Energy utilization of CO2 in converter smelting

Member company

China Baowu Steel Group Corporation - TISCO

The Challenge

CO_2 recycling in the steelmaking process, CO_2 converter bottom-blowing technology, converter top-blowing CO_2 energization technology.

Why?

China Baowu TISCO Group is the largest joint producer of stainless steel and carbon steel in China, the recycling of CO2 is of great significance for TISCO Group to complete the task of energy saving and emission reduction. In addition, because stainless steel production requires the consumption of large amounts of argon, the price of argon is 2-3 times the price of CO2, the use of CO2 to replace argon is an effective way to reduce the cost of steelmaking production.

Needed action

1. Carbon steel converter top blowing CO_2, increase gas recovery, to prevent the explosion of the electric dedusting

After CO_2 is blown into the converter top gun, the C in the iron water reacts with CO_2 to produce CO twice as much as that produced by the reaction with oxygen, which can rapidly increase the CO content in the exhaust gas and advance the node of gas recovery, and the CO content in the recovered gas is higher than that of all top-blown oxygen (see Figure 1). Through production data statistics, the relevant furnace times with and without CO_2 in the top gun are compared separately.

1. The gas recovery can be increased by 6.57Nm3/t. The average amount of extra pure CO recovered per furnace is 674Nm3, which is 59Nm3 more than the CO_2 consumed, indicating that all the blown-in CO_2 is converted into CO.
2. The total gas recovery time is increased by 53s/furnace and the start of recovery time is advanced by 68s, which indicates that the gas recovery time can be effectively improved when top blowing CO_2.
3. From the above theoretical analysis and field practical verification, the converter smelting process can convert all CO_2 into CO and realize the purpose of CO_2 energy recycling.

2. Carbon steel converter bottom-blowing CO_2 instead of argon

In order to improve the bottom-blow stirring intensity of the converter, improve the proportion of CO_2 instead of argon while reducing the end oxygen content of the converter, steel and auxiliary material consumption, and the converter bottom-blow system was optimized, the bottom-blow element was changed from a gas permeable brick to a metal ring tube, and the number and location of the bottom-blow holes were optimized, and the bottom-blow control system and stirring process were developed (see Figure 2), which was effective in reducing the argon consumption, the end oxygen content of the molten steel and TFe content in the slag. As the implementation of the bottom-blowing CO_2 process aggravates the bottom erosion, shortens the lining life and affects the overall advancement of the top-bottom re-blowing CO_2 process, the converter online thermal bottom replacement technology was developed

to completely solve the problem of rapid bottom erosion. From the first bottom replacement on October 9, 2021 to the end of 2022, the bottom was successfully replaced four times, with an average time of 17 hours per bottom replacement, and the longest number of times the small bottom was used after replacement was 4271 and the shortest was 3631, which solved the problem of promoting the CO process in the converter.2

After our theoretical study on the application of CO_2 to replace argon in stainless steel converter, we carried out tests under different smelting stages and gas distribution process conditions, and conducted a comprehensive comparison in terms of temperature, consumption, resistant material erosion and reduction, respectively, to determine that CO_2 can be used in the stainless steel smelting process. But in the current process conditions of iron + alloy smelting process heat is insufficient, and the use of CO_2 heat absorption exacerbates the problem. From economic considerations, CO_2 can only partially replace argon in the current stainless steel smelting process, and the proportion of ultra-pure ferritic stainless steel CO_2 replacing Ar is stabilized at about 25% (about 5 Nm^3/t).

Action review

Specific: The converter production needs to consume a large amount of argon gas, the price of argon gas is 2-3 times the price of CO_2, using CO_2 to replace argon gas can reduce the cost of steel production, while the converter top blowing CO_2 can increase the amount of converter gas recovery.

Measurable: From June 2020-October 2022, it will replace only the use of argon gas by about 13,000 tons. Reduce 2,700 tons of ferro-silicon used for controlling the electric dust discharge explosion and increase gas recovery by 17 million m3, which has achieved significant effect of reducing argon consumption, increasing gas recovery and reducing CO_2 emission.

Achievable: By comparing the analysis before and after use, without considering the reduction of steel and deoxidizer consumption, from June 2020 to October 2022, the cost saving of using CO_2 alone is 35.23 million RMB.

Realistic: The project realizes the resource and energy utilization of CO_2 in the smelting process of stainless steel and carbon steel, reduces CO_2 emissions, and is of great significance to the energy saving and emission reduction and green development of the steel industry.

Time-bound: The project was completed on schedule and achieved the desired results.

Horizontal Expansion Capability

The company has overcome a series of technical problems in the use of CO_2 around the energy saving and emission reduction and green development of the industry, and developed a number of international leading process technologies such as online thermal bottom replacement of the converter, top blowing CO_2 control of the electric de-dusting explosion in the converter and the use of CO_2 in the stainless steel converter. The industrial application of CO_2 in TISCO's steelmaking process cannot only reduce production costs, but also store CO_2 in the form of converter gas to realize the energy utilization of CO_2 and reduce

carbon emissions. This technology can be promoted in the industry to drive energy saving and emission reduction in the steel industry.

Outcome

Since June 2020, the use of CO_2 to replace argon gas to form a large-scale application. By the end of 2022, the cumulative use of carbon dioxide gas is about 31,000 tons, replacing about 13,000 tons of purchased argon gas, reducing 2,700 tons of ferro-silicon used for controlling electric dedusting and increasing gas recovery by 17 million m^3 , which has achieved a significant effect of reducing argon gas consumption, increasing gas recovery and reducing carbon dioxide emission. Only the use of CO_2 a cost savings of 35.23 million yuan.

Other comments

At present, TISCO's CO_2 is sourced from external sources, and the usage quantity and cost are limited. After the completion of TISCO's CO_2 internal capture project in 2023, the annual output is expected to reach 50,000-60,000 tons, and in order to maximize the internal recycling of CO_2, the usage field and scale of CO_2 need to be further expanded, and the use of CO_2 as a protective gas for continuous casting and ladle stirring gas instead of Ar needs to be further studied, and the use of CO_2 in the treatment of slag needs to be promoted. The use of CO_2 in the process of steel slag treatment should be promoted, and the use of CO should be increased and its emission reduced.