Brief Discussion on Energy Saving of Building Sanitary Ceramic Kiln

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Abstract: Since the 11th five-year plan, “energy conservation, consumption reduction and green upgrading” has gradually become the theme of China's industrial ecological civilization construction. “High energy consumption, high emission, high pollution” building sanitary ceramics industry as a typical traditional industry, has been regarded as the key object of energy conservation and consumption reduction. Among them, furnace energy consumption accounts for more than 60% of ceramic production, so “furnace energy saving” is regarded as the “top priority” of energy saving. Furnace energy saving is a system of energy saving. Therefore, the factor of energy saved has included that construction materials, furnace structure, combustion technology, waste heat utilization, air surplus coefficient and automatic control. Based on the above influencing factors, this paper carries out research on furnace energy conservation, providing technical guidance for enterprises to save energy and reduce consumption, and helping the industry to transform and upgrade.

1. Introduction
Since the “Eleventh Five-Year Plan”, governments at all levels in China have attached great importance to the work of “energy conservation, consumption reduction, and green upgrade”. They have successively issued a series of related policies and measures to continuously strengthen the construction of energy-saving laws, regulations, rules, and standards systems. Industry, eliminate backward production capacity and optimize energy structure, etc., and continue to promote the work process of “energy saving, green consumption upgrade” in key industries in the industrial field. As one of the key industries in the industrial field, the building and sanitary ceramic industry has achieved unprecedented development in the past decade, and its product output has been the world of first for many years. However, the rapid development of the industry has also spawned many problems, among which the most prominent problem is the “high energy consumption, high emissions and high pollution” of its kilns. As the core equipment for ceramic production, kiln energy consumption accounts for about 60% of the total energy consumption. At present, the thermal efficiency of kilns in China's domestic ceramic industry is only about 28%, while kilns in related developed countries can reach more than 50%. Among them, the thermal efficiency of the kiln refers to the percentage of the heat required for the firing of the green body and the recovery of the waste heat to the heat input to the kiln. Therefore, the research on ceramic industry kiln energy-saving technology is of great significance to the implementation of the government's energy-saving policies, promoting the industry's “energy-saving and consumption-reducing, green upgrade”, and narrowing the gap with developed countries in energy-saving technologies. Therefore, this article selects the building sanitary
ceramic industry kiln as the research object, based on the kiln heat balance system, and focuses on analysing the factors that affect the energy efficiency of the ceramic industry kiln.

2. Energy saving analysis of influencing factors

The ceramic industry kiln refers to the equipment for firing ceramic blanks in ceramic production, generally refers to roller kiln [1], shuttle kiln (also known as drawer kiln) [2] and tunnel kiln [3]. Roller kiln refers to a kiln that uses continuous firing and uses rotating rollers as a means of conveying blanks; tunnel kiln refers to a kiln that uses continuous firing and uses a rail kiln as a means of conveying blanks; Fired, a kiln composed of a kiln car, a kiln chamber and a kiln door.

The factor of saving energy has included construction materials, kiln structure, combustion technology, waste heat utilization [4], excess air coefficient [5] and automatic control. The influencing factors of kiln energy saving are shown in Figure 1.

![Figure 1 Influencing factors of kiln energy saving](image)

2.1. Construction materials

The key construction material of the kiln is refractory, and the selection of refractory materials plays a vital role in the energy saving effect of the kiln. Refractory materials are mainly used to build kiln cars, kiln furniture and kiln walls, etc. It should meet but not limited to the following requirements:

- Light weight and high strength characteristics;
- With heat insulation, high temperature stability and chemical stability.

Ceramic Fiber[6] has the above-mentioned characteristics, such as light weight, high temperature resistance, small heat capacity, good thermal insulation performance, good high temperature thermal insulation performance, and no toxicity. Replacing heavy refractory bricks with them can not only greatly reduce the 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. The Ceramic Fiber is shown in Figure 2.

![Figure 2 Ceramic Fiber](image)
In addition, through the optimization of the kiln structure, the energy saving efficiency of the kiln can also be improved to a certain extent. For example, the frame type kiln furniture is compact, firm and reliable. Frame type kiln furniture is shown in Figure 3.

![Frame type kiln furniture](image)

**Figure 3 Frame type kiln furniture**

2.2. *Kiln structure*

The energy saving efficiency of the kiln is directly related to the kiln capacity.

- For roller kilns, the ratio of product area to the area of the kiln should not be less than 85%. In addition, consider the heat exchange efficiency of flue gas and product, that is, the two indicators of the space height of the kiln and the temperature difference of the cross section in the kiln (The lower the space height, which is the more energy saving. The smaller the temperature difference, which is the more energy-efficient);

- For tunnel kilns, that is, consider the density of the product kiln and the temperature difference between the upper and lower kilns. The kiln density should be as high as possible while ensuring that the flue gas conforms to the normal flow of the firing process (temperature, pressure, atmosphere). The temperature difference between the top and bottom of the kiln mainly considers that the temperature difference between the top and bottom of the smoke exhaust area should not be too large, so as to reduce the firing load of the green body in the oxidation area to achieve rapid firing, which is conducive to improving energy saving efficiency. Wide-body tunnel kiln is shown in Figure 4.

![Wide-body tunnel kiln](image)

**Figure 4 Wide-body tunnel kiln**

2.3. *Combustion technology*

Combustion technology also has a greater impact on the energy-saving effect of the kiln, which should meet but not limited to the following requirements:

- The air coefficient should match the firing temperature;

- For kilns that use an oxidizing atmosphere for product firing, the combustion method of oxygen-enriched combustion and combustion air temperature with a certain temperature should be used reasonably;
The combustion system should use energy-saving burners with sufficient combustion and no slagging.

2.4. Use of excess heat
Waste heat recovery is also one of the important ways to improve the energy saving efficiency of the kiln. The use of heat pipe heat exchange to recover high-temperature flue gas for heating the combustion-supporting air can improve the fuel combustion efficiency, and at the same time improve the internal thermal process of the kiln to help improve the energy-saving efficiency of the kiln. In addition, the recovery of high-temperature flue gas can also be used in the drying process, but the direct use of flue gas for drying does not meet environmental protection requirements. The kiln flue gas heat exchange system is shown in Figure 5.

![Figure 5 Kiln flue gas heat exchange system](image)

2.5. Air surplus coefficient
The excess air coefficient also has a certain influence on the energy saving efficiency of the kiln. The air surplus coefficient is measured in the chimney or in the positive firing zone. It is relatively simple to measure the position of the kiln chimney, but there are many influencing factors such as air distribution and air leakage. Although the measurement in the positive firing pressure area is more accurate, it has not yet formed a unified test standard.

2.6. Other
Factors affecting the energy efficiency of the kiln also include automatic control, auxiliary equipment regulation and output energy saving. For example, the kiln should be equipped with a complete automatic control and computer system to realize automatic control of heating, combustion, product transportation and other processes. Not less than 1.1-1.2 times the actual maximum demand.

3. Conclusion
At present, the global energy landscape is undergoing profound changes, the world's energy governance system is being restructured, and a new round of energy revolution is booming. As one of the world’s largest energy consuming countries, China is difficult to stay out of it. However, the structural problems of energy production capacity in the domestic traditional industry are still prominent, and energy conservation and consumption reduction still have a long way to go. Therefore, we must further advance the energy revolution, focus on promoting the development of high-quality energy, build a clean, low-carbon, safe and efficient modern energy system, and push the construction of ecological civilization to a new level.

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