Conference Paper

Mathematical Modeling of Determining the Composition of the Charge in the Cross Section of the Blast Furnace

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Abstract

When working on a multi-component charge, BLT cannot ensure the uniformity of the charge composition in the horizontal section of the blast furnace. In this case, there is a need to develop mathematical models and expiration portions forming material from the hopper to the subsequent creation of BLT software. With reference to the operating conditions of the blast furnaces of JSC 'EVRAZ NTMK', mathematical models were developed for the formation of materials in the silo hopper by the consecutive unloading of two skips; in the order of emptying the hopper; on the distribution of charge on top throat of the blast furnace. On the basis of combining the developed mathematical models, computer software was created to form portions of charge components, both in the BLT hopper and on the top throat. Created software product for calculating the formation of portions and the expiration of materials from the receiving hopper of the BLT allows you to quickly select the necessary load and optimize the process as a whole.

Keywords: blast furnace, burden, charging, bell-less top (BLT), sinter, pellets

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1. Introduction

The high-efficiency and economical operation of a blast furnace is largely determined by the way the movement and distribution of gases and charge in its working space is organized. One of the main factors affecting the nature of the movement of gases in the furnace is the distribution of the charge on the top throat during the loading [1, 2].

To load the charge, bell-less top devices (BLT) of the tray type are becoming more widespread. Such devices are convenient in operation and allow to create an optimum profile of the backfill on the top throat due to the available possibility of unloading the batch portion at a given point or the area of the top throat [3]. At the same time, the efficiency of using BLT on blast furnaces depends on the quality of mathematical

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models and the software of the loading process. Most of the mathematical models created, such as [1, 4, 5], determine the height of layers of ore and fuel parts along the diameter of the top throat (Figure 1). On the basis of this, the required local ratio of the ore portion of the charge to the coke is controlled.

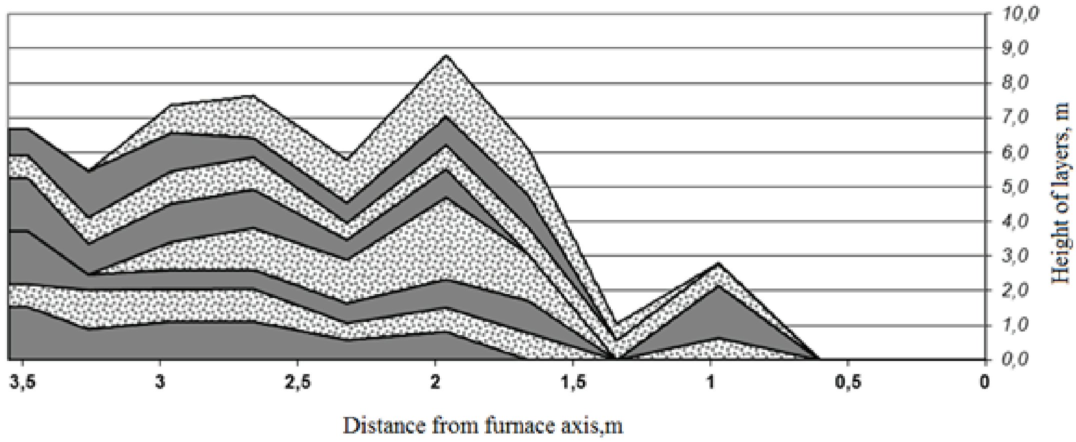

Figure 1: Distribution of ore and coke along the radius of the furnace.

A significant disadvantage of BLT is that when operating on a multicomponent charge, such devices do not ensure the uniformity of the composition of the charge on the top throat in both the circumferential and radial directions [3, 6]. Elimination of this deficiency is achieved only by preliminary mixing of the components of the ore portion of the charge in prescribed proportions, that is, transition to the use of a uniform charge. But preliminary mixing at a qualitative level is possible only on special equipment before the charge is supplied to the hopper of blast furnaces. A certain capacity for premixing is also provided by a conveyor system for supplying materials to the top throat.

In many blast furnaces, it is not possible to separately pre-mix the ore portion of the charge, and the loading complex includes two skip feeds to the BLT. For example, blast furnaces of JSC ‘EVRAZ NTMK’ [7] differ in such features of the burden charging complex. In these cases, it is appropriate and relevant to develop mathematical models for the formation of portions and the expiration of materials from the BLT silo with the subsequent creation of software for each specific device.

It should be noted that the direct operation of the distribution chute practically does not affect the required combination of dissimilar materials (in particular, to ensure or increase the homogeneity of the mixture) over the cross-sectional section in either the radial or the circumferential direction. Influence can be expressed only in the change in the amount of discharged burden on individual rings. The main influence on the arrangement of individual components of the ore part of the charge along the top section is provided by the formation of materials in the BLT silo [3], which is determined by the known mechanism of material flow from the bunkers (Figure 2).

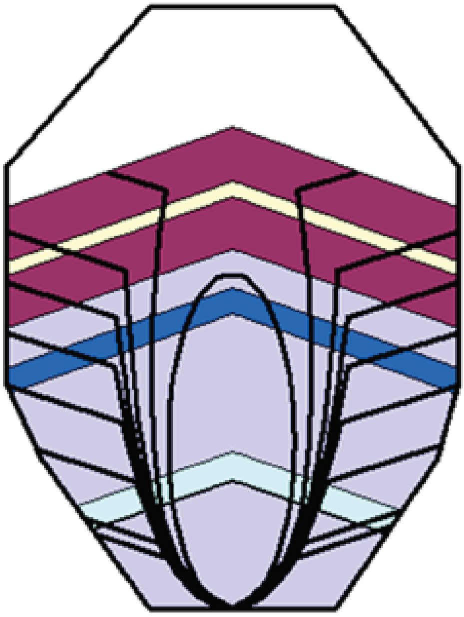

Figure 2: The order of unloading the BLT hopper.

With reference to the operating conditions of the blast furnaces of JSC 'EVRAZ NTMK', mathematical models were developed for the formation of materials in the silo hopper by the consecutive unloading of two skips; in the order of emptying the hopper; on the distribution of charge on the top of the blast furnace. Reduction in the complexity of the algorithms was achieved by introducing numerical values of the geometric dimensions of the BLT hopper and the top throat, as well as the volume of skips. On the basis of combining the developed mathematical models, computer software was created to form portions of charge components, both in the BLT hopper and on the top.

Program requires the introduction of initial data, such as: the order of load of materials for each of the two skips; weight distribution of these loads in two skips; predetermined division of the iron ore part of the feed along the rings of the top throat.

At the beginning of the calculation, the user is asked to select the type of material from the drop-down list for each portion in the two skips and determine the sequence of their filling. After that, the specified mass of each material (from the charge calculation) is entered and the total volume of the skip filling is automatically controlled. The last action, the user must specify the percentage distribution of materials over the top-ring. It is allowed to edit the type of materials, their volume-bulk mass and the angle of a natural slope of the selected material in a special table.

After the introduction of all the data, the user presses the 'Solution' key, which starts the algorithm for calculating the distribution of materials along the rings and outputs histograms from these data.

You can create a diagram of filling the hopper by pressing the 'Draw' button. The diagram is not typical and is built by special means. When constructing, the proportions of the thickness of the layers are calculated to the bunker itself, as a result of which, the diagram clearly shows the distribution of materials in the hopper volume.

Linking the mechanism of the outflow of material from the hopper with a specified division of the ore part of the charge along the rings of the top throat (with equal areas), the program determines the material composition of each ring (Figure 3).

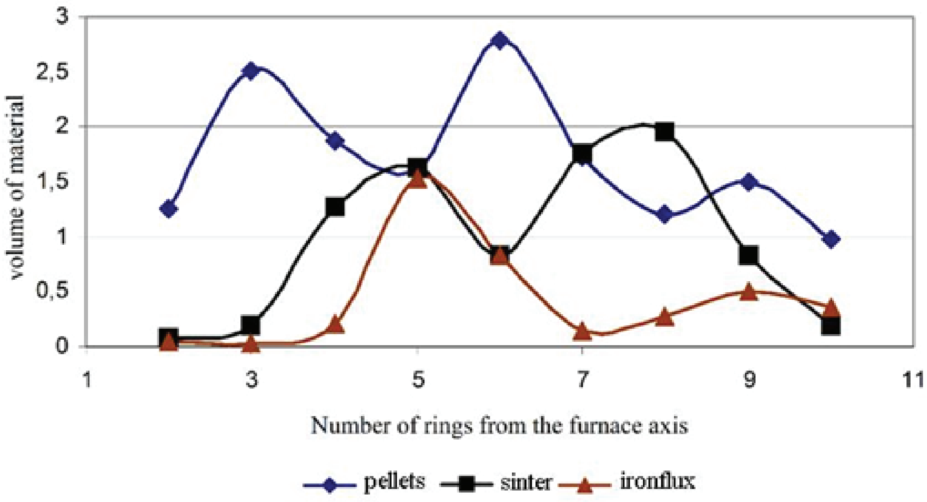

Figure 3: Distribution of charge components on top throat.

With known analyzes of charge components, the calculation of the chemical composition of a particular ring and even any point of the top is already a simple task (Figure 4).

Created software product for calculating the formation of portions and the expiration of materials from the receiving hopper of the BLT allows you to quickly select the necessary load and optimize the process as a whole. In particular, with the help of this program it was possible to improve the stability of the composition of the smelting products. The loading of the peripheral zone has also been optimized.

The flow of processes in the peripheral zone of the blast furnace has a predominant effect on the melting process as a whole, since the area of this zone is incommensurably larger than the central part and there are more favorable conditions for gas flow [8]. To ensure the effective operation of the peripheral zone and reduce the aggressive impact on the lining of the furnace, it is necessary to strive to minimize the ingress

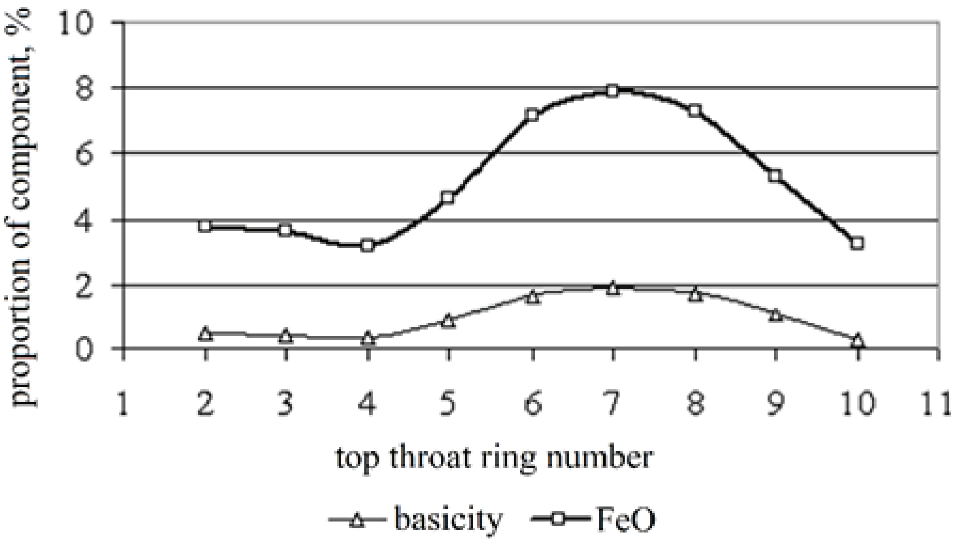

Figure 4: Chemical composition of charge on top throat.

of oxidized iron ore pellets to the walls. The solution of this problem becomes more complicated with a high proportion of pellets in the charge. Nevertheless, optimization of individual loading parameters still allowed to reduce the location of pellets at the walls of the top throat.

2. Summary

The developed mathematical models and software for determining the composition of the charge on the cross section of the blast furnace top throat allows the efficient selection of a rational load by using several components. The practice of using such software has shown the possibility of stabilizing the composition of fusion products and optimizing the loading of the peripheral zone.

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