactory results especially in ultrafine particle recovery, including the replacement of flotation columns [5]. In 1980, Byron Nielsen researched and designed the Knelson concentrator and put it into practical production for the first time, and then Laplante et al. developed the Falcon concentrator in 1994 based on Knelson.

In the experimental study, Eyüp S [6] adopted the Taguchi method for experimental protocol design, and determined the parameters affecting the enrichment effect of Knelson centrifugal concentrator. In terms of fine-grain difficult recovery in coal mine tailings, Filiz Oruçetal [7] based on ultrafine slime 10 μm from the Tuncbilek coal washing plant in Turkey 60%, ash up to 66%) carried out relevant selection experimental studies. Filiz Oruçetal [8] used cyclone to select the primary coal tailings and then selected by the Falcon centrifugal concentrator, which can obtain coal concentrate powder with ash content reduced to 36% and recovery rate of more than 85%. After more than a century, researchers have successively developed several new centrifugal sorting machines and have been put into practical application, making centrifugal sorting technology an important part of the beneficiation process chain. In addition, vertical vibrations have been found to delamirate the mixed particles in the particle bed: smaller particles gather below, and larger particles gather on top, which is known as the Brazil nut effect. That is, the separation mode of smaller particles on top and larger particles on bottom. T.Sykes[9] experimentally studied the self-organization behavior of particle chains in bulk particle beds under horizontal vibration conditions, and found interesting particle chain aggregation phenomena, which also made people see a new direction.

4. Domestic research status

In the 60s of the 20th century, Yunxi Company first introduced centrifugal force into the ore sludge beneficiation equipment, the main typical equipment is single drum, double drum centrifugal concentrator, double-layer and three-layer centrifugal concentrator, tandem centrifugal concentrator, etc., effectively reducing the lower limit of the recovery particle size of sludge, widely used in China's nonferrous and ferrous metal concentrator plants, which is a milestone in the history of China's resorting technology development [10]. Later, China developed a vibrating pendulum belt chute, which has additional mechanical shear dispersion pressure generated by longitudinal asymmetric

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reciprocating motion and additional fluid shear dispersion pressure generated by transverse swing. The SL type jet centrifugal concentrator developed by the Beijing General Institute of Mining and Metallurgy has the role of loosening the bed and continuously discharging concentrate, which is a new breakthrough in the recovery of fine-grained heavy minerals. In 1988, in the industrial test of treating 10μm waste tin ore sludge at Changpo Concentrator Plant of Dachang Mining Bureau, after a rough selection, a concentrate with a grade of 4.37% was recovered from the raw mud containing Sn0.54%, with a recovery rate of 53.29%, and the lower limit of the recovered particle size was reduced to 3μm, which was the lowest lower limit of the recovery particle size of the reseparation equipment so far [11].

In terms of theoretical research, many domestic scientific research institutions have also done a lot of work, and flow membrane sorting and density stratification are the theoretical basis for strengthening reseparation. According to the principle of Baguenot shear theory, Huang Shu analyzed and calculated the flow state and shear type of slurry flow in the commonly used ore sludge resorting equipment at home and abroad, and proved that it is desirable to use centrifugal force and shaking action to strengthen the sludge sorting. Li Guoyan believes that flow film beneficiation occurs in a dense liquid-solid two-phase flow, in view of the uneven characteristics of concentration difference in the flow film, the application of Baygnot experimental technology can determine the difference between particle dispersion pressure and effective pressure in the flow membrane of the inclined chute and centrifugal concentrator, which confirms that the Baynot shear dispersion effect plays a key role in the flow membrane beneficiation. Xiao Hongli [12] used the identification fitting method to establish a mathematical model of the self-balancing process of the feeding process of the centrifugal beneficiation system, and also established a nonlinear stochastic state space mathematical model of the Knelson concentrator to estimate the values of each state variable. The three stages of particle fluidization, sorting and saturation of centrifugal sorting are described, which reflect the dynamic law of sorting. Liu Zuoshi [13] and others studied the characteristics of the slurry flow membrane of the centrifugal concentrator and analyzed the computational model of the radial, tangential and axial dynamics of the flow membrane, and derived the distribution law and interconnection of the velocity field and pressure field during the particle motion process. Yang Jianwen et al. [14] verified the effectiveness of the Kneslon concentrator in recovering gold, lead, tungsten and other metals from heavy sand through heavy sand valuable metal separation experiments. Wang Yongxian et al. [15] used Kneslon centrifuge to effectively recover +20μm grain gold from an alteration rock mass gold mine, with a recovery rate of 33.85%. It is worth noting that in recent years, the "deep water" fine grain gravity equipment with vertical alternating flow and rotary flow, such as the Kelsey centrifugal jig and the three-product vortex cyclone, because its "vertical" vibration or "radial" vibration is not easy to attenuate, can keep the high concentration of the deep water layer particle group loose, and then sort according to the specific gravity, which is conducive to improving the processing capacity of the equipment and reducing the lower limit of the recovery particle size, providing a new way for the double separation of fine grain materials.

5. Research on new process of reselection technology

The method of combining multiple forces and gravity is the main development direction of the new process of reselection technology at present, and by sorting out the recent research on reselection new process in recent years, it can be mainly summarized into five aspects:

(1) centrifugal force-gravity method; The main representative is the centrifugal concentrator, whose centrifugal force is about 25 to 100 times the gravity, and can recover ore grains that are 5 to 10 times smaller than those in the gravity field. This is because spinning centrifuges can produce accelerations several times or even hundreds of times the acceleration of gravity. Therefore, in the process of light and heavy particle separation, the sedimentation velocity difference between the two components can be expanded by increasing the acceleration by intensive centrifugation, so as to achieve particle separation. However, the lower recovery limit of the centrifugal concentrator currently developed only reaches 10 microns, and there is still great potential.

(2) Mechanical force and gravity method; The main representatives are the Mozley MGS resorting machine produced in the United Kingdom and the development of the oscillating belt chute in China, and the ore grains are loosely layered under the action of flow film and shaking shear to achieve proportional gravity sorting. According to Baygnot's theory, vibration and shaking have longitudinal asymmetric reciprocating motion, which generates additional mechanical shear dispersion pressure and additional fluid shear dispersion pressure generated by transverse oscillation, and strengthens the sorting of ore sludge through shear.

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(3) Magnetic-gravity method; At present, it is mainly a magnetic tip chute and a magnetic hydrocyclone, which uses two movable magnetic plates installed under the chute feed end and discharge end to enhance the sorting of magnetic heavy minerals. Magnetic hydrocyclones use a magnetic force in the opposite direction of centrifugal force to discharge magnetic minerals from the overflow tube. However, this magnetic cyclone is not conducive to the recovery of large specific gravity of magnetic minerals.

(4) Interfacial force-gravity method; It mainly uses the interfacial force on the surface of fine ore particles combined with gravity to improve the efficiency of fine sludge reseparation, and there are two main research directions. One is to control the kinetic properties of the slurry, and recent studies have shown that controlling the pH value of the slurry and adding certain dispersants can improve the sorting efficiency of the sludge. The other direction is the selective flocculation reseparation method, which selectively flocculates the fine-grained mineral particles by adding chemical agents, and then uses gravity separation equipment such as shakers and chutes.

(5) Ultrasonic-gravity method. It is mainly the use of ultrasonic waves to disperse, stratify and clean the mineral surface of the slurry. Ultrasonic pretreatment can effectively clean the thin film on the surface of the mineral, providing a better environment for the next step of mineral particle reseparation or magnetic separation, thereby improving the sorting efficiency.

6. Conclusion

It can be seen from the above literature that scholars at home and abroad have studied the principle of fine particle gravification technology and equipment application through a large number of analyses and experiments, and have achieved fruitful research results. However, the traditional centrifugal beneficiation equipment still cannot carry out efficient and continuous separation of minerals, and a single force field can no longer meet the re-separation and recovery of fine particles, and the new process of composite force field reseparation composed of multiple force fields is the future development direction of fine grain reseparation.

For the development of gravity separation equipment suitable for fine minerals, how to optimize the advantages of some existing equipment, establish an effective composite force field, strengthen the sorting process, improve the sorting efficiency, reduce the lower limit of mineral recovery particle size and improve the discharge efficiency is its basic research direction.

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