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Simulation research on molten iron flow in blast furnace hearth based on Fluent

Shi JunHua[1], Xie Yue[2], Zhang XueFeng[2], Tang YaLing[2], Zhu ZhongYang[2]

1 Jiangsu Academy Of Safety Science And Technology, Jiangsu Nan'jing, China;

2 School of Computer Science and Technology, Anhui University of Technology , Anhui Ma'anshan, China

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Abstract: In order to simulate the hot metal flow and erosion behavior within blast furnace hearth, a 3D system simulation platform is established, which would be a great help to analyze all kinds of working condition due to arbitrary setting parameters about hearth structure and material properties. With the flexible parameterized control mechanism, the distribution about velocity field, pressure field, and temperature field can be simulated in this platform. The simulation results, which are mainly revolving round seven work conditions, show that the erosion degree about blast furnace hearth could be flexible and conveniently analyzed.

Keywords: Fluent; simulation; molten iron flow; blast furnace hearth

1. Introduction

Hot metal flow in blast furnace (BF) hearth is one of the most important factors which affect the life-span of BF hearth. Hot metal flow in BF hearth has been deeply studied, but there are still some severe problems. For example, it is impossible to visualize the working conditions in BF hearth. Furthermore, it has become a more urgent problem for researchers to find deeper reasons which decrease the life-span of BF hearth and to analysis the transitive relation between mass, energy, and momentum within BF hearth. Through the previous research, great achievements have been obtained about erosion behavior and hot metal flow, which are based on methods of actual BF anatomy[1,2)] and sample analysis technique[3)]. However, the experiment cost is very high.

In recent years, simulation research about unsteady multi-parameter model, which is often used in BF engineering, could be worked very well with Fluent[4)], one of the most mature CFD software. That is because of the high-speed development of computational fluid dynamics and full-fledged computer with low price, which enable greater calculation accuracy and reliability to the CFD analysis model. So Fluent has been widely used in engineering to solve problems and hot metal flow and erosion behavior in BF hearth. Fluent has Pre-Processor(Gambit), which can create mesh model flexibly, and also has perfect post-processing function, that enable Fluent build nephogram and curve graph about the simulation result of velocity field, pressure field, and temperature field. So, it has been widely used in many researching work. One of the typical representatives is an experimental device and method, which is introduced in paper [5]. This device include cylindrical transparent container, sealing cap, air release hole, sold air enclosure, and water outlet. A simulation system which is established based on the device can simulate hot metal flow in the bottom of BF hearth. In this simulation system, the sealing cap diameter can adopt with cylindrical

transparent container, so the air release hole can be set in the sealing cap tightly. Under the sealing cap, a cold air enclosure is set, which have many evenly arranged air outlet. There are also ingenious designs about this device to achieve realistic simulation about hot metal flow in BF hearth. However, there are also some deficiencies about this system: 1) Dead-man state is not considered as a factor to influence hot mental movement; 2) This device can only simulate hot mental movement at bottom of BF, not the whole BF.

This paper tries to describe how to analysis working condition within BF through numerical simulation system about BF area. Users can obtain hot mental movement situation in BF, only need inputting process parameters and operating conditions. Furthermore, the temperature field distribution detail of side wall and bottom can also be easily obtained by this simulation system, in accordance with which can judge affect factors to BF smelting by process parameters and operating conditions.

Combining BF Technology with computer simulation, the BF simulation system can be taken as a research and development platform to improve process and operation parameters, and give more technical support for optimization of the BF iron making process.

2. A mathematical model of hot metal flow in BF hearth

2.1 Hypothetical condition of mathematical model

It's very complicated to judge the condition of hot metal flow in BF hearth. In order to establish the mathematical model of the hot metal flow in hearth, here give some assumptions and approximations.

(1) Only hot metal flow is considered in the mathematical model, and the iron mouth is considered as the internal unvocal area.

(2) Assume that the tapping process is steady, which means, the molten iron level remains constant through the whole tapping process.

(3) Ignore the effects of chemical reactions and heat transfer on the flow area.

(4) Assume that hot metal flows at a uniform velocity throughout the whole inlet interface.

(5) Dead-man state assumption. According to Guo[4)] and others study on the shape and position of dead-man, from simple to complex, this paper assumes that dead-man has seven states. As shown in **Fig. 1** (a)-(c) belongs to sitting states; (d)-(g) belongs to floating states.

2.2 Control equations for the mathematical model of hot metal flow

The distribution of molten iron flow field in the hearth is solved by the mass conservation equation and the momentum conservation equation. The Knozeny-Carman equation is used to describe the resistance that the dead material column as porous media on the flow of molten iron. The descent speed of molten iron surface in hearth can be calculated by the speed of molten iron on iron exit. Then the continuity equation, momentum equation and ergun equation can be obtained with cross section of hearth as the entrance.