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Numerical Simulation of an Improved Structure for High-Resistance Grate Plates

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Abstract

In a typical cement plant, the cement clinker production consumes 80% of the total energy used in cement production. The grate plate is the main sector of the grate cooler, and its structure can be modified to receive electric power while cooling the clinker. In this paper, Ansys Fluent was used to simulate the flow field of an existing high-resistance grate plate. The structure of the existing high-resistance grate plate was improved based on the velocity and pressure fields. Results showed an improvement in the performance of the modified high-resistance grate plate—greater velocity and lower pressure drop were observed. When the pressure drop decreased by 51.58%, 2.84% of the total energy consumption could be saved. These results, to some extent, guided the rational design of high-resistance grate plates, and played an indirect role in energy conservation as well.

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Keywords: high-resistance grate plates; numerical simulation; flow field; pressure drop; energy saving

Introduction

Cement industry is one of the most energy intensive industries in the world, and China's cement industry is the world's largest energy consuming industry [1, 2]. In China, cement manufacturing contributes to about 12-15% of the total energy consumption [3, 4]. A large amount of the heat dissipated can be recovered to reduce the energy consumption in cement plants [5]. In a typical cement plant, 25% of the total energy source is electrical energy and 75% is thermal energy [6]. Meanwhile, 22% of the

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electrical energy is required to operate fans to cool the hot clinkers [7]. Grate coolers are important equipment in cement industry that recover heat from the hot clinkers. Cooling air flows through the grate plate of the grate cooler. The quality of the flow field of the grate plate plays an important role in cooling the hot clinker. The high-resistance grate plate is an important part of the grate cooler, and its resistance is higher than that of the common grate plate. There is a layer of cooling clinker in the high-resistance grate plate, which reduces the leakage and protects the high-resistance grate plate from high-temperature corrosion. Fig. 1. shows the cooling process of the grate cooler.

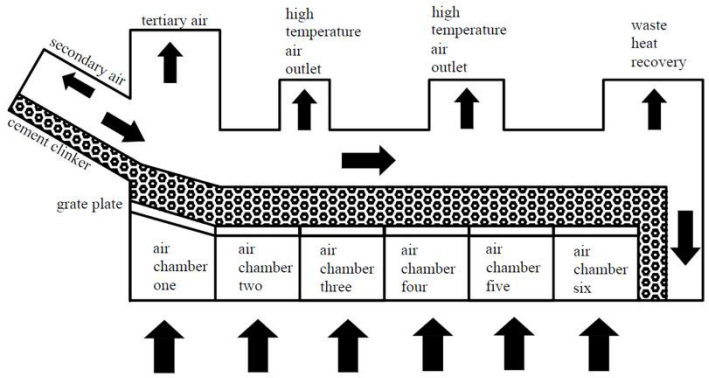

Fig. 1. the cooling process of the grate cooler

In the grate cooler, the energy recovery efficiency influences the energy saving. There is a heat loss of about 35-40% while cooling the clinker [6]. By increasing the heat-loss recovery efficiency during the process of cooling the hot clinker, high-temperature flue gases can be recovered and energy consumption can be reduced. Ahamed et al. [8] optimized the operational parameters of a grate-clinker cooling system. Mujumdar et al. [9] published an integrated model of the clinker cooler in the cement industry. Clinker production accounted for 94.3% of the total energy loss in the whole process [3]. At the same time, the pressure loss when cooling air flowed through the grate cooler was also a reason for energy wastage. On one hand, the velocity at the outlet of the grate plate influences the cooling of the clinker. The greater the velocity in the grate plate, the higher the temperature of the cooling air. On the other hand, the power consumption in the fans is a function of the product of air volume and pressure drop. When the air volume is a constant, a decreased pressure drop indicates reduced power consumption in the fans. Changing the material of the grate plate can only increase the resistance and heat-transfer performance, and cannot improve the flow field of the grate plate. Another direct way to reduce energy loss is to change the structure of the grate plate, because improving the structure of the grate plate is the most effective way to achieve an enhanced economic performance. Through this, a lower pressure drop can be achieved, thus, the electricity consumption in the fans will decrease.

Numerical Simulation

1.1. Model data

Ansys Fluent was used to simulate the flow fields of an existing high-resistance grate plate and an improved one. Because of the symmetry of the high-resistance grate plate, the middle part of the grate plate was used in the numerical simulations. The related information is as follows.