

Observation of Sinosteel's Effective Ecologisation and the Direction of Green Metallurgy Development

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Abstract: The metallurgical industry raw material industrial sector, providing metal materials for all sectors of the national economy, is also the material basis of economic development, but its dependence on natural resources, consumption intensity, and has a greater impact on the quality of the environment, so the development of metallurgical industry ecology has become an important topic. The study examines Sinosteel's practices in areas such as low-carbon mining, energy-efficient engineering, employee environmental training, and international cooperation, highlighting its efforts to promote industrial ecology. Key initiatives include the adoption of advanced technologies for waste heat recovery, hydrogen-rich carbon cycle processes, and digital solutions to optimize resource utilization and minimize emissions. Furthermore, this paper discusses the broader development direction of China's metallurgical industry, emphasizing low-carbon innovation, digital transformation, talent cultivation, and enhanced pollution management. By addressing systemic inefficiencies and fostering green practices, Sinosteel exemplifies the potential for metallurgical enterprises to achieve sustainable growth. The findings underscore the importance of integrating technological innovation, policy reforms, and corporate responsibility to ensure the industry's green transformation. This research offers valuable insights for global metallurgical enterprises aiming to balance economic growth with environmental preservation.

Keywords: Sustainable development, green metallurgy, metallurgical industry.

1. Introduction

The report of the 20th CPC National Congress put forward the main line of development of 'promoting green development and harmonious coexistence between human beings and nature' and pointed out that respecting nature, adapting to nature, and protecting nature are the inherent requirements for building a modern socialist country in an all-round way. It is necessary to firmly establish and practice the concept that green water and green mountains are golden silver mountains and plan for development at the height of the harmonious coexistence of man and nature [1]. As large-scale iron and steel enterprises are established along with the socialist market economic system, how to fulfill the relationship between the development of the metallurgical industry and green sustainable development has become an important issue today. The green development strategy requires a systematic approach to optimize the entire material cycle, from natural materials, processed materials, components, products, and waste products to final product disposal. As one of the key enterprises in China's metallurgical industry, Sinosteel Enterprises has been vigorously promoting the process of

green development strategy, which has achieved remarkable results in the domestic market and won wide recognition in the international market. Its goal is to achieve green and low-carbon transformation of the whole process through technological innovation and management improvement, to build a resource-saving and environment-friendly enterprise, and to contribute Sinosteel's wisdom and solutions to the green transformation of China's iron and steel industry.

2. Analysis of China Sinosteel Group Corporation's Green Development Strategy

2.1. Company Profile

China Sinosteel Corporation is a central enterprise supervised by the State-owned Assets Supervision and Administration Commission of the State Council. Sinosteel is mainly engaged in developing and processing metallurgical mineral resources, trading and logistics of metallurgical raw materials and products, and related engineering services and equipment manufacturing. Since the 1980s and 1990s, Sinosteel has established iron ore resource bases in Australia and other places, controlling a total of more than 2 billion tons of iron ore resources, and has delivered 230 million tons of high-quality iron ore to China, bringing tens of billions of profits to the country.

2.2. Practicing the concept of industrial ecology analysis

Continuously building green steel is the environmental dimension of sustainable development, Sinosteel focuses on environmental protection in the process of development, develops a low-carbon economy, and enhances the environmental protection level of upstream and downstream enterprises. Has organized the preparation of 16 energy-saving and environmental protection project declaration materials and multi-party communication and coordination to promote the project. And issued 'Sinosteel Group energy saving and emission reduction, clean production practical technology compilation,' better implement the new 'Environmental Protection Law,' set up the company's backbone in environmental protection and a good image.

2.2.1. In the mining sector

Sinosteel Mining Development Co., Ltd. to build digital low-carbon mine development concept and technology as the support, efforts to reduce investment in mine construction and production costs and innovative mine management model to build low-carbon mines, environmentally friendly mining industrial system to minimize ecological disturbance to obtain the maximum economic benefits and the minimum governance difficulties, so that the mine project and the environmental environment co-development[2]. In addition, Sinosteel Mining Development Co., Ltd. has implemented the concept of a 'six-dimensional mine' to promote the green construction and intelligent operation of mines comprehensively.

2.2.2. In the field of engineering equipment

Providing environmental protection and energy-saving services for the metallurgical field, the company has completed more than 20 TRT turnkey projects and dozens of other environmental protection and energy-saving projects. The breakthroughs in hydrogen-rich carbon cycle blast furnace technology and belt-roasted pellet technology have put the company in a leading position in the field of low-carbon smelting. Waste heat power generation technology recovers the flue gas waste heat originally discharged into the air through the air cooler and recovers it through the waste heat boiler to generate electricity, which not only recovers heat energy and reduces environmental pollution but also promotes the more stable operation of the mineral heat furnace [3]. The treatment of sewage through physical or chemical means, physical adsorption, settling pollutants, or using pharmaceutical

agents' chemical reactions to make sewage purification and reduce pollution to achieve the treatment of sewage.

2.2.3. In the field of employees

Sinosteel Group puts the investment, utilization, introduction, motivation, and development of human resources in the first place of enterprise development, forming a good situation of 'seeking, employing, educating, promoting and retaining,' and formulating and implementing training plans for different talent teams in different categories and at different levels, enriches the forms of training and focuses on interpreting relevant environmental protection laws and regulations issued by the state recently. It also focuses on interpreting the relevant environmental protection laws and regulations recently issued by the state to enhance the awareness of environmental compliance of managers and employees at all levels of the enterprise.

2.2.4. In the field of environmental protection assessment

Sound environmental protection assessment mechanism. First, it is strictly prohibited to build new, renovated, or expanded projects without the approval of an environmental impact assessment. Second, it is strictly prohibited to discharge pollutants above pollutant discharge standards. It is also strictly prohibited to illegally dump, discharge, or dispose of toxic and harmful substances such as radioactive wastes, hazardous wastes, and dangerous chemicals. It is strictly prohibited to discharge heavy metal pollutants and persistent organic pollutants containing lead, mercury, cadmium, etc., above the standards. It is strictly prohibited to discharge pollutants through concealed pipes, seepage wells, seepage pits, irrigation, and other ways of discharging pollutants. It is strictly prohibited that radioactive sources are out of the safety supervision and protection control. Lastly, it is strictly prohibited to entrust units without legal qualifications to collect, store, use, and dispose of hazardous wastes, such as waste mineral oil, waste emulsion, waste acid, waste alkali, wastewater treatment sludge, and so on. These assessment mechanisms promote the construction of a good atmosphere in the enterprise, enhance the efficiency of resource utilization, and reduce the waste of resources.

2.2.5. In the field of social responsibility

On the one hand, developing energy-saving and environmentally friendly products, continuously improving the Group's overall environmental level from the persistent improvement of the environmental management system, sound energy-saving and environmentally-friendly assessment mechanism, constructing the emergency response mechanism for environmental affairs, and upgrading the environmental management capability. On the other hand, building an emergency response mechanism for environmental accidents, the Group continuously encourages its affiliated enterprises to build an emergency response and disposal system for environmental accidents that is well-prepared, commanded, fast, efficient, and uniformly coordinated, compiles and improves the emergency response plan for environmental incidents, and improves the Company's ability to respond to environmental public crises through the construction of emergency response mechanisms.

2.2.6. In the field of international cooperation

Sinosteel is a large enterprise company engaged in metallurgical technology cooperation in China and has built iron ore and other resource bases in many places, which not only provides more mineral resources for China but also drives local economic development. It has built resource bases of iron ore, chrome ore, nickel ore, and other resources in China as well as in Australia, Cameroon, South

Africa, Zimbabwe, Indonesia, and the Philippines, and possesses a relatively rich number of mineral resources and a strong capacity of ore mining and processing.

To create an environmentally friendly and favorable atmosphere, it has always been committed to the ecological and environmental protection of the regions in which it is located, endeavoring to reduce the impact of its production and operation on the environment and actively promoting the sustainable development of society. The various principles and concepts of Sinosteel's environment in Australia [4] reflect Sinosteel's commitment to establishing a responsible Chinese corporate image as its responsibility, adhering to the fulfillment of its social responsibility, and practicing sustainable development on a global scale.

3. Analysis of the development direction of China's metallurgical industry

3.1. Overview of the current situation

At this stage, because coal and coke account for nearly 90 percent of energy input, carbon emissions from China's iron and steel industry account for about 15 percent of the country's total carbon emissions, making it the manufacturing industry with the highest carbon emissions in China. According to preliminary statistics, the total carbon emissions of the iron and steel industry are about 1.8-1.9 billion tons, and the carbon emission intensity of tons of steel is about 1.8-1.9 tons of CO₂/ton of steel. China's non-ferrous metal metallurgy industry emissions of exhaust gas pollutants accounted for about 5.94% of the total national emissions, the current promotion and application of exhaust gas pollution control technology in the segment mainly includes copper smelting flue gas dust collection, aluminum electrolysis flue gas dry purification, etc., the flue gas treatment of aluminum hydroxide gaseous suspension roasters usually use multi-stage cyclone separation of alumina, electrostatic precipitator dust removal cleaning technology.

3.2. Development direction analysis

The recycling rate of non-ferrous metal resources in China is low, only 30%, and the 'three wastes' generated by the metallurgical industry are still prominent. Green metallurgy has also stepped into the public's view. Green metallurgy refers to the complex material metallurgical process of resources, energy efficiency, and environmental benefits of the maximum; it is a comprehensive consideration of resources, energy consumption, and environmental impact of the metal smelting model. The development direction of the metallurgical industry is a reasonable industrial layout, advanced technology and equipment, a high level of intelligence, strong global competitiveness, and green, low-carbon, and sustainable. Looking ahead to the technology of the metallurgical industry in the new era, the development trend is positioned as a technological system that comprehensively responds to the challenges of resources, energy, and the environment, with the core issue being the promotion of environmental protection and material recycling.

3.2.1. Increase the use of advanced technology and technology

Currently engaged in the metallurgical industry safety and production supervision departments, should be further in-depth to pay attention to and strengthen the current international most advanced information technology products and the use of various advanced information technology, through modern technology means, to further enhance the metallurgical industry in the field of technology, improve the quality of safe and effective metallurgical products and effective operation of the system of production technology, to further promote and effectively improve the sustainable and high-speed and stable development of China's metallurgical industry. Improve the sustainable and high-speed stable development of China's metallurgical industry.

In the enterprise production practice, a large proportion of the use of iron and steel recycling materials will be the future of low-carbon metallurgy, which is an important direction of development, saving the use of blast furnace iron at the same time, significantly reducing CO₂ and pollutant emissions. Actively open up the frontier in the emerging field of energy saving and environmental protection, vigorously develop chromium-free, low-sulfur environmentally friendly materials, and environmental protection equipment, research and development of iron and steel industry flue gas desulfurization and dust removal, carbon dioxide capture and use of environmental protection technology [5]. In addition, the development and use of clean energy also provide a convenient channel for the solution of the carbon emission problem, and renewable energy sources such as wind energy and solar energy can be used to reconstruct the metallurgical industry layout.

3.2.2. Digital development

Digital technologies can also be empowering. Through computer simulation and generative design technology, researchers and developers can optimize the performance of new materials, manufacturing processes, and product performance indicators [6]. Fan Tiejun proposed that the national carbon peak carbon neutral ‘1 + N’ policy system, clearly put forward to promote the deep integration of emerging technologies such as big data, artificial intelligence, 5G, and green low-carbon industries, as well as to promote the integration and development of digitalization, intelligence and greening in the industrial field. In this context, digital technology can be fully integrated with the iron and steel industry, thereby reducing energy and resource consumption and achieving double improvement in productivity and carbon efficiency. It is recommended to study the establishment of a digital platform based on the industrial Internet for ultra-low emissions and low-carbon collaborative control to achieve the carbon flow visible, manageable, and controllable, as well as carbon emissions monitoring, statistics, benchmarking of the entire production process of the enterprise to optimize the production process and management with carbon efficiency as the core to achieve the production process of carbon emissions process target control, carbon emissions early warning and control, and carbon emissions reduction and pollution reduction and collaborative management and control[7].

3.2.3. Industrial layout adjustment

The structural adjustment of China's iron and steel industry layout is facing new challenges, continues to accelerate the pace of optimization and restructuring of iron and steel enterprises, focusing on the comprehensive efficiency of the industry to improve, reasonably strengthen industrial concentration, resolutely eliminating the loss of large, heavily polluting industries [8]. Based on the background of the industry with sufficient production capacity, the introduction of advanced energy sources, from raw material procurement to product manufacturing and then to waste treatment, comprehensively improves the level of green management to form a complete green industrial chain.

3.2.4. Cultivation of talents

Adhering to the employment concept of being ‘people-oriented and making the best use of talents,’ we focus on cultivating cross-cutting talents in metallurgy and chemistry, environmental protection, and other industries to provide comprehensive intellectual support for basic research on green metallurgy and carbon emission reduction. Metallurgical enterprises learn from the management mode of Sinosteel, put the investment, utilization, introduction, motivation, and development of human resources in the first place of enterprise development, attract talents with various kinds of preferential conditions, motivate talents to innovate, and create a scientific research and innovation highland. Build a platform for information technology resource sharing, exchange, and popularisation

of science and technology, carry out specialized publicity of science and technology at a high level, and improve the public's attention, recognition, and participation in green metallurgy.

3.2.5. Optimize pollution management

Promote the iron and steel manufacturing process of environmental risk sources, intelligent monitoring of pollution sources, plant, plant air quality, and water quality monitoring to achieve pollution management, environmental monitoring, and iron and steel intelligent manufacturing depth of integration, environmental governance more effective, to overcome the difficulties, and increase the environmental protection transformation efforts to fully achieve ultra-low emissions[9].

Accelerate the organized emissions governance to fill the shortcomings, the effective control of disorganized emissions, source reduction, process control technology application is more in-depth, the total amount of pollution emissions continues to reduce the total amount of corporate environmental governance is more effective. In addition, the development of waste heat use and other new methods and paths of energy recovery, the formation of key processes and equipment, and the promotion of cross-process, cross-industry energy recovery.

4. Conclusion

The metallurgical industry, as a vital pillar of economic development, must confront its environmental and resource challenges to align with global sustainability goals. This study highlights key directions for the broader metallurgical sector, including digital transformation, low-carbon innovation, talent cultivation, and enhanced pollution control. These strategies are essential not only for mitigating environmental harm but also for ensuring the long-term competitiveness of the industry. As the metallurgical sector evolves, the integration of corporate responsibility, policy reforms, and technological advancements will be critical in achieving sustainable growth. Sinosteel's practices serve as a valuable blueprint for other enterprises aiming to transition towards green metallurgy. By addressing systemic inefficiencies and fostering collaboration, the industry can contribute meaningfully to global efforts in combating climate change and promoting environmental preservation.

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