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## Discussion on the Model of Mining Circular Economy

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### Abstract

This paper expounded the status quo of the development and utilization of mineral resources and the generation and development of circular economy. It revealed the connotation of mining circular economy and cleared the specific content of 3R principle. On this basis, it discussed the model of mining circular economy in enterprise, industry park and society level according to the present situation of mineral resources recycling in China. Then with the development of circular economy in enterprise level as an example to construct a system of circular economy at coal mine enterprise.

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### 1. Introduction

Circular economy thoughts into China by the 1990s, and then caused a greater response. The combining of the discussion of theory and the practice of enterprise promote circulation economic research continuously. In the last few years, mining circular economy developed and extended out from the circular economy<sup>[3]</sup>. The study of the development of it, mainly in the theory, technology and regional aspects. Under the guidance of the circulation economic theory, mining circular economy study its nature and connotation, the development model and the basic principles it followed with the ecology, systematics, thermodynamics and sustainable development theory as the foundation. The technology support for realizing the mining circular economy technical is the environmentally sound technology (or

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environmental friendly technology), whose characteristics are less pollution emissions, reasonable utilization of resources and energy, recycle more waste and product, and take the environment acceptable way to dispose the remnants waste<sup>[4]</sup>. The main form includes clean production technology, waste comprehensive utilization technology, pollutant abatement technology, etc. Based on the study of theories and technology, Li Fuping<sup>[5]</sup>, Xu Shuitai<sup>[6]</sup> and Liu Jinping<sup>[7]</sup> comment on the condition of the development and utilization of mineral resources in Guangxi, Jiangxi, Jiangsu and other regions, analysis the necessity to develop mining circular economy and put forward corresponding countermeasures and suggestions.

## 2. Connotation of Mining Circular Economy

Circular economy is, in essence, an ecological economy. Relative to the “resources - products – waste” at the tradition linear economy character, it is the abbreviation of closing material cycle economy. Right now, we still do not have a consistent idea of what the definition of circular economy is. The more authoritative definition comes from a speech given by Ma Kai, head of the National Development and Reform Commission, at a national conference on circular economy in 2004. He said circular economy with a highly efficient use of resources and recycling as the core, "reduction, re-use, resource of "principle to low consumption, low emission, high-efficiency features, in line with the concept of sustainable development model of economic growth, it's a closed feedback process of “resource-product-renewable resource”, and finally achieves “optimal production, optimal consumption, minimum waste”.

The traditional mining production is based on mineral resources to form a "mineral exploration-exploitation-primary product processing-fine product manufacturing-product consumption-waste dumping" one-way operating mode<sup>[8]</sup>. Mining circular economy refers to an economic system, which follow the characteristics and natural ecological rules of mineral resources and mineral products and take highly efficient exploit and comprehensive utilization of mineral resources as the core. It constitutes a closed-loop material flow as “mineral resources—mineral products—renewable mineral resources” according to mineral exploration, exploiting, processing, melting, deep processing, consumption and other processes. And the material flow to inner overlap with the energy flow and information flow depend on it to reach the harmonious development of global environment and social progress<sup>[9]</sup>.

## 3. 3R Principle of Mining Circular Economy

Most scholars agreed that the principle that circular economy should follow is “Reduce, Reuse, Recycle”, or “3R” for short. Reduce belongs to the input method, aiming at reducing the flow of material and energy into the production and consumption process. Reuse belongs to the procedure method with the purpose of extending the time-intensiveness of product and service. Recycle belongs to the output method, requiring materials to return to renewable resources after making use of it.

Mining circular economy abide by the 3R principle, it's specific meaning are as follows:

### (1) Reduce

During the process of exploitation, processing and utilization of the mineral resources, Reduce mainly is shown as: ①realizing the efficient exploitation of resources by mechanization, automation and exploit optimization; ②reducing mining dilution ratio and ore loss ratio and enhancing the recovery rate of mineral-processing and smelting to improve the total recovery of resources by studying mining processing and melting technology of complex difficult mining and refractory ore. ③raising the comprehensive benefit of resource development by reducing emissions of various pollutants such as tailing, gangue and mine wastewater<sup>[10]</sup>.

### (2) Reuse

On the one hand, it displayed in the cyclic utilization of mine wastewater. The main sources of mine wastewater are discharged ore pit water and wastewater discharged from concentration plant or coal preparation plant. There are physical method, chemical method and biological method in treating wastewater. The principle of each method is to separate the harmful substances or turn it into harmless substances. Nowadays, more and more concentration plants or coal preparation plants started using the closed cycle technology. They do not discharge the wastewater and dispose it inside the system, then the water is reused. 70% of coal mine areas in China are short of water. Therefore, disposing ore pit water resourceful to meet the civil use standard or at least industrial standard, so that the industrial water of concentration plants or coal preparation plants get recycled, which is of particularly great significance. According to the research, mine pit water treatment cost is about 50% of tap water. Compared to groundwater supply project, mine pit water not only saves the ground water resources fee and hoisting expense but also saves the discharge over standard will, which has a great potential in environmental and economic benefits.

On the other hand, pay attention to the development of tailing and associated mineral can reach the effect of reducing pollution and changing waste into valuables. There are two ways to comprehensive utilize waste and tailing. The one is further recovers the useful components from it. As the development of mineral processing technology, the components that cannot or is difficult to be recovered can be recovered now. That makes the low-grade ore and tailing that used to be treated as waste rock be utilized and associated components in associated mineral be recovered, which both reduced the total amount of waste and increased the resource extent. Generally, tailing processing and utilization is advisable on economy. Because crushing and grinding cost 49% to 56% of the total cost of the mineral processing processes to obtain concentrates. Of course, under specific conditions, we should determine if tailing processing and utilization is reasonable or not through the calculations of technical economy. The second is to produce new substances, mainly is building materials, using waste tail as raw material. Utilizing the tailing as resource. For example, it is used as building materials such as cements, building ceramics, glass, cast stone products and tile products. It also can be used for farming fertilizer, reclamation for mined area or goaf stowing, road making, coal waste fired power, etc. In 1996, the national emissions of coal gangue is 60.93 million ton, 5.87 million ton is used for power generation, 6.07 million ton for the production of building materials, 7.23 million ton for filling up subsidence, 2.81 million for road making, 4.29 million ton for the others. The utilization ratio is 43%.

### (3) Recycle

Recycle requires reducing garbage creation as much as possible by processing the mineral resources products that have completed its functions so that it becomes available resources again and can enter the market or productive process secondary. At present, the total value of renewable resources recovery in major developed countries has reached \$250 billion a year and grew by a 10% to 20% annualized rate. In the world, 45% of the steel output, 62% of copper, 22% of aluminum, 40% of lead, 30% of zinc and 30% of paper products are from renewable resources recovery.

As the degree of our country industrialization continues to improve, the amount of metal consumption rapidly increased, so as the recyclable metal scrap. Greatly developing the technology and market of secondary use of metal is conducive to relieve the pressure of mineral resources supply, energy consumption and environment. For instance, recover aluminum from beverage cans, recover manganese, zinc and hydrargyrum from waste battery, translate waste plastic into petrol and diesel, etc. For example, reusing aluminium scrap collected in the society recovery network by mixing with primary aluminium, which formed a closed loop and, consequently, developed the secondary aluminium industry. Utilize aluminium scrap not only decreased the development of primary aluminium and aluminium product waste but also saved lots of electricity. It is estimated that recycling 1kg aluminium scrap can save about 46 kW · h electric energy<sup>[11]</sup>.

#### 4. Discussion on the Mode of Mining Circular Economy

Mining circular economy can be implemented at the level of enterprise itself, mine area, mineral value chain and system.

##### (1) Individual mining enterprise or Mining Group mode

Individual mining enterprises or Mining Group mode is an internal loop. It is a basic form of expression of circular economy in micro level. The waste generated during the production returned to the original production process or other manufacturing process as raw materials or a substitute for raw materials after suitable treatment. For example, recycle gallium from mother liquor of Bayer alumina plant through ion-exchange method, then the solution returned to the main flow, which achieved a comprehensive recovery of gallium, reduced the pollution and improved the economic efficiency. Moreover, using total tailing cemented fill mining method can stay all the waste rock in the mine and used for underground filling, which can basically realize zero discharge.

##### (2) Mining ecological park mode

Mining ecological park mode is a kind of industrial symbiosis, taken mining industry as the core and belonged to middling cycle. It turned the waste, energy and by-product that cannot be digested in one mining enterprise into raw material or power of another enterprise. Mining industry transverse coupling and resources sharing with different industry department such as power generation, chemical industry, light industry and construction industry to form an enterprise network so that the material flow, energy flow and information flow can flow harmoniously in it. Taking ferrous metal mining as an example. Ore excavation, mineral processing, sintering, iron-making and steel-making enterprise transverse coupling with Other industries and enterprises to constitute a ferrous metal mining ecological park. Precipitator dust of sintering, iron-making and steel-making can be used as the raw materials of sintering production. Building a cement plant, then blast furnace slag and copper converter smelting slag can be the main raw material of slag portland cement. The large amount of residual heat and waste heat generated by sintering, iron-making and steel-making can be delivered to municipal heating system. The sintering, iron-making and steel-making production of Angang, Shougang, Benxi steel and Baogang are the main heat source in the heating period of their city.

##### (3) Social wide circulation mode

As a part of overall social circulation, mining circulation system and other subcyclings combine with each other to force mining circular economy closed in various formats and different scale. Mining industry not only has a relationship with manufacture but also involved in husbandry, environmental protection industry, tourism and public affairs to provide society with products, material, energy, water, gas and service. For example, developing the abandoned mine as a place with various purposes, and the ecological restored mine can become the scenic spot and science education spot. The whole society changing the speed of development and improving the consumption patterns to reduce the demand for mineral resource and truly realize reduction. National attention to the recovery of minerals and the sustainable use of mineral-bearing products to slow down the flow rate of minerals within the circulation, improve efficiency in the use of mineral resources and reduce the pressure of pollution disposal. In all, raising people's awareness of green consumption and taking eco-design, green technology and other measures to realize the mining huge cycle.

#### 5. Application Practice of the Model of Mining Circular Economy

The establishment of the model of mining circular economy has an important role in pushing the application of circular economy in mining industry. Establishing a reasonable model is an important way to increase the level of circular economy. Here with coal mine enterprise as an example to construct a circular economy model at enterprise level, as shown in fig. 1.

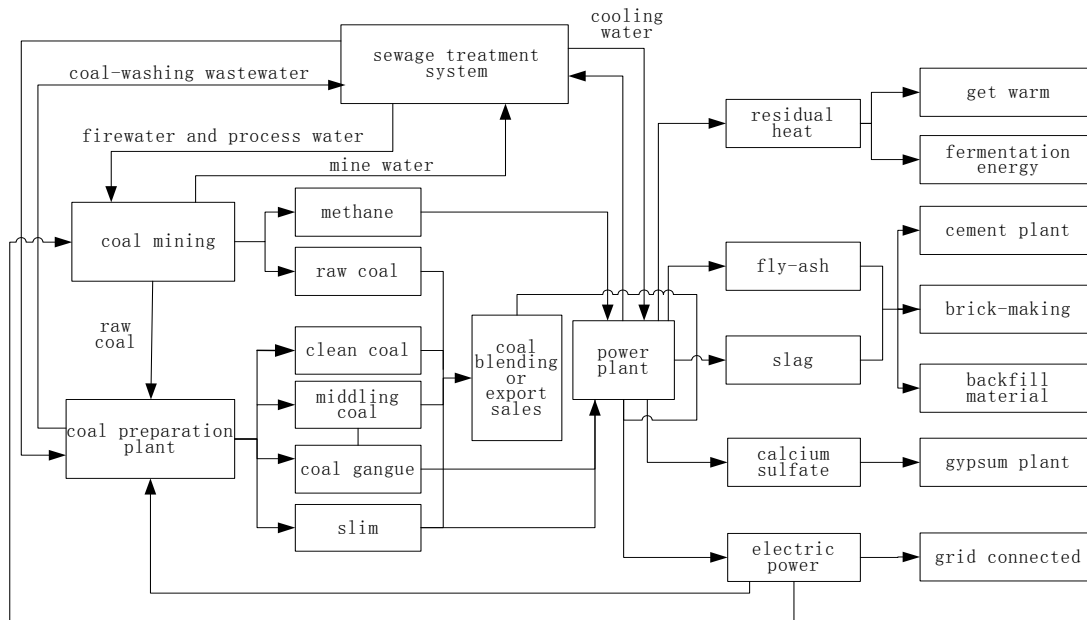


Fig. 1. Circular economy model of coal mine enterprise

The masterstroke of developing circular economy of coal mine enterprise is coal mining-coal preparation-electric power. After the coal mine exploitation, part of raw coal enters the coal preparation plant and the other part blending with commercial coal after coal preparation to supply other industries and enterprises as fuel. Building a power plant near the coal enterprise, we can use coal gangue and slime after coal preparation as well as methane extracted from fiery mine as the main fuel. Electric generated by power plant is mainly used as productive power for coal mining and preparation and household electricity for mining area. The remaining power paralleled in the power grid. Slag, fly ash and other wastes can be used as the raw material for building materials, cement and brick-making industry and backfill material of green mining. Residual heat can be used for getting warm and be the fermentation energy of brewing industry. Calcium sulfate can be used as the raw material for gypsum plant. Coal-washing wastewater and mine water can be used as power plant cooling water as well as firewater and process water of mine and coal preparation plant after disposing with the disposing system, which not only saved water resource but also solved the problem of environmental pollution caused by direct discharging.

Developing circular economy in mine industry has a significant impact on solving the problem of shortage of mineral resources, resource waste and environment pollution, raising resource utilization ratio and the sustainable development of national social economy. After several years of practice, China has accumulated a foundation for the development of circular economy in mining industry, with the feasibility of it. Establishing a mining circular economy system at society level is a complex and massive project,

which need the support of national policy and funding and also require enterprises and society to improve awareness of the importance of developing circular economy.

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