Analysis of energy saving in domestic ceramic industry kilns

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Abstract: Ceramic industrial kiln refers to the combustion equipment for ceramic production, which generally refers to roller kiln, shuttle tunnel kiln and shuttle kiln. Roller kiln refers to the kiln with continuous firing and rotating roller as the vehicle of the billet body; Tunnel kiln refers to the kiln which adopts continuous firing and takes rail kiln car as the transport vehicle of billet body. Shuttle kiln refers to the kiln which is fired intermittently and consists of kiln car, kiln chamber and kiln door. Factors influencing energy saving of kiln include construction materials, kiln structure, combustion technology, thermal insulation performance and automation control.

1 Introduction

In recent years, with the continuous tightening of domestic environmental protection policies, central and local governments have issued policies and regulations on energy conservation and emission reduction in the building Sanitary wares industry. For example, the Circular of the State Council on the issuance of the "13th Five-Year" Comprehensive Work Plan for Energy Conservation and Emission Reduction (GFA [2016] No. 74) :By 2020, the energy consumption per unit added value of industrial enterprises above designated size should be cut by at least 18 percent from the 2015 level, and the energy use efficiency of key energy-consuming industries such as the electric power, steel, non-ferrous metals, building materials, petroleum, petrochemical and chemical industries should reach or approach the world's advanced level. Implementation Suggestions on the Standardization Work of Industrial Communication Industry Serving the Construction of "One Belt And One Road" by the Ministry of Industry and Information Technology [2018] No.231:"Combined with the construction status of China's cement, glass, ceramic and wall material production lines in the" One Belt And One Road "countries, promote China's advanced engineering design, technical equipment and products in this field, complete sets of standards and systems" go global ""Circular on accelerating the promotion of industrial energy conservation and green development Department of Industry and Information Technology Joint Section [2019] No. 16: "Support the application of high-efficiency and energy-saving technology and process in key energy-consuming industries, promote high-efficiency and energy-saving boilers, motor systems and other general equipment, and implement system energy-saving transformation. We will promote the

transformation of cleaner production in key industries such as coking, building materials, non-ferrous metals, chemical industry, printing and dyeing ".

Ceramic industry is a typical industry with high energy consumption and high emission. The key to the green development of the industry is energy saving in the kiln. Kilns consume a lot of resources every year. According to the statistics of relevant institutions, the annual energy consumption of building sanitary ceramic kilns is equivalent to more than 60 million tons of standard coal, ranking first in the ceramic industry. The annual energy consumption of daily ceramic kilns is more than 10 million tons of standard coal, and the annual energy consumption of other ceramic kilns is nearly 30 million tons of standard coal. In addition, a large number of waste flue gas will be emitted in the sintering process of ceramic industrial kilns. The flue gas contains a large number of particulate matter, nitrous compounds, oxides and sulfides, which aggravates the formation of "haze" in the air. According to relevant statistics, the ceramic industry annually produces more than 1.5 million tons of NOX, more than 21.5 million tons of SO2, more than 800,000 tons of dust, heavy metals and their compounds and other pollutants. More than 60% of energy consumption in ceramic industry comes from sintering process. The main equipment in the firing process is the kiln. Therefore, the focus of energy conservation and emission reduction in the ceramic industry is the energy conservation and emission reduction in the kiln.

2 Cause analysis Analysis of factors influencing energy saving in kiln

Ceramic industrial kiln refers to the ceramic production of ceramic body firing equipment, generally refers to the roller kiln, shuttle tunnel kiln and shuttle kiln. Roller kiln

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refers to the kiln with continuous firing and rotating roller as the vehicle of the billet body; Tunnel kiln refers to the kiln which adopts continuous firing and takes rail kiln car as the transport vehicle of billet body. Shuttle kiln refers to the kiln which is fired intermittently and consists of kiln car, kiln chamber and kiln door. Factors influencing energy saving of kiln include: construction materials, kiln structure, combustion technology, thermal insulation performance and automation control.

2.1 Construction materials

The key construction material of kiln is refractory material. The selection of refractory material plays a crucial role in energy saving effect of kiln. ReFRACTORY materials are mainly used for masonry kiln car, kiln furniture and kiln wall, etc., which shall meet but not limited to the following requirements: light weight, high strength characteristics; It has adiabatic, high temperature stability and chemical stability. Ceramic fiber has the above characteristics, light weight, high temperature resistance, small heat capacity, good thermal insulation, good thermal insulation, non-toxic and other characteristics. Replacing the heavy refractory brick with it can not only greatly reduce its weight, heat storage and bulk density, but also reduce the temperature and heat dissipation of the outer wall of the kiln, and improve the energy saving efficiency of the kiln. In addition, through the optimization of the kiln structure, the energy saving efficiency of the kiln can be improved to a certain extent, such as the frame kiln furniture, which is compact, firm and reliable.

2.2 Kiln structure

The energy saving efficiency of kiln is directly related to the capacity of kiln. For roller kilns, the ratio of the product area to the kiln area shall not be less than 85%. In addition, the heat exchange efficiency between flue gas and products is considered, that is, the space height of the kiln and the temperature difference of the cross section in the kiln (that is, when the same products are fired with the same quality, the lower the space height, the more energy saving, and the smaller the temperature

difference of the cross section, the more energy saving). For tunnel kiln, the density of product loading kiln and the temperature difference between the upper and lower tunnel are considered. The density of kiln should be as high as possible under the condition of ensuring the normal flow of flue gas in line with the firing process (temperature, pressure and atmosphere). The temperature difference between the upper and lower parts of the kiln should not be too large in order to reduce the firing load of the billet in the oxidation zone and realize rapid firing, which is conducive to improving the energy saving efficiency.

2.3 Combustion technology

Combustion technology also has a great impact on the energy saving effect of the kiln, which should meet but not limited to the following requirements: air coefficient and firing temperature should be consistent; The combustion modes of enriched oxygen combustion and combustion air temperature with certain temperature should be reasonably adopted in the kiln where products are fired in oxidized atmosphere. The combustion system shall adopt energy saving burner with full combustion and no slagging.

2.4 Thermal insulation performance

Ceramic products in the kiln firing process, to preheat, firing and cooling stage, the firing temperature reaches about 1200°C, insulation performance is directly related to the heat utilization rate, good insulation performance is one of the important ways of energy saving efficiency of the kiln. Other factors affecting the energy saving efficiency of the kiln also include automatic control, auxiliary equipment regulation and output energy saving, etc. For example, the kiln should be equipped with complete automatic control and computer system to realize automatic control of heating, combustion, product transportation and other processes.

According to the industry survey, the statistics of relevant energy consumption data are shown in Table 1, Table 2, Table 3, Table 4 and Table 5.

Table 1 energy consumption index requirements per unit product of ceramic tile (board) kiln

The product type		Energy consumption per unit product* (kgce/m ²)	
		Finished kiln	Newly built, renovated and expanded kilns
Bibulous rate $E \leq 0.5\%$		≤ 4.7	≤ 4.3
$0.5\% < \text{Bibulous rate } E \leq 10\%$		≤ 3.7	≤ 3.3
Bibulous rate $E > 10\%$	Once-Firing	≤ 3.6	≤ 3.2
	Twice-Firing	≤ 4.8	≤ 4.5
*The energy consumption per unit product includes the energy consumption of kiln firing process and kiln drying process			

Table 2 energy consumption index requirements per unit product of sanitary ceramic kiln production

The product type	Energy consumption per unit product (kgce/t)	
	Finished kiln	Newly built, renovated and expanded kilns
Sanitary wares	≤200	≤165

Table 3 energy consumption requirements per unit product for daily ceramic kiln production

The product type			Energy consumption per unit product （kgce/t）	
			Finished kiln	Newly built, renovated and expanded kilns
Ceramics for daily use	Once-Firing	Sintering temperature>1280℃	≤400	≤360
		Sintering temperature≤1280℃	≤300	≤270
	Twice-Firing		≤540	≤486
Ceramics for daily use	Once-Firing		≤330	≤297
	Twice-Firing		≤460	≤414
Bone China, high quartz China			≤100	≤90

Table 4 Requirements for surface temperature rise of kiln body

The product type	The surface temperature of the kiln rises (°C)			
	Finished kiln		Newly built, renovated and expanded kilns	
	Side walls	Kiln top	Side walls	Kiln top
Ceramic tile (board)	≤50	≤70	≤45	≤65
Sanitary wares	≤35	≤55	≤30	≤50
Ceramics for daily use	≤45	≤60	≤40	≤55

Table 5 Exhaust temperature requirements

The product type	Exhaust temperature (°C)	
	Finished kiln	Newly built, renovated and expanded kilns
Ceramic tile (board)	≤300	≤280
Sanitary wares	≤200	≤180
Ceramics for daily use	≤220	≤200

3 Conclusion

At present, there is a lack of standardization research in the field of energy saving of ceramic industrial kilns at home and abroad, and there is a certain gap in the technology level of energy saving of kilns at home and abroad. Due to the lack of constraints and guidance of relevant standards, the production of domestic ceramic industry kilns focuses too much on the development of "customization" and the realization of production capacity, which to some extent leads to the overall high energy consumption of the kilns, the poor energy conservation awareness of the industry and the disorderly development of the industry. In addition, it can be found from the actual situation of various countries that the energy saving technology level of kilns in developed countries such as Italy is higher than that in China, and the energy efficiency utilization rate of kilns is higher than that in China. Therefore, the research on energy saving technology in the ceramic industry kiln industry needs to be strengthened, and relevant energy saving and emission reduction standards need to be formulated as soon as possible, so as to provide effective technical

support for the energy saving and green development of the industry.

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