Comprehensive Utilization of Iron Tailings in China

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Abstract. Iron tailings are the main component of industrial solid waste, and their resource utilization has attracted the attention of the whole society. Based on the introduction of chemical mineral composition of iron tailings, the comprehensive utilization status of iron tailings is analyzed. Some existing problems are put forward and relevant Suggestions are given.

1. Introduction
Iron tailings are the waste residue discharged from iron ore after they are selected by the ore dressing process. With the rapid development of iron and steel industry, the scale of iron ore development has been increasing, and the emission of tailings has also increased. According to statistics, the annual tailings discharged by iron ore dressing plants in China are about 130-170 millions t, and the existing iron tailings are about 2.6 billions t [1]. The stockpiling of tailings will occupy land and pollute the environment. Moreover, the factories have pay the land expropriation fee, transportation fee and landfill fee, which increase the production cost and cause the waste of resources. Therefore, more and more attention has been paid to the utilization of tailings.

2. Chemical mineral composition of iron tailings
Iron tailings are composite mineral raw materials. In addition to containing a small number of metal groups, its main mineral components are gangue minerals such as quartz, gabbro, hematite, calcite and garnet. Its chemical constituents mainly include SiO₂, Al₂O₃, Fe₂O₃, CaO, MgO, and a small amount of P, S, Na, K and other elements. The content of chemical composition varies greatly with different regions and refining process [2-5].

3. Comprehensive utilization of iron tailings in China

3.1. Reselected tailings and recovered valuable minerals
The asketoushan iron ore dressing plant adopts JHC type torque ring permanent magnetic separator and BX magnetic separator, which can recover about 65% iron concentrate powder of grade from tailings [6]. Yang [7] applied the combined process of strong magnetic separation and flotation to treat iron tailings of a vanadium titanium magnetite mine in Sichuan, and obtained qualified titanium concentrate with a grade of 48.87%, with a recovery rate of 85.51%. Sun [8] adopted once roughing, twice sweeping and fourth selective closed-circuit flotation processes for iron tailings, and recovered...
the copper elements, and obtained copper concentrate with copper grade of 23.7% and recovery rate of 68.9%. In order to fully recover this resource, Maanshan mining research institute\[9\] successfully studied the separation process of strong magnetic one-thick two-stage shaking table, and selected garnet concentrate with a grade of 97.4%, with a recovery rate of 41%. Baotou steel concentrator adopts a combined flotation process to recover rare earth concentrate and niobium from strong magnetic tailings. The recovery rate is 57.34% of rare earth concentrate and 35.58% of niobium\[10\].

3.2. Building materials produced by iron tailings
The main chemical constituents of iron tailings are aluminum, silicon, calcium and magnesium oxides. The content of aluminum and silicon is high, and most of them are non-metallic minerals, which are very similar to building materials, and this can also provide the precondition for the application of iron tailings in building materials industry. At present, China's iron tailings have achieved remarkable results in the application of building materials, mainly in making bricks, as road building materials, preparing cement and concrete.

3.2.1. Brick. At present, there have been a lot of research and application in the production of building bricks by iron tailings in China. According to different technologies, the iron tailings can not only prepare building wall bricks such as sintered bricks, steam pressed bricks and non-fired bricks, but also prepare building decorative surface bricks. Ma 'anshan mine research institute USES the high silicon iron tailings of qidashan and asketou mountains as the main raw materials, mixed with a small amount of aggregate, calcium cementing materials and additives, added a moderate amount of water, evenly stirred and extruded into the 60t pressure machine for forming, moulding and standard curing for 28 days, and successfully made the non-firing bricks \[11\]. Sun \[12\] prepared sintered porous bricks using handan tailings of high calcium and magnesium by extrusion. Zhang jinrui and Jia qingmei \[13,14\] took the iron tailings in tangshan area as the main raw materials, mixed with a certain proportion of coarse aggregate cement, formed by specific methods, and then by steaming and steam curing, the steaming bricks with an iron tailings content of more than 50% were studied. Shi \[15\] et al. added 20-30% chengchao iron tailings on the basis of the formula of vitrified brick, and obtained the vitrified brick whose main crystalline phase is calcium feldspar. The colored lawn tile, floor tile, wall tile and so on were successfully developed by the tailings in the asketou mountain iron mine of bensteel \[16\].

3.2.2. As road building materials. Applying iron tailings to road engineering can consume a lot of iron tailings and reduce the cost of road engineering. China's iron tailings as road building materials are still in their infancy. Yang qing\[17\] conducted an experimental study on the road performance of the inorganic binder to stabilize the iron tailings, and the research results showed that 11% cement, 31% lime, 2% cement and 12% lime stabilized iron tailings can meet the strength requirements of the low-grade road base. Sun \[18\] studied the performance of limestone fly ash to stabilize the crushing road of iron tailings, and analyzed the influencing factors and mechanism of lime fly ash to stabilize the strength of iron tailings gravel. The test results show that the technical indexes of lime fly ash to stabilize iron tailings and gravel meet the requirements of current specifications and can be used as the basic material in various levels of roads.

3.2.3. Cement and concrete. The low price iron tailings are used as the raw materials of cement production and applied to concrete, which will bring great economic benefits. Li\[19\] made cementing materials from iron tailings, blast furnace slag, cement clinker and gypsum with a ratio of 30:34:30:6, whose strength can reach the standard of 42.5 grade silicate cement. Wang\[20\] used the dashehe iron tailings of Shougang to make the autoclaved aerated concrete with strength grade A3.5 and density grade B06 with 60% iron tailings, 25% lime, 10% cement and 5% gypsum.

3.3. Microcrystalline glass
Microcrystalline glass with different properties can be prepared from iron tailings. On the basis of studying and analyzing the components of iron tailings in Tangshan area, used sintering technology to make microcrystalline glass with diopside as the main crystal phase [21]. Li prepared lightweight magnesium olivine thermal insulation materials that meet high temperature fire resistance through different process comparison using Anshan high-silicon iron tailings [22].

### 3.4. Backfill the goaf area

Underground mining is the main method of mining in our country, and the mining area left behind after mining ore brings great hidden danger to mine safety. Using iron tailings to fill the goaf can solve the problems of mine safety, tailings stockpiling, filling aggregate cost and so on. Zhou [23] have good effect on filling the goaf with dry tailings of an iron ore factory in Chengde area. At Mazhuang iron mine, Laiwu mining Co., LTD., after grouting iron tailings, sediment and cementitious powder are mixed and stirred. The concentration of mixed slurry is controlled at about 55%-60%.

### 3.5. Reclamation of vegetation with tailings pond

Reclamation of tailings pond can reduce tailings pollution, reduce land resource waste, and optimize mine environment. The local iron ore plants of Qianan and Zunhua county in Tangshan area have discharged the tailings on the waste beach of Luanhe river, covering a layer of 25-30cm on the surface for reclamation and land reclamation. Various crops have been planted successfully, and more than 10 million yuan of economic benefits have been obtained [25]. Anshan iron & steel mining co., LTD has reclaimed the tailings pond of the Donganshan sintering plant, and built a multi-functional ecological park on the tailings pond with an area of 200 km².

### 4. Analysis of problems in utilization of iron tailings

1. Low utilization rate and extensive utilization method

   At present, the comprehensive utilization rate of iron tailings in China is only about 7%, far lower than the 60% utilization rate in developed countries. The exploitation and utilization of iron tailings resources is not optimistic. Many mining enterprises adopt extensive utilization methods, such as recycling valuable metal elements or directly using sand and stone as substitutes. Table 2 shows the development and utilization of tailings in some enterprises. Even that some enterprises carry out research on high value-added products, because the process is relatively complex and the cost is high, so far, it is still basically in the laboratory and pilot stage.

2. Weak basic work and lack of data support

   There is no statistics on the comprehensive utilization of resources in China, and no detailed data on the stock, composition and distribution of iron tailings are available, which is not conducive to making scientific decisions on the comprehensive utilization of iron tailings resources.

3. Weak awareness of utilization of iron tailings resources

   Many mining enterprises have not set up the correct value concept of iron tailings resources. Some people think that iron tailings are solid wastes discharged from mines and have no development and utilization value. Some have limitations on their value. The development and utilization of iron tailings resources by the competent authorities of the industry should not only be promoted, but also included in the normal assessment indicators of mining enterprises.

4. Lack of capital investment and insufficient policy support

   Some achievements have been made in the comprehensive development and utilization of iron tailings. But due to the disconnection between "production, study and research", practical scientific research results have been transformed and popularized to a low degree. At the same time, the state lacks necessary investment in the technical development of iron tailings resources, which makes mining enterprises lack the motivation and enthusiasm to develop and utilize iron tailings resources. Although some preferential policies have been issued in recent years, such as the reduction or exemption of income tax on comprehensive utilization of resources and the reduction or exemption of value-added tax on partial comprehensive utilization of products, the implementation of specific
operations has been poor and has not been fully implemented, making it difficult for the efficient utilization of resources.

5. Suggestions on improving comprehensive utilization rate of iron tailings

For our country, the comprehensive utilization of iron tailings resource are still at the early stage, although there are a certain achievements in recent years, but its degree of development and utilization is still very low, far cannot meet the requirement of economic and social sustainable development. Suggestions from the policy support, scientific research, exchanges and cooperation in the aspects are proved for reasonable and efficient iron tailings comprehensive utilization of resources.

(1) Improve policies and regulations and strengthen support
The state and local governments should give sufficient attention and support to formulate laws, regulations and policies and mechanisms for sustainable development in the comprehensive utilization of resources.

(2) Strengthen exchanges and cooperation and improve utilization technology
The comprehensive utilization of iron tailings involves many fields of cross-industry and multidiscipline. The cooperation between enterprises and scientific research institutions should be strengthened to carry out large-scale projects of comprehensive utilization of iron tailings resources, to tackle technical problems and keep innovating.

(3) The transformation of scientific and technological achievements into productive forces is focused on. The comprehensive utilization of many iron tailings in China is in the laboratory or pilot stage.

(4) The bulk utilization is the main one, and the classified utilization is the auxiliary one. China's iron tailings heap stock is huge and should be mainly used in bulk first to solve the problem of utilization rate. At the same time, due to the differences in physicochemical properties of tailings in different regions, tailings can be classified and utilized according to their own characteristics.

In a word, the comprehensive utilization of iron tailings is difficult, but the prospect is vast. With the joint efforts of the government, relevant departments, universities and mining enterprises, the utilization of iron tailings in China is bound to usher in a sound development.

6. Conclusion
The application status and existing problems of iron ore tailings in China are analyzed in this paper, and some feasible Suggestions are put forward, which will be of great significance to promote the efficient utilization of iron ore tailings in China.

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