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Production Practice of Solid Waste Desulfurizer Disposal in European Metallurgical Furnace

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Abstract: In order to realize the OY Smelting Furnace disposal of solid waste, municipal waste, form a model of steel enterprises and urban integration, through the production practice of smelting furnace, analyzes the mechanism of solid waste disposal, and proposed the disposal of solid waste desulfurization agent and disposal method: According to the theory to guide the actual production process, the test ton of iron with 10-15kg of desulfurizer in the production process does not affect the quality of molten iron and slag quality.
Keywords: OY smelting furnace; solid waste disposal; desulfurizing agent

Introduction

Currently, the domestic steel industry is generally facing pressure from energy consumption, cost, and environmental protection. With the advancement of urbanization, the problem of urban solid waste discharge and disposal is becoming increasingly prominent [1]. In the context of severe overcapacity, technological upgrading of the steel industry is also urgent. Baosteel Europe Metallurgical Furnace is an innovative and developed non blast furnace smelting reduction ironmaking process based on Baosteel Luojing COREX-C3000. It has the technical advantages of using less coke, low pollution, and flexible operation [2]. Since its opening in June 2015, the European Metallurgical Furnace has undergone a series of technological upgrades around stable operation. With the improvement of understanding and operational control level of the European Metallurgical Furnace, rich production practice experience has been accumulated [3]. The production process technology of the European smelting furnace is a new type of process technology developed on this basis. It has strong adaptability and economy for the production and operation of local mines and coal resources in Xinjiang, especially in the treatment of industrial waste and urban garbage, which has unique advantages that traditional blast furnaces do not have.

The European smelting furnace is divided into two containers: upper and lower, and the upper reduction vertical furnace; Lower melting gasification furnace. From the perspective of the facilities of the European smelting furnace, various types of waste can be added to the furnace from the vertical furnace and gasifier according to the characteristics of the waste, or can be added through the tuyere and burner by spraying. With slight improvements, the equipment conditions for treating various types of waste can be met.

1 Mechanism of solid waste disposal in European metallurgical furnaces

When the European smelting furnace is in normal production, the temperature inside the gasifier is above 1050 ℃ and the pressure is 0.4 Mpa. The furnace maintains a high-temperature redox atmosphere, and the temperature, pressure, and redox atmosphere fully meet the process requirements for various waste disposal. The nearly 3200 cubic meters of content in the gasifier allow sufficient time for various types of waste to undergo decomposition reactions. According to calculations, the shortest time for various types of waste to be converted and decomposed in the incinerator is also 45 seconds. Compared with the decomposition time of

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2-5 seconds in general incineration treatment devices, the European metallurgical furnace has a significant advantage in treating waste. From a process perspective, the European smelter can achieve 100% harmless treatment of waste.

From the comparative analysis of three commonly used waste disposal devices, namely European smelters, incinerators, and general gasifiers, European smelters have obvious advantages in terms of treatment mechanism, reaction temperature, time, pressure, and types of waste treatment. And it has super strong processing ability. After disposing of hazardous waste in incinerators and general gasifiers, the fly ash is classified as hazardous waste and needs to be solidified and landfilled, resulting in waste filling of the site. As time goes on, there is still a possibility of hazardous waste decomposing into the soil. After the disposal of hazardous waste in the European smelting furnace, the products are molten iron, slag, dust removal ash, and coal gas. Molten iron is transformed into steel through steelmaking and rolling; The slag is transformed into raw materials for making cement through the use of slag powder; The addition of dust removal ash for recycling in sintered ore; Gas is used to generate electricity through a boiler, and the waste gas after combustion is converted into standard gas emissions through desulfurization and denitrification [4]. During the entire process of disposing of hazardous waste, the European Metallurgical Furnace can completely harmless hazardous waste, which is more environmentally friendly and saves land resources. There is no risk of hazardous waste decomposing into the soil. The coking process of Baosteel Iron and Steel Plant uses over 1000 tons of desulfurizer annually in production. The replaced iron oxide based desulfurizer can be used as a raw material for solid waste disposal in European smelters.

2 Analysis of the reaction principle for the disposal of iron oxide based desulfurizers in the European metallurgical furnace

2.1 Analysis of the reaction principle of iron oxide based desulfurizers

The mixed fuel from the coal loading bin is fed into the gasifier, where the molten pool is at high temperature [5]. In the reducing atmosphere of the gasifier, the sulfur compounds in the hazardous waste desulfurizer react with the alkaline substances in the furnace material in the melting zone of the gasifier to form stable sulfides that are only soluble in slag. The reducing gas from the gasification zone on the top of the gasifier enters the reducing shaft furnace through a surrounding pipe, and the sulfides in the reducing gas react with the metal Fe in the shaft furnace to generate FeS, FeS enters the molten gasifier through the DRI downcomer and undergoes desulfurization in the gasifier slag. The reaction is as follows:

$$FeS + Cao = CaS + Fe + \frac{1}{2}O_2 - 4.18 \times 1995KJ/Kg$$

(endothermic reaction)

Among them, the gas in the dome gasification area of the gasifier is a reducing atmosphere mainly composed of CO, with specific components including 9.29%CO_2, 70.96%CO, 14.57%H_2, 1.07%N_2, and 4.11%H_2O. The European metallurgical furnace adopts a two furnace three stage process, which achieves efficient gasification of dry coal powder at the top of the gasifier arch by spraying dry coal powder and oxygen at the burner; By reducing the bottom of the vertical furnace and adding cold gas, the reverse gas flow and the central airflow of the vertical furnace distribution are suppressed. Cold gas accounts for 20% of the total gas entering the reduction shaft furnace, while the remaining 80% is the reduction gas in the surrounding pipe. The reduced gas at the top of the gasifier arch first enters the cold cyclone dust collector through the gas generation pipeline for dust removal. Part of the reduced gas enters the reduction vertical furnace through the surrounding pipe and reacts with the furnace materials before being mixed with the top gas for output. The other part of the reduced gas is directly output after washing in the washing tower. Among them, the dust collected in the cold cyclone dust collector is sprayed together with oxygen into the dome of the gasifier. Using the European smelting furnace system to reduce the atmosphere and convert sulfur in hazardous waste into elemental sulfur. After a chemical reaction in the furnace, metal iron reacts with sulfur in the reduction shaft furnace to form FeS, which is then desulfurized in the gasifier to form CaS, achieving fixed slagging of sulfur. The slag is economically treated as a building material.

2.2 Analysis of sulfur behavior in European smelters

In the reducing atmosphere of the gasifier, the sulfur compounds in the desulfurizer react with the alkaline substances in the furnace charge in the melting zone of the gasifier to form stable sulfides that are only soluble in the slag. The reducing gas in the top gasification zone of the gasifier enters the reducing shaft furnace through a surrounding pipe, and the S compounds in the reducing gas react with the metal Fe in the shaft furnace to form FeS. The reaction equation is:

$$Fe + \frac{1}{2}S_2 = FeS$$

The metal Fe in the vertical furnace exists in an excess state, and the desulfurization of sulfides in coal gas is achieved by using the vertical furnace material bed as the filter layer. FeS enters the melt gasifier through the DRI downcomer. Desulfurization is carried out on the slag of the gasifier. The reaction is as follows:

$$FeS + Cao = CaS + Fe + \frac{1}{2}O_2 - 4.18 \times 1995KJ/Kg$$

(endothermic reaction)

The reducing gas from the dome of the gasifier enters the cold cyclone dust collector through the gas generation pipeline, separating and collecting solid particles carried in the gas. It can be used as a substitute for the dry coal powder injection back into the furnace in the two furnace three-stage process mentioned above, achieving the effect of solid waste reuse. Not only can it achieve the repeated and full utilization

of fuel and furnace materials, but it can also return the solid sulfur carried out with the solid particles to the furnace for desulfurization, The gas enters the reduction shaft furnace through a casing, which corresponds to the furnace wall of the reduction shaft furnace and is uniformly equipped with several inlet ports, allowing the gas to be evenly distributed into the reduction shaft furnace. Combined with the above vertical furnace distributor, the gas phase sulfur is further mixed with the furnace material to achieve better desulfurization effect.

3 Production Practice of Desulfurizer Disposal

3.1 Adding reasonable desulfurizers

The amount of waste desulfurizer used is calculated based on the desulfurization capacity of the furnace slag, and the target sulfur content of molten iron is below 0.07% as a qualified standard [6]. According to the sulfur and sulfur load per ton of raw fuel consumed per ton of iron, as well as the theoretical calculations of desulfurization in the ironmaking process and slag desulfurization capacity, adding 10-15 kg of desulfurizer per ton of iron does not affect the quality of molten iron. The desulfurization capacity of slag can meet production needs without the need for additional investment.

3.2 Reasonably using the silo to add desulfurization agents

Uniformly lay the weighed desulfurizer on the middle layer of the material and mix the materials, forming a natural layer on the transportation belt. During the transportation process, it is completely mixed through two intermediate transfer bins and stored in the coal loading bin; The hazardous waste desulfurizer is used in the middle tank of the storage tank group, and a weighing hopper is set below the tank to achieve uniform laying of the desulfurizer in the middle layer of the material. The program automatically controls the process of screening fuel, and synchronously weighs the waste desulfurizer according to the proportion setting through the batching weighing system; Add independent screening and weighing equipment to each silo under the storage tank group to achieve fuel screening and weighing of hazardous waste desulfurizers.

3.3 Improving desulfurization efficiency through fabric operation

When adding furnace material from the hopper to the reduction shaft furnace, the material groove intermittently and regularly adjusts the swing angle to form different radius material circles, with a maximum material radius of 3.5 meters, thereby achieving full coverage of the material surface circumference radius of 3.5 meters. This not only achieves large-area spiral layer by layer material distribution, but also ensures the uniformity of the material distribution, so that the sulfur entering the gas phase is fully and uniformly mixed with the descending furnace material in the reduction shaft furnace, Thus, the furnace material can better absorb the sulfur entering the gas phase, and more sulfur can enter the gasifier to achieve slag fixation of sulfur, in order to achieve better desulfurization effect. The angle corresponding to the gear position is shown in Table 1.

Table 1 Angle corresponding to gear position

Gear position	0.4	0.8	1.2	1.6	2.0	2.4	2.8
Angle / °	4.97	8.1	10.8	15.2	20.4	26.3	29

The angle parameters of DRI flap fabric are shown in Table 2.

3.4 Thermal system management stabilizes furnace conditions

There are a total of 9 temperature measuring thermocouples TIR24415-24417, TIR24425-24427, and TIR24435-24437 in three directions of furnace material and furnace temperature, all of which are ⩽ 890 ℃ . The temperature of molten iron is 1500 ± 20 ℃ . If the temperature of molten iron is lower than 1420 ℃ or lower than 1450 ℃ for two consecutive furnaces, the fuel ratio should be increased by ⩾ 80 Kg/tHM. At the same time, the slag alkalinity should be adjusted according to the slag making system. If the above measures still cannot alleviate the decrease in molten iron temperature, then reduce the melting rate by 20 t/h, increase the total fuel ratio by 50-100 Kg/tHM, and pay attention to observing the trend of furnace temperature; If the temperature of molten iron is below 1400 ℃, the melting rate will be reduced to 80 t/h (reducing air flow), and the fuel ratio will be increased to above 950 Kg/tHM. The temperature of the gas at the top of the gasifier arch is controlled by operating the dust burner. When the oxygen flow rate reaches the upper limit of 5000 Nm^3/h, the total gas flow rate of the burner remains basically unchanged. After the blowing is completed, it should be put back into operation in a timely manner. The temperature of the gasification furnace arch is controlled between 820 and 900 ℃.

3.5 Management of slag iron operation

Firstly, the rest time of the iron mouth should be shortened as much as possible to avoid long-term rest; Secondly, in principle, it is not allowed to use the same iron mouth continuously, except when the iron mouth is resting; Once again, special attention should be paid to the changes in [S] in molten iron; Finally, when the furnace condition is poor, with high [Si] and low [S], and poor slag iron fluidity, the residual iron in the main ditch should be promptly discharged according to the situation after blockage. After 50 minutes of blockage (30-40 minutes in the new ditch), a thin slag shell has formed in the main ditch for 4 hours (2-2.5 hours in the new ditch). The surface of the main ditch has condensed by 20-30 mm, and the slag surface under the rice husk has risen. After 8 hours of blockage (5 hours in the new ditch), the slag surface in the main ditch has condensed, and the interface between the 100 mm slag and iron layers has solidified. It is necessary to pay attention to the solidification of slag and iron in the main ditch and handle it properly [7].

From August to October 2023, Eurosmelter successively

disposed of desulfurizer per ton of iron at 10-15 kg, and the overall sulfur load per ton of iron increased to around 10 kg. By controlling the furnace temperature and maintaining appropriate alkalinity, Eurosmelter's pig iron quality remained stable as a whole.

Table 2 DRI flap fabric angle arameters

Radius/m	0	0.5	1.0	1.5	2.0	2.5	3.0	4.0	4.5	5.0
Angle / °	-30	/	/	-22.7	-21.2	-19.1	-16.7	-11.0	-7.7	-4.0

With the increase of desulfurization dosage, the amount of treatment agent consumed by the gas system increases, the corrosion rate of system valves accelerates, and the maintenance frequency of the European metallurgical furnace gas system increases.

4 conclusion

Through the research and analysis of the production practice of solid waste desulfurizer disposal in the European Metallurgical Furnace, the following conclusions can be drawn: (1) During normal production of the European Metallurgical Furnace, the temperature inside the gasifier is above 1050 ℃, the pressure is 0.4 Mpa, and a high-temperature oxidation-reduction atmosphere is maintained inside the furnace. The temperature, pressure, and oxidation-reduction atmosphere fully meet the process requirements for various types of waste disposal; (2) Theory guides the actual production process, and the addition of 10-15 kg desulfurizer per ton of iron during the production process does not affect the quality of molten iron and slag.

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