

# The Carbon Reduction Effect of the Tailings Recycling

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**Abstract:** The tailing is a kind of mine solid material that is hard to be re-sorted after the ore separation. Most of the mines in our country build tailings reservoirs on the earth's surface to reserve the tailings. Due to the limit of the ore separation technique at that time, most of the tailings reserved contain a large number of valuable constituents and the grade is very high. The potential value is remarkable. While, the tailings piled up on the earth's surface will cause a series of environmental impact including air pollution, land degradation, vegetation deterioration, geological disasters, etc. On the base of the concept of tailings recycling and low-carbon mining industry, this paper discusses the necessity of the tailings recycling management and the methods of tailings recycling. And taking the iron mine as example, it analyzes the economy of resources and the low-carbon effect of the tailings recycling, and concludes that the carbon reduction effect of tailings recycling is significant.

**Keywords:** Tailings, Low-carbon Mining Industry, Tailings Recycling, Low-carbon Effect

## 1. Introduction

Tailings are discarded solid materials of the mine, which are very difficult to be separated, recycled and made use of after the useful minerals are selected because of the limited technical and economic conditions. The tailings are abundant, concentrative distribution and the granules are small. On the one hand, the tailings still have some useful components because of the low ore dressing recovery percentage which is caused by limited technique of preparing or pursuit of low cost of ore processing. On the other hand, there are large number of integrating deposits and additional deposits, and the useful constitutes which are integrated or associated in some deposits have much higher value than the main mineral. While many of these integrated or associated minerals and useful components are left in tailings.

There are abundant mineral resources in our country, however, the per capita quantity of possession is only 58% of the world's average possession per person. In China, there are less large scale mineral deposit, and the most of ore are mineral intergrowth, lean and difficult to separate, in which useful resources are less. Therefore, it is of far reaching importance for our country's low-carbon economy strategy to implement tailings recycling and develop and make good use of the large amount of tailings.

## 2. Status in Quo of Tailings Discharge in China

### 2.1 Methods of tailing discharge

In China, most mines build tailing reservoirs on the ground to stockpile tailing. Special planning for metal tailing's comprehensive utilization (2010~2015) which was published by relevant departments on 11<sup>th</sup> Apr 2010 indicates that, there are 12718 tailing reservoirs in China at present, including 1526 tailing reservoirs in construction and 1024 closed ones. By the year 2007, the total quantity of stockpiled tailings in our country is 8.046 billion t. Now, the quantity of stockpiled increases more than 40 million t per year. In 2007, nearly 1 billion t of tailings discharged in China. Analysis results of 12 main mineral tailings discharge are shown in Table 1.

**Table 1 Analysis Results of 12 Main Mineral Tailings Discharge in China**

Mineral	Throughput of raw ore per year	Tailings Production Rate	Discharge value per year	Remark
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	(10 thousand t)	(%)	(10 thousand t)	
Iron	23 000	55.42	12 700	
Gold	4 073.1	92.97	3 786.76	
Copper	5 494.39	96.04	5 276.61	
Lead zinc	2 223.2	74.74	1 661.61	
Tungsten-tin	1 430.55	95.0	1 359.02	
Molybdenum	1 682.8	96.5	1 623.9	
Nickel	483.13	89.0	429.99	
Pyrite	771.69	54.04	417.02	Associated pyrite not included
Phosphorus	2 072.67	48.83	1 012.08	Suppose that 20% of the raw ores are not separated and 80% are selected
Rare Earth	811.81	95.94	778.85	Baotou Rare Earth Mine not included
Total	42 043.34	70.06	29 455.56	Based on the average tailings rate

Data source: Current Status and Solutions of the Comprehensive Utilization of the Major Mineral Resources in Our Country, consulting project of the Chinese Academy of Engineering--Research on the Sustainable Development Strategy of the Mineral Resources in Our Country.

Tailing reservoir is a kind of irrigation works structure engineering which is complex and needs huge investment. The expenses spent on building the tailing reservoir occupy 5%~40% of the enterprise's total cost. What's more, maintenance of them also needs a large amount of fund. According to figures, in our country for each ton of tailings, the metallurgy mine need spend 1~3 Yuan on building and spend 3~5 Yuan on production and management. Now there are more than 400 tailing reservoirs, so operation fee per year is up to 750 million Yuan<sup>[1]</sup>.

Therefore, tailing recycling is not only good for reasonable development of resources and environment protection, but also can promote improving economic performance and self development for the bargh.

## 2.2 The potential value of the tailings

Due to the limit of the ore separation technique at that time, most of the tailings discharged in our country in history contains a mass of valuable constituents of high grade. Taking the iron ore as example, the amount of the iron mine tailings in our country is increasing by 20% averagely per year in recent years. In 2007, the iron mine tailings discharged in our country is about 440 million ton, and the average grade of iron in the tailings is 12%, some even is 27%. The present total storage of iron mine tailings considered as 4.5 billion ton, there is 500 million ton iron in the iron mine tailings in our country. For example, the old tailings of Yun Nan Xi Ye Group are over 100 million ton in quantity, in which the average percentage of tin is 0.15%, and the lost tin is over 200 thousand ton.

On the other hand, due to the neglect of comprehensive investigation and evaluation of the ore deposit, the neglect of comprehensive utilization of the valuable symbiotic and concomitant constituents, the limit of ore separation technique and the unreasonable separation process, and the insufficient knowledge of the valuable functions of some symbiotic and concomitant constituents, etc., a large number of valuable symbiotic and concomitant constituents are left in the tailings unrecovered. According to the document<sup>[2]</sup>, the comprehensive utilization rate of Chinese mine resources is quite low. According to the investigation, in the 246 large and medium-sized mining enterprises in China with symbiotic and concomitant constituents, actually 32.1% of the enterprises don't do the comprehensive utilization of the valuable constituents. Even for those implementing the comprehensive utilization, the standard is very low. Among the 1, 845 key mining enterprises in the investigation, only 2% have a comprehensive utilization rate over 75%, 15% have a utilization rate over 50%, yet 75% have a utilization rate lower than 25%. Moreover, the total recycling rate of the mining enterprises'

comprehensive utilization is generally low. Over 70% of the mining enterprises have a comprehensive recycling rate lower than 40%.

From the analysis above it can be inferred that, even not considering the integral utilization of the tailings, the potential value of the usable constituents in the existing tailings in our country is quite remarkable.

## **2.3 The influence of the tailings to the ecological environment**

### **2.3.1 Environmental pollution**

Firstly, the tailings itself contains pollutant or harmful constituents. Various kinds of chemical agents added during the ore separation process remain in the tailings. Directly piled up on the earth's surface without any treatment, it not only occupies a large number of land, but also pollutes the surrounding environment seriously. Secondly, on the condition of piling up on the earth's surface, the tailings gets oxidized, hydrolyzed and effloresced. When the chemical migration of the migratory elements takes place, the original pollution-free constituents turn into polluting constituents. Thirdly, through the interaction with the tailings, the surface water flowing through the tailings reservoir dissolves some harmful constituents, carries and transfers them, then expands the polluting area. Some mining enterprises even directly discharge the tailings into the lakes and rivers, which directly causes the water pollution, watercourse blocking, large-area ecological damage and environmental pollution. At last, in some mining enterprises of our country, the ore disseminated grain size is very small. In order to achieve the monomer dissociation, the ores must be fine-grinded. As a result, after the tailings is discharged into the reservoir and dries up naturally, when it's windy, the tailings sand on the surface will be blown continuously to the surrounding area. It will cause air pollution, land degradation and vegetation deterioration in that area. It's very harmful to the surrounding ecological environment.

### **2.3.2 Geological disasters**

The tailings has the characteristic of easy-flow. The tailings reservoir is actually a source of man-made debris flow. Especially those that were not normatively designed and constructed, as well as the weak, dilapidated and dangerous tailings reservoirs are accident-prone of dam slope instability or dam break. Once there's an accident, the damage it causes is huge. In our country, the dam break accidents of tailings reservoirs are reported from time to time.

## **3. The Recycling of the Tailings**

The tailings recycling means the process that taking the tailings into the scope of resources management, by all kinds of engineering technique and approaches, to recycle the valuable constituents or the integral as the raw materials of some products and then change the tailings into usable resources. With the development of the economy and the advancement of the technique, it has been possible to change the tailings that used to be waste into usable resources. Not only the valuable constituents could be recycled, the tailings could also be utilized as a whole, even some new materials or new products could be developed from the tailings.

### **3.1 The management of tailings recycling**

Firstly, it should be on the base of the low-carbon mining industry principles, convert the traditional view that treats the tailings as mining production waste, fully set up the tailings resources concept, establish relevant regulations and policies, take the tailings into the scope of resources management, make a reasonable plan and make full use of it. For example, if the tailings mining rights regulation was established and the tailings mining rights was set up, then the tailings recycling and its reasonable exploitation and utilization could be institutionalized, the tailings resources could be developed orderly and effectively.

Secondly, an overall tailings investigation should be carried out in order to find out the present status of the tailings storage. To carry out the tailings resources investigation is groundwork of tailings recycling

and necessary basic job. It mainly include the basic data of the quantity and time of the tailings storage, the yearly emission load, the valuable constituents type, the composition of size fraction, the content of the usable minerals, the objectionable constituents and the distributional characteristics, as well as the hydrogeology, the engineering geology, the environmental geology and the exploiting technical condition of the mine area. And a data base of the tailings resources should be found.

Thirdly, there's a wide range of mine tailings and the composition is complicated. The tailings recycling involves multiple subject fields, including many basic theoretical issues and theory application issues, as well as many engineering technical issues. Therefore, we should enhance the basic study and technical innovation of the tailings recycling, study the advanced technique, equipments and technology of the tailings recycling, and develop new methods of tailings recycling.

### **3.2 The methods of tailings recycling**

Since the tailings recycling doesn't require much investment or equipment, doesn't need further long-distance transportation, requires no complicated preprocessing such as ore reduction, grinding and sieving. Its economic benefit, energy saving effect and environmental benefit are all significant. The methods of tailings recycling could be divided mainly into two aspects as follows.

#### **3.2.1 Recycling the valuable minerals by second-time separation**

As mentioned above, most of the mine tailings earlier stored in our country contains multiple high-grade valuable metallic and nonmetallic minerals. A lot of usable resources exist in the tailings, so the second-time separation of the tailings has a large potential in recovery and utilization. At present, some mineral enterprises have paid attention to the second-time separation of the tailings and they have succeeded. For example, the Jin Chuan Nickel Mine further recycles the nickel from the tailings. As a result, the nickel ore separation recovery rate is increased from the past 50% to the present 90%. Meanwhile, the Cu, Co, Ag, Se and the platinum group metals are also recycled<sup>[3]</sup>. Recycling the valuable minerals from the tailings by second-time separation needs short construction period and low investment while it can bring quick returns; it could be large-scale production with a low cost; it comprehensively recycles various kinds of valuable metals and nonmetallic elements, and extended the life cycle of the mine; it could achieve multiple success in the economic, social and environmental benefit.

#### **3.2.2 The integral utilization of the tailings**

The tailings with less recovery value or the final tailings after the second-time separation could be utilized directly as an integral. For instance, the tailings could be used as construction materials, soil amendment and magnetized compound fertilizer, filling material for the mined out space. The tailings reservoir could also be reclaimed for cultivation to recover the productivity of the land. There have been many successful examples of tailings recycling in this way. But the integral utilization of the tailings still need a lot of research and study including seeking new methods of recycling, new technique and the development of new products.

## **4. The Carbon Reduction Effect of the Tailings Recycling**

The greenhouse effect leads to the global warming, which is one of the biggest environmental problems that draw the attentions of the international community. The greenhouse effect is caused by the emission of gases such as CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O and so on. Among the greenhouse gas, CO<sub>2</sub> is the biggest cause of the global warming, and its greenhouse effect accounts for 60% sauces of the total atmospheric greenhouse effect<sup>[4]</sup>. The energy consumption is the main source of the carbon emission. According to the consistency of energy conservation and CO<sub>2</sub> emission reduction, the low-energy-consumption must be emphasized. The energy consumption of mining industry takes up a large proportion in the energy consumption of the whole national economy, which is close to 10%. The relevant documents show that, in all kinds of the energy consumption of the mine, the exploiting takes up 49% of the energy consumption, the ore reduction and grinding take up 20%, the filtrating and drying take up 1%, the ore

pulp pumping and ventilating take up 17%, the air compression system takes up 5%, the lighting takes up 5% and the heating takes up 3%<sup>[5]</sup>. The mine tailings don't require exploiting, reduction or grinding, and have a lot of useful constituent or resources that could be integrally utilized. Even only by second-time mineral separation to collect the valuable constituent from the tailings, the energy conservation and carbon reduction effect are significant.

In the "Special Planning for the Comprehensive Utilization of the Metal Tailings" jointly issued by the Ministry of Land and Resources, the Ministry of Information and Industry, etc., the goal was set that the comprehensive utilization rate of the metal tailings should be increased from the present 10% to 20% by 2015. Taking the iron mine tailings for example, a brief analysis of the energy conserving and carbon reducing effect of the second-time mineral separation from the tailings is given below.

At present, the total storage amount of the iron mine tailings in our country is 4.5 billion ton, which adds 0.13 billion ton per year; the average grade of iron in the tailings is 12%. According to the goal in the "Special Planning for the Comprehensive Utilization of the Metal Tailings", the amount of the second-time mineral separation from the iron mine tailings in the next five years should be 1 billion ton. Setting the recleaning and recovery rate as 50%, and the grade of powdered iron as 65%, the second-time mineral separation from the iron mine tailings could recycle 90 million ton of powdered iron.

The energy consumption of the iron mine production is influenced by the exploiting method, the technical condition, technical equipments, management standard, etc. So far, there has been no unified energy consumption quota in our country. According to the statistical data of the iron mining enterprises, the comprehensive energy consumption of the iron mine exploitation in our country could be set as 1.45 tce/t. Therefore, in the next five years, the second-time mineral separation from the iron mine tailings could reduce the energy consumption by  $90 \times 1.45 = 130.5$  million tce. The CO<sub>2</sub> emission factor of the standard coal is 2.763 ton/tce<sup>[6]</sup>. Consequently, the CO<sub>2</sub> emission amount could be reduced by  $130.5 \times 2.763 = 360.57$  million ton. The carbon reduction effect is significant.

The above is just a brief analysis of the carbon reduction effect of the iron mine tailings recycling. If taking the other metal mine tailings recycling into consideration, as well as the reduction of the energy consumption of ore reducing and grinding, it could not only recycle a large amount of mineral resources but also generate significant carbon reduction effect.

## 5. Conclusion

Compared with the other solid mine waste such as rubbish, coal gangue, etc., the tailings recycling is much more difficult, complicated in technique and faced with much challenges. To achieve the mining industry development in a low-carbon-economy way, the tailings recycling is becoming more and more important. To accelerate the mine tailings recycling, firstly, the technical progress and innovation of the enterprises must be taken seriously, and the innovative technologies as well as the advanced and applicative techniques must be employed to carry out the mining recycling; secondly, the nation should play an important role in the tailings recycling by establishing the technical standard, enhancing policy management and strengthening legal guarantee.

As the mining resources becoming less and less - even exhausted, the ecological environment becoming worse and worse, the tailings recycling has become the inner demand of the sustainable development of Chinese mining industry. The tailings recycling has many effects: (1) The mining industry is essentially the exploiting of non-renewable resources. The mining resource is less and less as being exploited, and it's non-renewable. By recycling the metal and useful component in the tailings, it increases the utilization rate of mining resources, and it's conducive to the supporting capacity of the mining resources to the national economy; (2) The tailings recycling is able to stop the tailings dust from polluting the air and destroying the land resources, avoid the geological disaster caused by dam break of tailings reservoir, improve the environmental image of mining enterprises. The environment problems caused by the exploitation of mining resources are often due to that the resources are not used

reasonably; (3) Low carbon meaning energy conservation, the mining tailings recycling can save a lot of energy and have huge potential for carbon reduction. It's the inevitable choice to set up the view of low carbon economy and carry out the low carbon development of mining industry. Therefore, it should be said that the mining tailings recycling is very promising and will surely become a new economic growth source of our mining industry.

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