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Negative entropy mechanism of the circular economy development countermeasures in mining area

Long Ru-yin*, Zhang Xiao-ting

School of Management, China University of Mining & Technology, Xuzhou 221116, China

Abstract

For a long time, the development and utilization of coal resources has made important contribution to the development of China's national economy. However, at the same time, it has damaged environment in the mining area seriously. Therefore, developing circular economy in the mining area promotes the regional sustainable development. In this paper, according to entropy flow generated in the process of exploiting coal resources, the authors advise to introduce the related industries which consume the entropy flow and realize entropy reduction in the mining area. By reviewing and analyzing the development of circular economy in Pingdingshan Coal Mining Group as an example, the authors conclude that development of circular economy and the introduction of negative entropy flow could promote the balance of the ecosystem and increase order in the mining area.

Keywords: mining area; entropy; the circular economy

1. Introduction

Before new alternative energy sources are popular, China's one-off energy is still mainly coal. From information of State Administration of Work Safety: China's coal output was 2.523 billion tons in 2007. However, for a long time, the extensive exploitation in the mining area damages the surrounding environment seriously. Once the damage is more than the ecological carrying capacity of the ecosystem, this will result in imbalance on the ecosystem, which can not be restored. According to incomplete statistics, China's the total coal gangue accumulation is about $40 \times 10^8$ t at present. There are coal gangue hills over 1500 Blocks, covering an area of about $1.2 \times 10^4$ hm$^2$, and annual emissions are still more than $1.5 \times 10^8$ t. Coal gangue has become China's biggest industrial solid waste, but the utilization rate is very low, which was only 42 percent in 2005, causing a great waste of resources. Per year national mine water is about $45 \times 10^8$ m$^3$, the utilization rate in 2005 was only 48.95%. Most mine water that is not processed and contains coal powder, rock powder and other pollutant emit outside damaging the mining area and its surrounding environment seriously. The actual pumping volume of Coal gas is only about $23 \times 10^8$ m$^3$ and less than 15% of the actual gas emission. In the mining area, it is absolutely necessary to develop recycling economy,
introduce negative entropy flow, realize the orderly development of Eco-economic System, gain the maximal development benefits by the minimal resource consumption and the minimal pollution[3].

2. Entropy theory

In 1864, French physicist Clausius put forward a physical quantity and a new function - the entropy for the first time in his "mechanical theory of heat". He found that with absolute temperature of an object as volume, if $\Delta S$ is difference between the entropy $S_2$ of the objects after sucked into the heat and its entropy $S_1$ before sucked into the heat, or $\Delta S = S_2 - S_1 = \int_1^2 \frac{dQ}{T}$ with integral. Similarly, if the object was removed $\Delta Q$, its entropy will reduce $\Delta S$. If there are two objects contacting each other, one of its temperature is $T_1$, the other is $T_2$ ($T_1>T_2$), the heat will flow from high-temperature object to the low. The decreasing entropy of high-temperature object is $-\frac{\Delta Q}{T_1}$, while decreasing entropy of low-temperature object is $\frac{\Delta Q}{T_2}$ and the total entropy change of the two objects: $\Delta S = -\frac{\Delta Q}{T_1} + \frac{\Delta Q}{T_2}$. Because $T_1>T_2$, $\Delta S = -\frac{\Delta Q}{T_1} + \frac{\Delta Q}{T_2} > 0$. Because the heat transfers certainly from high temperature to low temperature in the isolated system, the entropy in the isolated system will never reduce[4].

In 1877, Austrian physicist Boltzmann proposed Boltzmann relationship, set up the connection between the entropy and the microscopic system, and gave statistical significance to the entropy. Boltzmann expanded the meaning of entropy from kinetic theory and considered entropy as a size which measures the degree of confusion that molecular exercise (disorder degrees. Entropy described the disorder degree of system. Boltzmann simultaneously gave the formula for calculating the entropy. Entropy ($s$) and the disorder degree of system $\Omega$ has the following relationship: $s = k \ln \Omega$. In the formula, $K$ is the constant of Boltzmann-$1.3 \times 10^{-23}$J/degree, and $\ln$ is the natural logarithm. At the same time, $s = dis + des$, $des$ is the outside entropy change that is caused by the system exchange materials and energy with the outside world; $dis$ is the internal entropy change that is caused by the irreversible process in the system. In the formula, $dis$ is always greater than 0. If the outside world provide adequate negative entropy flow, $des < 0$ and $|des| > dis$, so $s < 0$. System absorb negentropy(flow) from the environment in order to achieve its own reduction of entropy. "Absorb negentropy from the environment" may be understood as liberation of heat. That is forming negative entropy flow[5].

For "organic system" as the cycle of economic systems, to maintain its existence, it must absorb negentropy from the environment. That is to export material to the outside space, release energy and transmit information constantly. In other words, if the entropy flow which the system releases to the environment is more than which the system absorbs from the environment, the entropy of the system will reduce and the structure of the system will become more orderly. It may realize entropy decrease, only if open system absorbs negentropy from the outside space. Conversely, if the social systems are closed or entropy absorbed from the outside world is not negentropy, the total entropy will not reduce, but increase. That is, the entropy decrease is the process of reducing the resource consumption, reducing environmental pollution and maintaining ecological balance. The substance of the theory about the entropy decrease is developing circular economy with science and technology fully and rationally.

3. Analyze circular economy in the mining area based on entropy theory

3.1. Entropy increase in the mining area

Operation mode of the traditional economy in the mining area is the one-way linear economy of material and energy, namely: resources - products - waste. The mining area can be seen as almost a closed system, lacking exchange of information and material with the outside world, without negative entropy flow, entropy flow in which is not consumed and it is only the system where entropy increases constantly. At present, national mining areas discharge 45 million tons coal gangue, 40 million tons coal-washing wastewater, 2 million m$^3$ coal slime and so on per year, most of which are utilized[6]. Extensive production mode which should not recycle caused a lot of waste, the destruction and occupation of land resource, the destruction and pollution of water resource and the atmosphere,
such as environmental pollution becomes increasingly serious. This trend continues that must result in eco-economic system in the mining area develop to high-entropy, to disorder and chaos, and ultimately to destruction, as shown in Figure 1:

3.2. Entropy increase in the mining area

This situation is mainly due to inadequate mining industry chain management, and the entropy material flow generated in the mining area can not be consumed by the corresponding industries. Circular economy is a ring-type economy of energy cycle of matter, that is, resources - products - renewable resources - recycled products. In order to realize circular economy in the coal mining, it must be an open eco-economic system, absorbing negative entropy from the external environment and introducing intravenous industry[7]. Mining area relies on low-entropy material and energy absorbed form the environment to implement its own metabolism and emit high-entropy material and energy, so that its entropy decreases constantly as a dissipative structure that promoted their orderly development[8].

Downstream industries in the mining area absorb entropy which the coal industry releases, which is positive entropy for these coal companies. If it’s unable to be released, it will result in disorder coal industry. We need to introduce some industries to consume entropy which is released by coal industry and the entropy is just negentropy that these industries need. Negentropy flow released by downstream industries may be also required by coal industry.

Entropy material and energy generated in the process of coal mining are coal bed gas, coal gangue, fly ash, gas, mine inflow, mining collapse, and other associated minerals. In accordance with different entropy flows generated by the coal industry, different negentropy flows need to be introduced to consume the entropy. Specific analysis is as follows:

- Construct power plant of low calorific value
  We utilize coal gangue and coal slime to build power plants of low calorific value. The solid waste is entropy flow, generated by self-development of coal industry. If it can not to be consumed, the coal industry will be gradually depleted. Power plant absorbs the waste as negative entropy flow and then exports negative entropy flow such as electricity and hot steam, which can be exported to other industries as power or can be back to the coal industry. Coal industry absorbs the negative entropy flow, consumes entropy flow and realizes entropy decrease.

- Set up construction material factory
  Coal gangue and fly ash not only cover land and pollute underground water, but are also able to self-ignite, pollute air, and damage environmental in the mining area that causes entropy increase and leads to disorder. Setting
up cement, brick and other construction material factories can consume these entropy substances, save valuable land resources and resolve solid waste.

- Recycle land and water resources
  With the ever increasing coal mining areas, land subsidence and many abandoned mines appear. We can consume entropy through some positive activities such as use of coal gangue, coal ash to landfill. We can build factories, redevelop agriculture on back-filled land and develop new tourist attractions if the condition allows. Mine water after purification can be used by the aquaculture, or be used to spray green plant.

- Deep-processing of associated minerals
  If some associated minerals are in the absence of deep processing, they will result in the deterioration of the environment. The process of entropy increase causes ever increasing confusion and vulnerability in the economic ecosystem of mining area. Developing deep processing industry of associated minerals in the mining area shifts from entropy increase to entropy decrease of their own industries. This is the process of absorbing negative entropy for the deep processing industry, while it is a process of consuming entropy for the coal industry.

- Extract and utilize gas
  In fact, gas generated by coal mining is a cost-effective and clean energy. However, gas which is not extracted can lead to serious security accident and result in destructive entropy increase in the coal mining area. If advanced technology is actively made use of, entropy will be released effectively, which is absorbed and utilized as negative entropy of other industries. In this way coal mining industry can not only control its own entropy increase, but also promote entropy decrease of other industries.

The specific analysis above of the process of the entropy decrease as shown in Figure 2:

Fig. 2. Mining area develop circular economy to entropy decrease

4. Case study
Pingdingshan Coal Industry (Group) Limited Liability Company (hereinafter referred to as "Pingmei") was set up in 1955, and was the first super-large coal base explored, designed and constructed by New China independently. Pingmei has produced cumulatively more than 630 million tons of coal, smelted more than 84 million tons of clean coal, which has made important contribution for the national and local economic development for more than 50 years. However, for a long time it pursued simply extensive economic growth and neglected resource utilization, which caused serious damage especially to the mining area and surrounding ecological environment. Pingmei accumulated 53.82 million tons of coal waste piles, occupying an area of 2.66 million m². In the meanwhile, it emitted 2 million tons of coal gangue, produced 0.5 million tons of coal slime and 0.2 million tons of fly ash each year. In addition, it also caused a large area of land subsidence each year and emitted a lot of harmful gas and sewage. At this rate, Pingmei’s eco-economy system will continue to increase the entropy and result in resources exhaustion, economic recession, and environmental deterioration ultimately.

Since 1980's, Pingmei began to develop recycling economy and introduce related industries to make up for the missing industrial chain that consumed the entropy flow generated by coal mining.

4.1. Industry chain consuming negative entropy flow of coal gangue, coal slime and fly ash

Pingmei consumes $2.3 \times 10^5$ t coal slime, $3 \times 10^5$ t coal gangue, generates $6 \times 10^8$ kW • h power and achieves 180 million RMB sales revenues each year through its three comprehensive utilization power plants. On this basis, it prepares actively $2 \times 5$ MWe coal slime plant, $2 \times 13.5$ MWe pithead power plant and $2 \times 30$ MWe generator project of Ruiping Company. In addition, it accelerates the cooperation with the Huadian Group, Huaneng Group and other large-scale power enterprises. As shown in Figure.3:

Pingmei makes use of coal gangue and fly ash to develop new types of building materials (gangue cement, fly ash cement, fly ash concrete block, etc.), with an average annual consumption of coal gangue $1.7 \times 10^5$ t, fly ash $1 \times 10^5$ t and achieves the annual production capacity of cement $1.5 \times 10^5$ t, fly ash concrete blocks $3 \times 10^3$ m³, coal gangue sintered hollow bricks $6 \times 10^7$, accelerator 6000t. Next it will accelerate the construction of 3 million tons of cement clinker, 0.6 million m³ of fly ash concrete blocks, 0.2 billion coal gangue sintered hollow bricks and 0.3 million m³ aerated concrete blocks and other projects, in order to enhance further comprehensive utilization of coal gangue and fly ash that can consume coal slime, coal gangue, inferior coal, low heat value fuel 7 million tons, fly ash 0.75 million tons, as Shown in Figure. 4:

Fig. 3. Industry chain consuming negative entropy flow of coal gangue and coal slime
4.2. Repair and use subsided land

Because of mining, there is nearly 14 thousand mu of land subsidence. Since 1992, Pingmei has invested 116 million accumulatively for the governance of land subsidence. 11 thousand mu of land has seen reclamation. This has eased malignant progression of entropy increase in the mining area. Pingmei reclaims collapsed pits without water with gangue filling process and digs fish ponds in the collapsed pits of deep water in which it raises fish, plants vegetables and fruit. There is 470 mu of subsided land in Xinbei village and Xinnan village near the eighth mine, 386 mu of which is perennial water accumulation. Pingmei transforms and builds 16 fish ponds. There are 119 mu of water areas. These bring along the local rural economy effectively, as shown Figure.5 below:

4.3. Recycle mine water

Pingmei has 14 mine water treatment plants and 5 sets of water purification facilities, with a designed daily capacity of treating 0.164 million tons of waste water. Each year more than 38 million tons of treated mine water that meets quality standard for domestic drinking is consumed by the industrial production and livelihood of the workers. At present, reutilization rate of the mine water achieves 78 percent and it has become an important water source of living and production in the mining area. As shown in Figure.6:
4.4. Make use of gas

In order to reduce atmospheric pollution due to gas emission, it will build a 2000KW gas power plant which uses 23.04 million m$^3$ of gas, as shown in figure.7:

5. Conclusion

The whole earth is a dissipative system. It’s an inevitable process of entropy increase and energy exhaustion. We must develop recycling economy, try our best to recycle our limited resources and play its biggest utility. This article analyses circular economy in the mining area from the point of entropy theory. Major products in the mining area are coal, but a lot of wastes generated from coal mining have led to entropy increase in the mining area. However, these wastes are useful resources to other industries which are introduced to consume the wastes. They generate a useful negentropy flow to achieve effective recycling utilization for resources. Finally, by studying the case of Pingmei Group this paper concludes that development of circular economy could promote entropy decrease and increase orderliness in the mining area.

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