

Current Situation and Development Trend of Comprehensive Governance of Coal Gangue

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Abstract

In China, the mining volume of coal is great, coal gangue has become the top of the list of annual emissions of industrial waste in China. In this context, how to carry out reasonable comprehensive utilization and comprehensive governance of coal gangue has become an urgent problem to be solved. This paper analyzes the coal gangue composition and the coal gangue related laws and regulations introduced in recent years, and at the same time, the future direction of coal gangue comprehensive governance is studied by combining the examples of Tunlan coal gangue mountain and Yangquan coal gangue mountain governance.

Keywords

Coal Gangue; Comprehensive Governance; Development Trend.

1. Introduction

China, as the largest country in the world in terms of coal mining and use, accounts for 50.7% of the total global coal production and 54.3% of the global coal consumption in 2021. Coal also occupies a very high proportion in China's energy mix, with total coal consumption accounting for 56% of total energy consumption in 2021 [1]. Coal gangue is exactly the solid waste generated from the coal mining process and coal washing process in the production of coal mines. Given the large amount of coal mined in China, coal gangue has become the most emitted industrial waste in China, with nearly 1/4 of the solid waste generated annually [2].

In western developed countries such as the United States, the comprehensive utilization rate of coal gangue has reached more than 90%, while the current comprehensive utilization rate in China is still very low, about 50%. In the future, China is bound to move toward carbon neutrality. In this context, how to rapidly develop advanced technology to make the comprehensive utilization of coal gangue more reasonable is undoubtedly a difficult problem to be overcome at this stage.

2. Component Analysis of Coal Gangue

The chemical composition of coal gangue includes Al_2O_3 , SiO_2 , in addition to a small amount of Fe_2O_3 , CaO , etc.; among them, SiO_2 accounts for the highest proportion, about 52%-65%; Al_2O_3 is the second, about 16%-36%; the remaining components all account for about 0.5-3% between. From its chemical composition, it can be seen that coal gangue contains low carbon content, but has higher hardness than coal [3].

3. Relevant Laws on Coal Gangue Governance

For coal gangue governance, a number of relevant documents and regulations have been issued in China visible in recent years, including but not limited to Technical Essentials of Comprehensive

Utilization of Coal Gangue, Technical Guidelines for Utilization of Coal Gangue, Ecological Restoration and Governance Program of Coal Gangue in Taiyuan City.

September 1, 2020 witnessed the official implementation of the Law of the People's Republic of China on the Prevention and Control of Solid Waste Pollution, which clearly stipulates the basic principles of solid waste pollution prevention and control as "reduction, resourcefulness and harmlessness". At the same time, the permit system for industrial solid waste discharge, solid waste classification and governance provisions, industrial solid waste generators joint and several liability system were proposed in the document. These not only regulate the generation and control of solid waste from the source, systematically strengthen the supervision of solid waste pollutants, toxic and hazardous substances, hazardous waste, but also increase the penalties for violations. In a practical sense, these initiatives will have a profound impact on the way solid waste is handled and recycled in all sectors of society.

In 2021, the National Development and Reform Commission (NDRC) issued a new guiding opinion on the comprehensive utilization of bulk solid waste in the 14th Five-Year Plan, encouraging research on solid waste resource treatment technology and comprehensive utilization of resources. Some local governments have already introduced some relevant supporting policies and implementation plans, evidenced by that the people's government of Yulin City issued the Management Measures for the Prevention and Control of Industrial Solid Waste Pollution in Yulin City (for trial implementation) (implemented on August 1, 2021). In the future, regulations and policies on solid waste will be introduced more intensively [4].

4. Harm of Coal Gangue

First of all, the long-term accumulation of coal gangue and not effectively managed will undoubtedly bring great harm to the ecological environment, such as causing soil and air pollution, serious waste of land resources, aquatic ecosystem damage. Coal gangue mountain is usually open-air, through the accumulation of wind and rain, the internal heat of the gangue mountain gradually accumulation; Once the temperature reaches the combustion point of combustible materials, it will directly lead to the spontaneous combustion of the residual coal in the gangue pile. When coal gangue spontaneous combustion, a variety of toxic and harmful gases will be generated, which not only reduces the ambient air quality around the gangue mountain, but also affects the health of the residents in the mine area and leads to the death of vegetation.

Secondly, because the natural inclination of coal gangue is usually $38^{\circ}\sim 40^{\circ}$, it is very easy to be affected by various external environmental factors and geological disasters such as landslide, mudslide and collapse will occur when a large amount of coal gangue is deposited and the slope is too large.

Furthermore, some of the elements in coal gangue, such as gallium and germanium, belong to rare elements, which are of greater recycling value, and these have important applications in aerospace and integrated circuits; therefore, their long-term accumulation is bound to cause great waste of resources and economic losses [5].

5. Governance Cases and Analysis of Coal Gangue

5.1 Governance and Land Use of Coal Gangue in Yangquan

Yangquan coal gangue mountain, located in the northern gully of Yangquan 307 compound line, is 80m high, covers an area of 123,449 m². Because the gangue mountain is originally blind ditch and ditch body part of the loess cover, so the gangue mountain surface area is slightly larger than its area, with a total of 135061.58 square meters. Given the high content of fixed carbon and pyrite in the composition of this gangue, there is local spontaneous combustion. Even if the fact is that it has been controlled, but part of the coal gangue is still exposed, and the natural area of the western slope is about 11,000 m². [6].

Yangquan Coal Group in Shanxi Province uses “loess cover, slope compaction, vegetation restoration” of the gangue treatment process, to be closed in a mine in Yangquan coal gangue hill for ecological recreation park planning and construction, the purpose is to more effectively improve the coal gangue caused by local spontaneous combustion. Regional environmental testing shows that the detection results of sulfur dioxide in this Yangquan-mine gangue mountain are 0.108-0.122, and the detection results of nitrogen dioxide are 0.096-0.108 mg/m³. According to Technical Guidelines for Environmental Impact Assessment-Atmospheric Environment, it is known that the results meet the requirements of secondary atmospheric quality, and the detection results of TSP and PM10 exceed the standard by 20%. In a comprehensive view, the mine gangue mountain is located in the regional air environment quality condition is good. According to the sound environment detection, the daytime and nighttime noise detection values of the monitoring points are 45~55dB, which is a good sound environment, and there is no waste generation because no one lives around. Regarding the construction of a mine ecological recreation park in Yangquan, it can use the coal gangue mountain as a filler and eliminate the spontaneous combustion of coal gangue; while reusing the waste, it also improves atmospheric pollution, water pollution and visual pollution, making a positive contribution to the ecological environment here.

5.2 Governance and Land Use of Coal Gangue in Tunlan

The coal gangue mountain in Tunlan, located in Taiyuan, Shanxi, has a north temperate continental climate, poor soil, poor vegetation diversity and uneven distribution. The mine field covers an area of 73.33km², and there are four treatment methods.

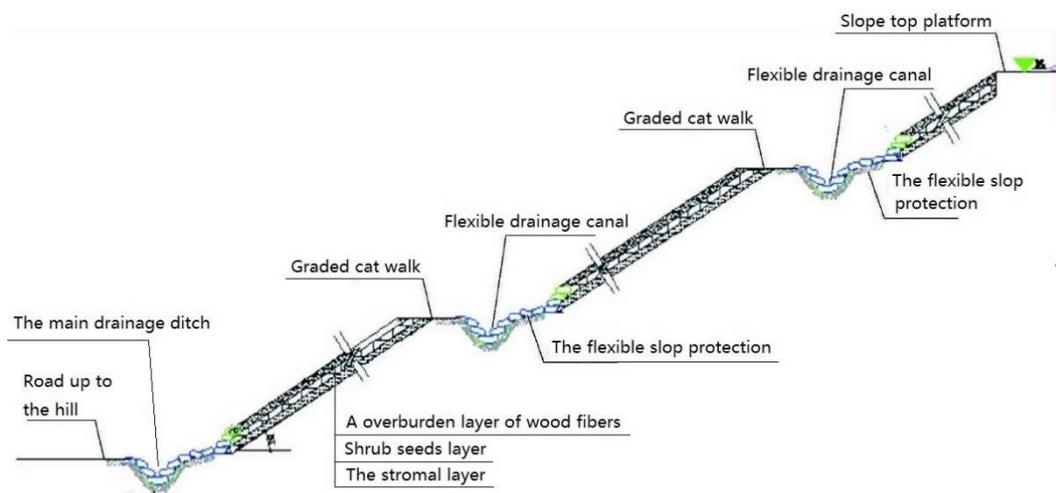


Figure 1. Sketch map of mountain reshaping technology [7]

Firstly, a comprehensive temperature measurement technique was used to measure the temperature of the high-temperature burning area; the “pin-pattern” temperature measurement method was used for the holes, as this survey method allowed limited monitoring of the spontaneous combustion zone, thereby detecting the fire in time and preventing its re-ignition. Secondly, the open fire area and the high temperature area were excavated and grouted by using the “pin-pattern” trenching and grouting technique, and the coal gangue hill was crushed in layers. Testing proves that this step can effectively extinguish and cool down the spontaneous combustion area and prevent its reignition. Again, by using the principle of multi-stage slope counter, the slope length of the original gangue pile can be effectively reduced to reduce the risk of landslide. Given that the stability of the coal gangue mound is related to the success of comprehensive governance, how to ensure its stability becomes a key part. The technique is to form a multi-stage composite mountain with slope separation and counter-stand from top to bottom. In this way, the slope separation and counter-stand technique reduces the soil load and landslide risk on the slope, and also promotes the rapid growth of vegetation. Finally, six

steps are adopted in the vegetation restoration stage, as follows. Firstly, the topographic and geomorphological conditions related to plant growth were analyzed, secondly, soil improvement and plant configuration were targeted, secondly, the principle of “suitable trees for suitable land” was adhered to, with native species as the mainstay and exotic plants added appropriately, and finally, the plant restoration was reviewed periodically.

Through the treatment, the spontaneous combustion of coal gangue mountain has been effectively controlled and the heavy metal content has been greatly reduced. Therefore, the integrated treatment model has achieved the expected results.

6. Research on the Development Trend of Coal Gangue Governance

According to the 2014 revised version of the Management Measures for Comprehensive Utilization of Coal Gangue, it can be concluded that the national policy mainly encourages the comprehensive governance of coal gangue in the following six aspects: the first is underground filling of coal gangue; the second is circulating fluidized bed power generation and cogeneration of coal gangue; the third is coal gangue production of construction materials; the fourth is the recovery of mineral products from coal gangue; the fifth is the land reclamation of coal gangue and ecological restoration of gangue mountain; the sixth is other bulk, high value-added utilization methods.

Different treatment options can be used according to different local conditions.

In the case that the stock of coal gangue is huge, the treatment measures should be based on filling the well, making building materials or greening and covering. For example, the core of coal gangue governance and land use in Yangquan is to cover the coal gangue mountain with greening and comprehensive governance, turning the coal gangue mountain into an ecological park. In the coal gangue mountain in Fengfeng mine district of Handan, the comprehensive governance measures adopt underground filling, which is a technical solution to fill a large amount of gangue; and the underground filling enjoys few filling steps, large filling volume, low cost and high degree of automation.

When the coal gangue mountain is a long-term type, it is basically in a “slabbed” state, so it can be treated with the technique of greening the landscape by mulching. For example, the integrated governance of the coal gangue in Tunlan is based on the “field-pattern” trenching and grouting technique, followed by multi-stage counter slope and finally green cover, which is used to create a landscape. Biotechnology is used to improve the vegetation type and cover area of coal gangue slopes.

When the content of SiO₂ and Al₂O₃ in the coal gangue mountain is in line with the Technical Guidelines for the Utilization of Coal Gangue, the coal gangue mountain can be used as a raw material land for generating gangue bricks. Since it can replace clay to protect precious land resources and its performance basically meets the specified requirements, this method is being explored to multi-species, multi-function and large-scale production at this stage.

In addition, give that coal gangue contains a large amount of trace elements such as zinc and copper, which is much higher than the trace element content in ordinary soil, so it can be used to make organic fertilizer and develop new green fertilizer products, thus achieving ecological and environmental sustainability.

7. Conclusion

As a large coal country, China receives abandoned coal gangue mountains which have a huge impact on our environment. As people’s awareness of environmental protection has gradually increased in recent years, the requirements for the environment have become higher and higher, and the treatment of coal gangue piles is also imminent. Although China has introduced relevant policies for this, but the promotion of the comprehensive utilization of coal gangue governance is still relatively slow; At the same time, there are still shortcomings in various integrated governance technologies. In view of this, there is still a need to increase the investment in scientific research and to conduct in-depth

research and continuous innovation on the issue of coal gangue at this stage. It is necessary to explore new ways to maximize the use of coal gangue.

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References

- [1] BP. BP Statistical Review of World Energy 2021. London, June, 2018.
- [2] Z.S. Hu, X. Zhang. Experimental Study on Coal Gangue as Road Base Material. *Coal Processing and Comprehensive Utilization*. 2022(2): 88-91.
- [3] Q. Zhen, F. Zhen. *The Comprehensive Utilization of Coal Gangue--An Associated Resource with Coal. CCS*, 2015.
- [4] L. Li, Y.P. Xia, L.K. Zhang, C.F. Xu, S.X. Yang, Y. Yang. Industrial Policy and Development Direction of The Comprehensive Utilization of Coal Gangue. *GEOLOGY OF SHAANXI*, 2021, 39(2): 96-101.
- [5] J. Zhang. Comprehensive Treatment of Coal Gangue and Its Development and Utilization. *Modern Industrial Economy and Informationization*, 2021(9): 149-150.
- [6] C. Xin. Land Use and Environmental Impact Assessment of Yangquan Coal Gangue Hill after Treatment. *Modern Industrial Economy and Informationization*. SWCC, 2020(5): 50-68.
- [7] G.L. Lu, B. Zhang, Y.B. Wang, Y.S. Guan, G.Q. Li, J Gu, W.P. Wang. Study on Coal Gangue Comprehensive Treatment Mode of Tunlan Mine, *Modern Mining*. 2020, 614(6): 209-212.