Test and Analysis of Metallurgical Converter Equipment

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Abstract: Oxygen top-blow converter is the main equipment in steel making, and its work reliability decides the security and economy of steel production. Therefore, how to design and test analysis of convertor has been an important subject of industry research. Geometric modelling and structure analysis of converter tilting device by using Pro/E program .The design Principle, basic design structure were analyzed in detail. The computer simulation software of metallurgical converter equipment and how to use it were introduced .It developed by VC++ software. The position of barycentre and moment curve in No.3 and No.4 are calculated. The converter acceleration down dip can be resolved by comparing the moment curve and center curve. *Copyright © 2013 IFSA.*

Keywords: Converter, Three-dimension model, Test, Analysis, Simulation.

1. Introduction

In recent years, the steel industry is developing rapidly, and pneumatic steelmaking is an important component in the steel industry. Therefore, the quality and output of the steel is directly related to the steel industry. To ensure the quality and yield of the steel, first of all ensure the safe operation of the converter equipment, especially the tilting part of the converter, it is not only the focus of the design converter, but also the difficulty. There are four converters in some iron and steel enterprise and the 4 # converter is a 60-ton converter, during the converter tapping or sampling, a lot of problems occur to 4 # converter in the actual production process, such as the accelerating the down – dip of the converter. According to statistics, this situation occurs 1-2 times per year. Once the molten steel poured out, which brings not only the economic losses but also the accidents of life. Many lessons have been learned at home and abroad from the accidents of converter "pouring steel" [1]. Now, the 12.5 planning is carrying out that is to adjust the

production structure of excess industry and improve the resource utilization. All these measures are carrier out to make sure the safety of the production.

The slag influent the converter deeply when the converter is tapping and sampling. The slag not only erodes the mouth of the converter, but also accumulates greatly. The slag is a long distance from the trunnion centerline of the converter which has a great influence to the dumping moment. Therefore, the slag is an important consideration when we design the converter.

The content of this paper is the 4 # converter and the goal is to reduce the hidden trouble during the production through the analysis and calculations, finally, the feasibility of the measures are given to make sure the safety of the converter [2].

2. Three-Dimensional Model of the Converter

The converter model is divided into six main parts: the furnace mouth, slag panels, cold water pipe,

and steel plate of the mouth, the furnace body, bottom and internal firebrick. There are many problems about the 4 # converter. This article introduces the 3 #converter as a comparison in order that these problems are analyzed in more detail. 3 # converter is an 80-ton converter, which is similar to the 4 # converter on mechanical structure. Two converters are base on frequency control and the lowest frequency is 50Hz; the difference between the two converters is the bottle of the converter. One is round bottle such as Fig. 1 the other is tip such as Fig. 2.

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Fig. 1. The structure of the 4# converter.

Fig. 2. The structure of the 3# converter.

3. Converter Simulation Software

3.1. Description

In this paper, the design of the software is base on VC ++ [3], the main function is to imitate the converter operation; describe dynamic center curve of the converter and dumping moment curve and torque curve. The software can quickly and accurately get the center position of converter no matter what state it is, the converter tilting Moment curve is gotten much more easily. Observe dumping moment curve of the converter to find out the reason for pouring steel.

3.2. Basic Design Ideas

The two functions of this software include the static center of mass and dynamic center of mass. The slicing method and integral method is applied to calculate the center position curve of converter dynamically. First determine the intersection position between the steel surface and the furnace wall, and then calculate the center position of the steel, finally the results are obtained by the cumulative.
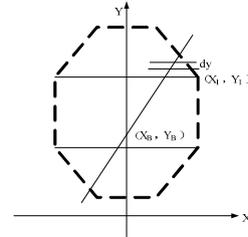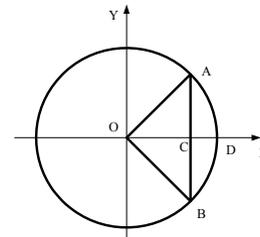

Fig. 3. The brief structure of the converter.

Fig. 4. The converter sections.

First, calculate the weight and center of mass coordinates of the small unit dy. α' is equal to the $\angle COB$, the fan-shaped area of the OAB is S1, the triangle area of the OAB is S2, ρ is the density of steel and ε is the control accuracy, vertical coordinate of the small unit dy is y.

The surface area of the molten steel is S3= (S1-S2), the center coordinates of fan of OAB in the direction of x is $L1 = 2OA \cdot \sin\alpha'/(3\alpha')$, the center coordinates of the triangle OAB in the direction of x is $L2 = 2OC/3$ .so the center of the area of ADBC in the direction of x is $L = (S1 \cdot L1 - S2 \cdot L2)/(S1 - S2)$ .so the weigh of dy is $Z_i = (S1 - S2) \cdot \varepsilon \cdot \rho$, the moments of the x-axis of the center of the small unit dy is $M_{xi} = L \cdot Z_i$. The moments of the y-axis of the center of the small unit dy is $M_{yi} = y \cdot Z_i$ [4].

According to (1) and (2), the center of mass coordinates formula:

$$x = \frac{M_{x1} + M_{x2} + M_{x3} + \cdots + M_{xi}}{Z_1 + Z_2 + Z_3 + \cdots + Z_i} \quad i = 1,2,3\cdots , \quad (1)$$

$$y = \frac{M_{y1} + M_{y2} + M_{y3} + \cdots + M_{yi}}{Z_1 + Z_2 + Z_3 + \cdots + Z_i} \quad i = 1,2,3\cdots \quad (2)$$

3.3. Friendly Interface of the Software

It is very easy to run the software, before running the software, please enter the specific parameters of the converter in parameters dialog box as Fig. 5. According to the data stored in TXT files, the curves of the steel center and molten steel dumping moment [5], then the curves are displayed in the view of the software. You can see the picture of molten steel and converter rotation when software is running, which is shown in Fig. 5.
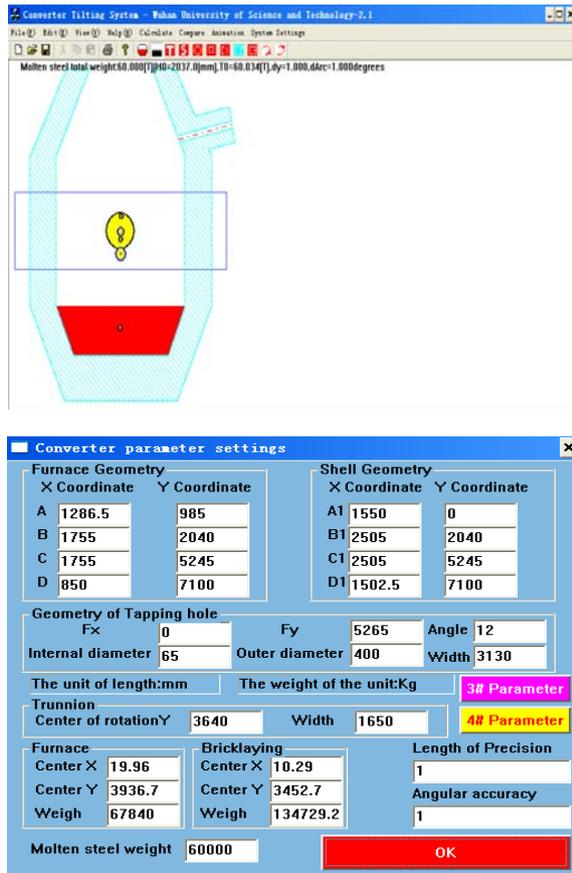

Fig. 5. Software Interface.

4. Calculation and Analysis of Center

Calculation of the software mainly refers to the center of mass of the converter and the center of mass is part of the calculation of dumping moment. Dumping Moment refers to the force acting on the ear axis when the converter is in the oblique. It is the main reference parameters of the converter on designing and calculations. The converter tilting moment is mainly composed of three parts, including empty furnace torque, hydraulic torque and friction torque. Among them, the empty furnace moment is caused by the weight of the converter as well as subsidiary parts, its curve of the rotation can be got by formula; Hydraulic torque is mainly caused by the weight of the molten steel, and its moment is difficult

to calculate, and the center position change complexly, because it is the change with the rotation of the converter; The friction torque converter tilting ear axis caused by the friction force on the ear axis when the converter tilts, direction and converter tilting is in the opposite direction, the size remained unchanged.

Friction torque and air furnace torque calculation is very simple, do not repeat them here, the characteristics of the software is the calculation of the hydraulic torque converter which overcomes the previous shortcomings calculation is not fast and inaccurate. The software of the theory is base on the integral method and slicing method.

From the above description, the converter tilting moment is composed of three parts.

$$M = M_K + M_Y + M_M , \qquad (3)$$

where M_K is the empty furnace torque, M_Y is the hydraulic torque and M_M is the friction torque.

4.1. Static Center Calculation of Converter

The definition of the static center is to calculate the center of main components of the converter. The article describes the method is base on the software which is designed for the converter. First, input the main parameters of the converter to the software, you can get the center curve of the converter that can be in any location. Table 1 shows the calculation results of the 3 # and 4 # converter [6].

Unit of data in Table 1 is mm; the distance is relative to trunnion centerline height of the furnace, in the other words, that means the relative value.

It can be seen from Table 1, the 3 # converter of the center is under the trunnion centerline after masonry the firebrick, 4 # converter of the center is also under the trunnion centerline. But with the slag in the furnace mouth, 4 # converter of the center is above the trunnion centerline. In other words, the converter of the motor torque is zero, it can not automatically reset at the effect of its own gravity and friction. From the above analysis, the slag is the main reason for dumping of the converter [7].

Table 1. The comparison of several cases of two converters.

Converter	4#Converter	3#Converter
With firebrick	-25.2	-248.2
Mouth with steel slag	51.3	-174.5
Weight of 2 tons	15.2	
Loaded 60T steel water	-436.7	-508
Centerline height of the trunnion	3640	3590

4.2. Dynamic Center Calculation

The calculation of the dynamic center of mass means that the change of the molten steel center when the converter is added molten steel. The operation method remains the same. The calculation of the dynamic center of mass is done at the same time, but instructed by two steps in this paper [8]. The center curve and torque curve of the 4# 60 t converter are shown as Fig. 6.
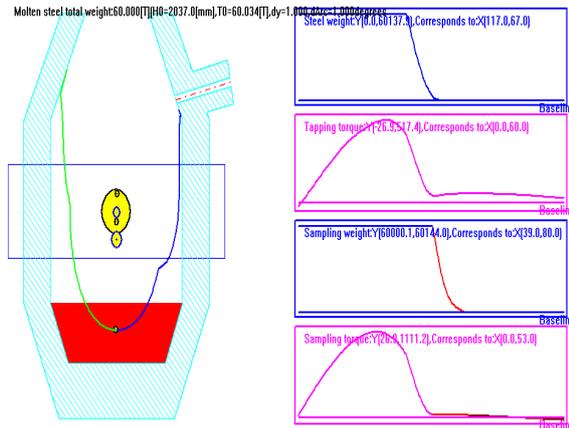

Fig. 6. The Center Curve and Torque Curve.

5. Dumping Moment Curve and Analysis

In the software, the dumping moment curves of 4# converter and 3# converter are got by setting the parameters that are shown as Fig. 7 and Fig. 8.
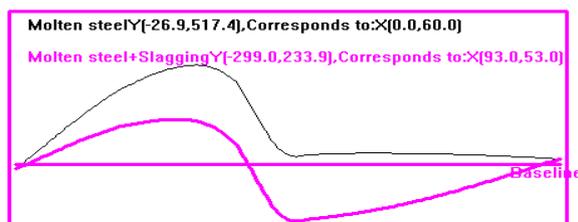
Fig. 7. The dumping moment curves of 4# converter.
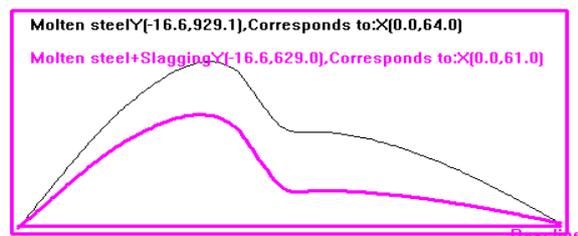

Fig. 8. The dumping moment curves of 3# converter.

Shown as Fig. 7, the thin solid line means the empty converter and the molten steel dumping moment curve, while the thick solid line means the empty converter, the molten steel and the slagging dumping moment curve [9]. The dumping moment curves of 3# converter are shown as Fig. 8.

From Fig. 7, it is got that the dumping moment of converter is positive and the dumping phenomenon is not occurred, when the slagging is not exited. But the dumping moment of converter is positive, if the slagging is exited.

From Fig. 8, Slagging tendency moment is larger than without the slagging tendency moment. However, the dumping moment is positive, so the 3# converter is safer than the 4# converter.

In short, lagging is the main reason which causes the converter to accelerate the down-dip, while the problem can be solved through increasing the weigh on the converter.

6. Conclusion

The software is designed to quickly get the converter dynamic center curve, which can be able to solve the problem of the converter dumping quickly.

The use of software is to observe the dumping torque curves dynamically, contrast and analyze the curves, the conclusion can be drawn that the main reason of 4 # converter "pouring steel" is converter center that is at above of the trunnion centerline, and as time goes on, the slag is accumulated in the converter mouth, all of these would cause the converter dumping quickly.

Therefore, Slag is the main reason for causing the converter dumping quickly, the measures can be taken in the converter bottom to increase the weight so that the total center of the converter is reduced below the trunnion centerline.

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