Research on Premixed Stable Combustion Process of Vertical Shaft Furnace for Coke Calcination

Shanhong Zhou[1], Chaodong Liu[2], Chao Liu[3], Ziqi Xia[4] and Michael Ren[5]

1. Senior researcher of R&D Center
2. Vice manager of aluminum reduction department
3. Researcher of R&D Center
4. Assistant researcher of R&D Center

R&D Center, Shenyang Aluminum and Magnesium Engineering & Research Institute Co., Ltd, Shenyang, China

5. Managing director, Sunlightmetal Consulting Co., Limited, Nanchang, China

Corresponding author: samizsh@163.com

Abstract

The traditional process and structure of vertical shaft furnace (VSF) are described, and the problems existing in the traditional process are deeply analyzed. Using CFD method and simulation, we developed an optimized premixed stable combustion process and furnace structure. We then carried out simulation calculations to obtain temperature distribution in the flue. At the same time, the turbulent saturated flame formed by the new process solves many problems of the traditional process. Through the simulation results of premixed stable combustion structure, it is concluded that the combustion flame changes from diffusion suspended flame, into turbulent saturated flame. This solves the problem of uneven heating due to the open-air valve, flame suspension. When adjusting the temperature of the flue, if the air valve opening increases from 10 % to 50 %, the total air combustion only increases by 20 %, even though the proportion of cold air increases nearly by 50 %, this indicates that the preheating air and cooling air temperature combined have a self-regulation effect on the control. Premixed stable combustion technology improves the adaptability of VSF to volatile content of raw materials and reduces the production cost.

Keywords: Vertical shaft furnace, Premixed stable combustion, Process simulation, Self-regulation.

1. Introduction

There are two kinds of technologies of dealing with green delayed petroleum coke used in prebaked anode: rotary kiln and vertical shaft furnace (VSF). But, the VSF is widely used because of quality of CPC, carbon loss and the stability of continuous production. Figure 1 shows the statistical data of CPC's production capacity from 2010, and we can know that the rotary kiln was replaced by VSF. The calcination companies overseas are planning to adapt Chinese VSF technology, and the matching anode plants of the large aluminum companies overseas are purchasing CPC produced by VSF [1-2].

2. Problems of the Traditional Processes

The preheating combustion air or the cooling combustion air is adopted in the traditional process of VSF, and the structure of the furnace is matching for the process. Figures 2 and 3 show respectively the furnace structure corresponding to the process.

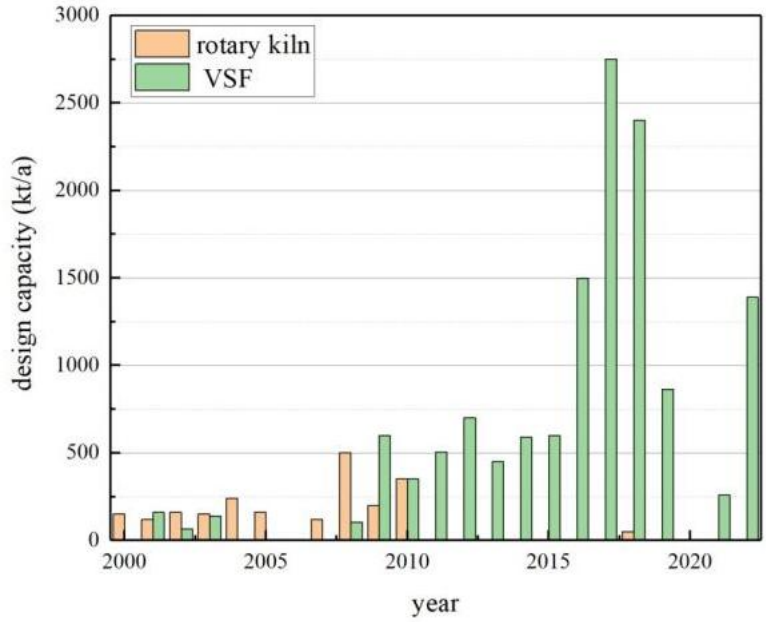

Figure 1. Production statistics comparison between VSF and rotary kiln designed by SAMI.

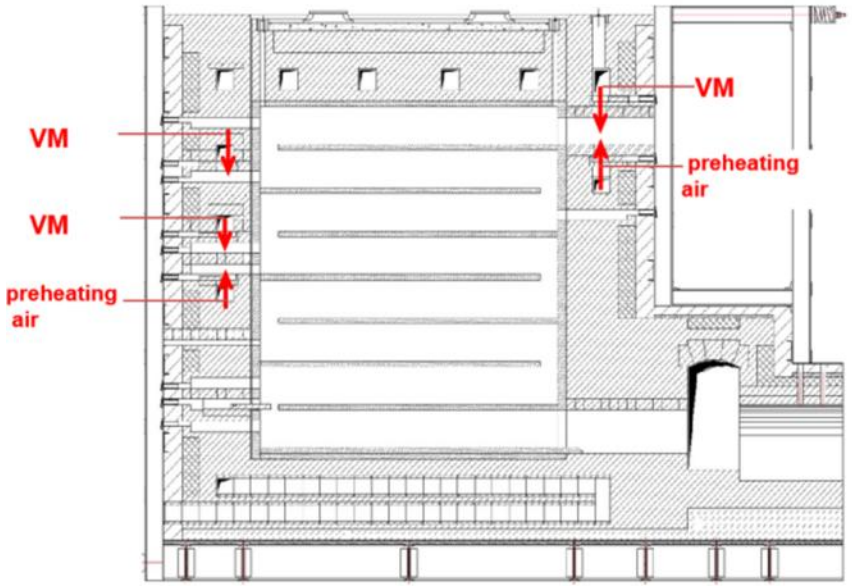

Figure 2. The furnace structure corresponding the preheating combustion air process.

The preheating combustion air process and furnace structure in the early stage as shown in Figure 2. The preheated air and volatile matters enter the flue from different positions, so there is burning flame in multiple layers in the flue. The position entering the flue of the fuel and air was reduced by optimizing. The biggest advantage of this traditional process is intense combustion and full flame, but it is no longer suitable for raw materials with increasing volatile content. There are two main defects:

1) When the volatile content of raw materials increases, the heat income of the VSF will increase. Under the environmental pressure, the volatile matters cannot be discharged, and will generate excessive heat, which finally leads to the phenomenon of "overcalcination" of CPC. The produced anode will produce more carbon dust and reduce the performance of the electrolytic cell.

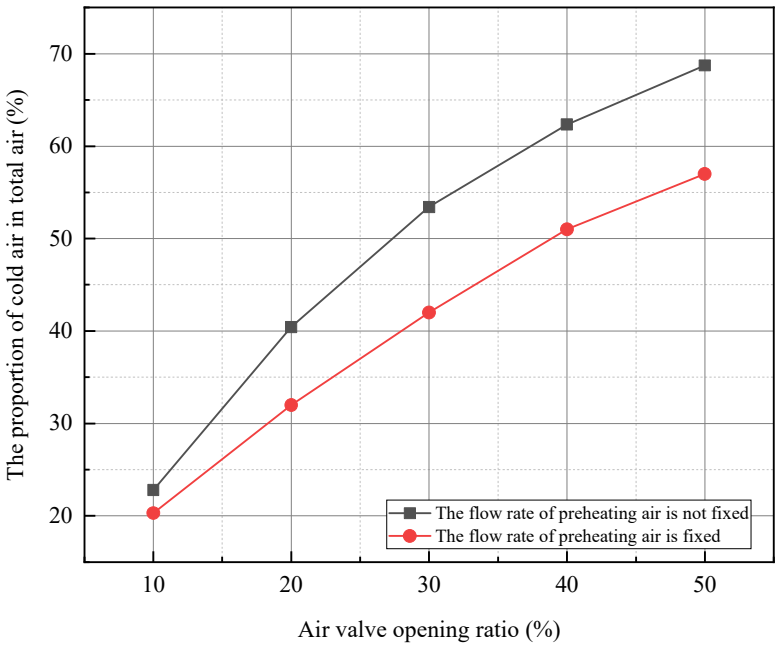

Figure 8. The curve relationship between the opening degree of air valve and the proportion of cooling air.

6. Conclusions

Using CFD as the calculation platform, and using the developed physical and mathematical model, the simulation calculation of combustion in flue of VSF is carried out. Through the combination of design and simulation optimization, the premixed stable combustion process is developed, which solves the following problems:

The premix stable combustion process changes the combustion mode, realizes the new process of preheating air and cooling air combustion, and at the same time changing the combustion flame from suspended diffusion flame, into turbulent saturated flame, solving the problem of uneven heating due to the open air valve, flame suspension.

On adjusting the temperature of the flue by increasing the air valve from 10 % to 50 %, the total combustion air only increased by 20 %, but the proportion of cooling air volume increased by nearly 50 %, indicating that the preheating air and cooling air temperature control effects superpose, showing system self-regulation.

The combustion in the flue and the temperature distribution state are more stable, which improves the adaptability of the VSF to the volatile content of raw materials, broadens the acceptable fluctuation range of volatile content of raw materials, and reduces the production cost.

7. References

1. Sun Yi, Xu Haifei, Wang Yubin, The comparison between vertical shaft furnace and rotary kiln for petroleum coke calcination*, Light Metals*, 2011: 917-92.
2. WANG Pingfu, LUO Yingtao, GONG Zhen, et al. Analysis on calcining technologies for pot calciner in China, *Carbon Techniques*, 2009, 28(5): 31−37.
3. ZHOU Shanhong, SUN Yi, LIU Chaodong. Numerical simulation research of the shaft kiln [J]. *Light Metals*, 2013(12): 33−36 *(in Chinese).*