Production process of 800 t/d sintered lime rotary kiln

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Abstract. This paper presents a detailed analysis of the production process and technical characteristics of the 800t/d sintered lime rotary kiln in Beitai Iron Mine of Bensteel Group Corporation Limited. The production process encompasses a number of key stages, including the charging of raw materials, firing, the crushing and screening of finished products, storage and transportation, exhaust gas treatment, and pulverized coal preparation. The study will prove a valuable point of reference for the enhancement of the overall performance of the domestic sintered lime industry.

Keywords: sintered lime, rotary kiln, production process, preheater, calcination.

1. Introduction

As a crucial industrial raw material, sintered lime plays an indispensable role in a multitude of fields, including steel production, environmental protection and construction [1-3]. In the context of steelmaking, the utilization of high-quality sintered lime not only enhances the efficiency of the process itself, but also markedly reduces production costs and improves the quality of the resulting steel [4,5]. Consequently, the exploration and optimization of sintered lime production technology has become a continuous and pivotal focus for the relevant industries.

Among the numerous techniques employed in the manufacture of sintered lime, rotary kilns have garnered considerable attention due to their capacity to produce a uniform and stable product, facilitate high levels of activity, enable a high degree of automation, and accommodate large production volumes [6-8]. The rotary kiln, with a production capacity of 800 tons per day, is one of the most common kiln types employed in the processing of sintered lime. It is therefore crucial to conduct research on the production process of the 800 t/d lime rotary kiln in order to facilitate the advancement of the entire sintered lime industry.

The objective of this study is to analyze the production process of the 800t/d sintered lime rotary kiln of the Beitai Iron Mine of Bensteel Group Corporation Limited. In addition to examining the current production process, the study will also investigate the existing problems and potential improvements. The findings of this study will serve as a reference for enhancing the overall level of the domestic sintered lime industry.

2. Rotary Kiln Process

2.1. Production Process

The rotary kiln production process utilizes limestones as the primary raw material and bituminous coal as the fuel source, which are conveyed to the rotary kiln for calcination into quicklimes, which are then employed for sintering purposes [9]. The rotary kiln process, schematically represented in Fig. 1, encompasses a series of key stages, including the raw material charging process, firing process, finished product crushing, screening, storage and transportation process, exhaust gas treatment process, along with pulverized coal preparation process.

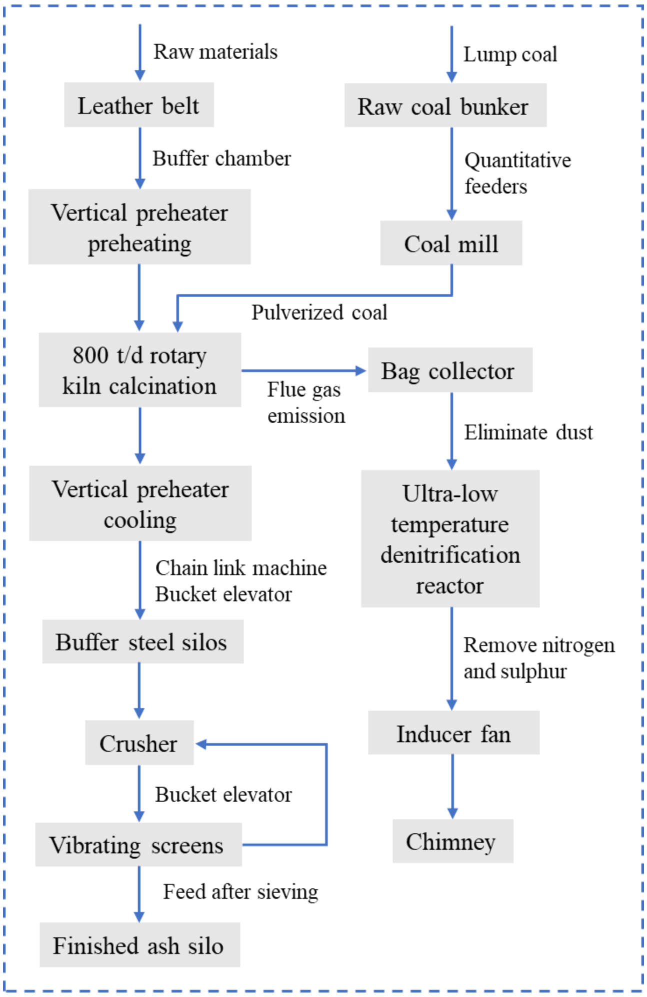

Fig. 1 The rotary kiln production process

2.2. Raw Material and Fuel Quality Specifications

The limestones, which serve as the primary raw material for the 800t/d rotary kiln, are sourced from the limestone mine operated by Beiying Mining Company. The calcium oxide content is a minimum of 48%, while the silica content is approximately 4%. The particle size range of the limestones is 18-50 mm, with a proportion exceeding 95%. The fuel employed was of the highest quality bituminous coal, with the relevant indicators presented in Table. I

Table 1. Bituminous Coal Indicator

Indicators	Ash content	Volatiles	S	C	H_2O
Data	≤11%	≤35%	≤0.6%	≥50%	≤13%
Indicators	Expansion coefficient	Abradability	Melting point	Calorific value	
Data	≤1.0	≥50	1300℃	≥23mJ/kg	

3. Rotary Kiln Raw Material Charging Process

The limestone raw materials, with a particle size of 18-50 mm, are conveyed to the vertical preheater via two belt conveyors: one located in the machine processing operation area and the other in the rotary kiln. Upon reaching its maximum capacity, the limestone materials can be transferred to the buffer silo, which is equipped with a three-way valve for precise control. A bucket elevator facilitates the transfer of the limestones to the belt conveyor and buffer bin, as well as directly to the aforementioned silo. It is imperative that the conveyor is securely connected to the subsequent process system during the loading phase. In the event of a failure of the previous process, it is possible to continue feeding by means of an auxiliary belt or bucket elevator without affecting the normal feed.

4. Rotary Kiln Firing Process

The rotary kiln firing process is illustrated in Fig. 2. Raw materials are conveyed by a loading system to the vertical preheater. The vertical preheater is equipped with 14 actuators, which divide the interior into 14 distinct compartments. Each compartment is equipped with a single exhaust pipe, and the preheating gas converges after exiting the preheater. Following preheating by the exhaust gas from the kiln end, the limestones are propelled by the hydraulic actuators and enter the 800t/d rotary kiln for calcination via the charging chamber. This rotary kiln has a direct diameter of 4.5 meters, a length of 63 meters and a slope of 3.5%. The rotary kiln is driven by a frequency-controlled motor, with an auxiliary motor incorporated to ensure stable operation. In addition, the kiln head and kiln tail are equipped with a spring-loaded blade-type sealing structure, which is simple and reliable.

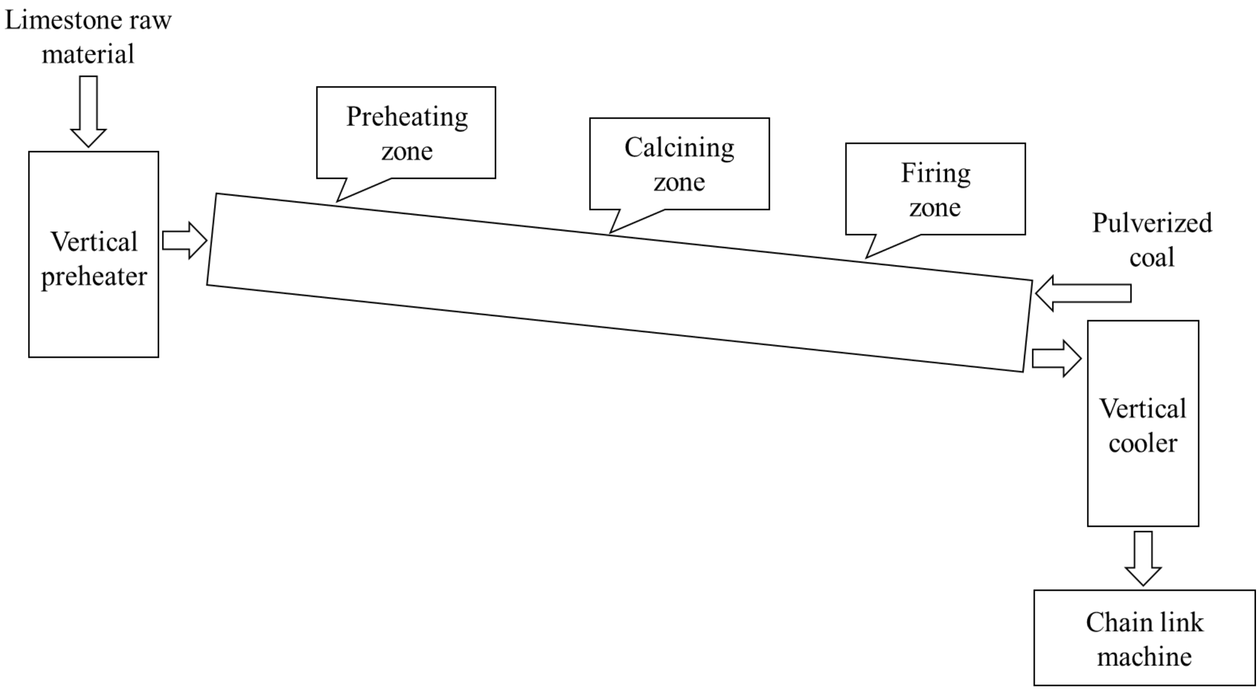

Fig. 2 The rotary kiln firing process

The process parameters for 800 t/d rotary kiln are shown in Table II, and the heat-up curve is presented in Fig. 3. In the calcination stage, the limestones pass sequentially through the preheating zone, the calcining zone and the firing zone. Limestone, which is composed primarily of calcium carbonate, undergoes a decomposition process that results in the formation of calcium oxide and carbon dioxide.

Table 2. Process Parameters

Process parameters	Normal values
Rotary kiln speed	0.2~1.6 r/min
Dedusting inlet temperature	≤220℃
Preheater centre temperature	850-1050℃
Kiln cylinder surface temperature	≤350℃
Kiln hood temperature	550~750℃
Cooler feed temperature	≥500℃
Kiln hood pressure	-50~-100Pa
Negative pressure at kiln end	-100~-300Pa
Primary air volume	2000~5400m^3/h
Secondary air volume	30000~65000m^3/h

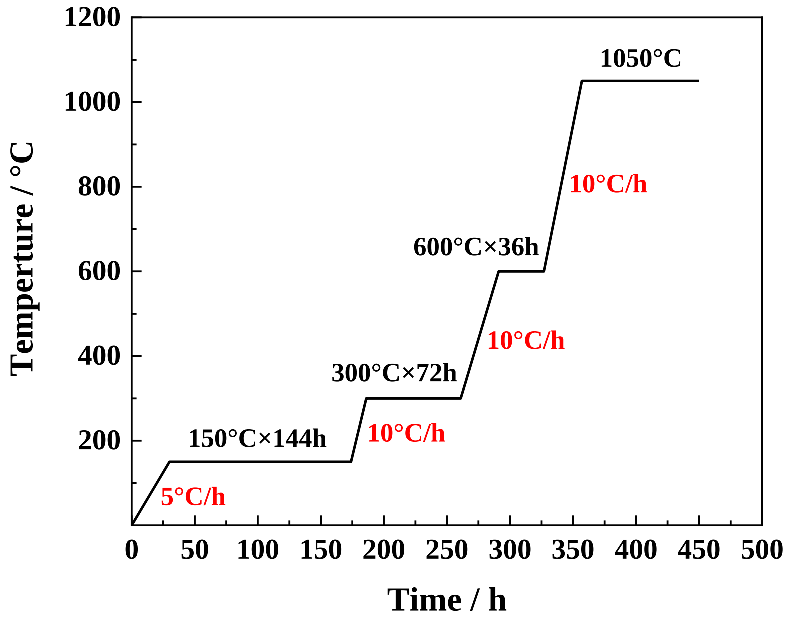

Fig. 3 The heat-up curve for 800 t/d rotary kiln

Following a calcination period of between 60 and 160 minutes, the calcined limestones, which are known as limes, are cooled using a vertical cooler. In a vertical cooler, the temperature of the lime can be significantly reduced by the direct contact between the cooling air and the hot lime, resulting in a notable decrease in the temperature of the lime. The cooled limes are conveyed via a chain link conveyor to a buffer steel silo for temporary storage.

The rotary kiln utilizes an automation control system developed by CITIC Kiln & Furnace Co. The system is highly automated, thereby reducing the need for manual labor, enhancing labor productivity and guaranteeing the stable operation of the equipment. During calcination, it is essential to maintain vigilance with regard to the measurement data at all times, and to make adjustments to the air flow in accordance with the prevailing conditions within the kiln. This approach enables the control of both the calcination effect and the output. In addition, in order to ensure the uninterrupted and stable operation of the roasting system, the rotary kiln operation area has formulated an emergency plan for water outage, an emergency plan for power outage and an emergency plan for the coal mill area.

5. Rotary Kiln Product Crushing, Screening, Storage and Transport Processes

The raw ashes from the firing system are conveyed to the buffer bin at the top of the crushing room via the chain conveyor and bucket elevator. They are then transferred to the vertical compound crusher via the quantitative feeder at the bottom of the bin. Following the crushing process, the proportion of crushed ashes with a particle size of less than 3 mm that meets the requisite criteria for sintering are about 70-90%. Furthermore, the crushed ashes are conveyed to the top of the powdered ash store by bucket elevator for screening. The materials below 3 mm in size that pass the screening test are deposited in the powdered ash store, while the materials that fail the screening test are returned to the buffer bin of the crusher via pipeline, thus forming a closed-circuit recycling system. A loading system is situated at the base of the pulverized ash store, with an additional sampler for finished powder.

6. Rotary Kiln Exhaust Gas Treatment System

The exhaust gases from the preheater are introduced into the waste heat boiler for a heat exchange. The volume of flue gas entering the waste heat boiler is approximately 88,000 Nm³/h. The temperature of the flue gas exiting the boiler is approximately 160-180°C. Subsequently, they pass through a bag filter with the objective of removing dust. The bag filter has a theoretical flue gas capacity of 240,000 Nm³/h and a total filtration area of up to 4,670 m³.

In order to comply with the local environmental protection policy, the gases undergo dedusting and are then passed through an integrated desulfurization and denitrification reactor operating at ultra-low temperatures of 70-180°C [10]. Figure 4 illustrates the reactor structure and the inlet and outlet pollutant concentrations. The self-built integrated device features two desulphurization beds and one denaturation bed, through which the flue gas passes successively in a radial flow manner. The desulfurization bed layers have a total filling volume of approximately 1.5 m^3, and activated calcium oxide solid granules are used as desulphurization agent. The denitrification bed layer is filled with approximately 0.75 m^3 of CDM-2CXTX catalysts. It can be demonstrated that this process is capable of maintaining NO_x emissions at a level below 10 mg/Nm^3. Finally, the flue gases are discharged into the atmosphere by the induced draft fan and the chimney.

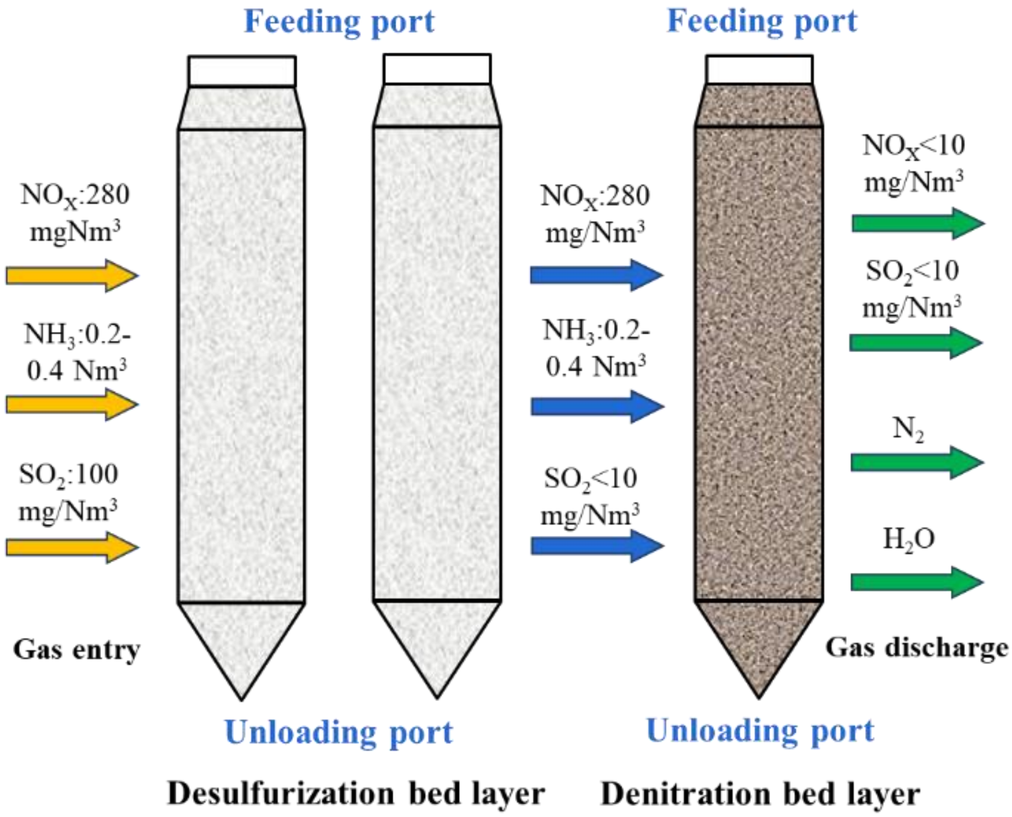

Fig. 2 The schematic structure of the integrated desulfurization and denitrification reactor

7. Pulverised Coal Preparation Process

The lump raw coals are transported from the external storage area to the bunker, which has a capacity of 1,000 tons. Subsequently, the materials are loaded by forklift trucks and conveyed via a belt conveyor to the hammer crusher, where they are reduced in size and then transported to the bunker by a bucket elevator. The hammer crusher has a processing capacity of 25 tons of raw coal per hour. The crushed coals briquettes are conveyed into the vertical coal mill for the purposes of drying and grinding, with the assistance of a quantitative coal feeder. Subsequently, the coal dusts, which have been classified as suitable for processing by the dynamic pulverize, are conveyed to the bag-type dust collector for collection and subsequent transfer to the coal dust bin. The filtered gas is released into the atmosphere via the fan, while the pulverized coal is conveyed to the rotary kiln by a Roots fan, following precise metering in accordance with the requisite specifications.

The hot air utilized for the drying of moisture in raw coal is derived primarily from the mixture of kiln tail and kiln head. The hot gas can be blended with the cold air by the cold air valve prior to its entry into the coal mill, thereby enabling the temperature of the hot air entering the coal mill to be adjusted to a range of 100-250 °C, which aligns with the requirements of the coal drying process.

8. Summaries

A comprehensive examination of the plant process has revealed that the 800 t/d sintered lime rotary kiln is capable of achieving a high throughput while simultaneously ensuring the production of a high-quality product and significantly reducing the negative impact on the environment. Concurrently, the implementation of automated control technology plays an instrumental role in enhancing the stability and reliability of the rotary kiln production process. This serves not only as a guideline for the design and operation of sintered lime rotary kilns, but also as a valuable reference point for the sustainable development of the entire metallurgical lime industry.

As technology progresses and environmental protection standards evolve, the production process of the 800 t/d sintered lime rotary kiln will continue to necessitate optimization and upgrading in order to maintain competitiveness. Further research could focus on optimizing energy utilization, the comprehensive utilization of raw materials and advances in exhaust gas treatment technology. Moreover, an investigation into alternative energy sources and raw materials with the objective of enhancing productivity, reducing costs and mitigating environmental impact represents a crucial avenue for future research.

Acknowledgments

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