Selection of Optimal Ingredients for Out-of-furnace Smelting Based on Computer Application

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Abstract. The optimization system software of the blast furnace batching studied in this paper is a complete set of blast furnace batching problem solutions. Its theory is based on the classic material balance and heat balance equations of blast furnace smelting. Blast furnace batching calculations used by most domestic steel companies are mainly based on forward calculation plus verification adjustment. Optimization of blast furnace batching based on linear programming the system can effectively improve calculation efficiency, and provide clear and unique optimization for blast furnace operators in all experience levels matching scheme.

Keywords: Blast Furnace, Batching Calculation, Optimization, Linear Programming

1. Introduction

The blast furnace is a melting furnace for extracting pig iron from iron-containing ore [1]. The furnace is generally in the shape of an upright cylinder, and the upper and lower ends are slightly smaller. The inner wall is fired with refractory materials [2]. A large number of water cooling devices are distributed around the furnace body to protect the furnace shell from melting at high temperatures [3]. In the production of blast furnaces, iron-containing raw materials (or main raw materials) mainly include sintered ore, pellets, natural iron content Ore, coke and solvents[4]. Especially, sintered ore is most suitable for blast furnace sintering by sintering of powder ore. Pellets are made from ore powder through ball forming process the auxiliary materials mainly include limestone, laurel, and honey stone. They can adjust the fluidity of the furnace are transported from the raw material yard to the hopper, which are respectively stored in the ore tank and the coke tank [5]. When the blast furnace needs to be charged, open the alarm door under the hopper and the raw materials will automatically flow out. After the hoof powder is weighed, it is unloaded into the feeding car or the loading belt and transported to the top of the blast furnace [6]. From the top of the blast furnace, the raw materials are continuously and evenly layered into the interior of the blast furnace through a distribution chute
controlled by a tilting motor and a rotating motor. There are several hot blast stoves outside the blast furnace, which are responsible for heating the air to degrees Celsius, and spraying the hot blast main pipe, surrounding pipe, and tuyere devices into the blast furnace from the tuyere in the lower part of the blast furnace. This is also the origin of the English name of blast furnace. Fuels such as heavy oil, pulverized coal, and oxygen-enriched, moisture-containing combustion promoters are injected into the hot air at the same time as being injected through the air outlet. The high-temperature hot air and the injected fuel, and the coke descending from the furnace top burn in the tuyere circulation area, emit heat, generate high-temperature reducing gas, and rise through the gap of the furnace charge to the furnace top.

During the ascent process, the furnace charge is heated while the furnace charge undergoes a series of physical and chemical reactions to cause it to melt and adhere near the $^\circ\text{C}$ isotherm to form a soft flame zone. After further heating, the liquid pig iron is melted through a loose coke layer and a dead material column that hardly participates in any reaction drips into the vicinity of the blast furnace. The tapholes at the bottom of the furnace outlet at the bottom of the furnace are discharged separately. The gas is led out from the top of the furnace. After dust removal, it is used as industrial gas.

The calculation of blast furnace batching is also called local furnace loading calculation, which refers to the calculation of the coke, ore, solvent consumption and ratio of smelting unit pig iron during the blast furnace ironmaking process under the given raw fuel conditions and smelting parameters. Many parameters and complicated calculation conditions. The blast furnace operator determines the weight of each batch of raw materials (referred to as batch weight) based on the blast furnace volume and other factors on the premise of knowing the raw materials, the chemical composition analysis information of the fuel, and the physical property analysis information data. The ratio of coke to the main raw material is determined by the conditions and smelting strength. The yield coefficient of each chemical component in the molten iron and the furnace is set according to experience. The range of furnace acidity and alkalinity according to the theory of furnace thermal control is based on the raw material properties and the yard. The inventory situation determines the approximate proportion of various raw materials in each batch, and finally the calculation results are obtained to meet all the above-mentioned constraints. The result of blast furnace batching calculation is an important basis for blast furnace production operation.

2. Establishment of mathematical model for optimized ingredients.

According to the principle of linear optimization, the dosing result calculated by the algebraic method is a "feasible" dosing plan that meets the dosing technical requirements of the metal thermal smelting of ferroalloys. And this "feasible" dosing plan seeks the optimal solution Establish the ultimate goal of the mathematical model of the optimal batching calculation. The linear optimal batching mathematical model is composed of an objective function and constraints.

Take the i-th ferroalloy raw material dosage as the decision variable, $X_i$ (independent variable, $I = 1, 2, n$), the number of raw materials used in the production of ferroalloy by any kind of metal heating method is a positive integer. The amount of each raw material can not be less than zero, that is, the decision variable satisfies the nonnegative condition: $X_i$ ($I = 1, 2, n$) n-dimensional abstract space common composed of $N$ non negative decision variables, each of which corresponds to a set of definite $x \cdot I (1,2, n)$ value. The practical significance is a feasible proportioning scheme as table 1.
Table 1. Assignment of elements

| Element | Alloy / % | Into the slag / % | Volatilize / % | For restore / % |
|---------|-----------|-------------------|----------------|----------------|
| Mo      | 99        | 0.5              | 0.5            |                |
| Fe      | 40 (30)   | 58 (70)          | 2              |                |
| S       | 80        |                  | 20             |                |
| P       | 40        |                  | 60             |                |
| Si      | 2         |                  |                | 98             |
| Al      | 1 (50)    | 150              | 99             |                |
| Cu      | 100       |                  |                |                |
| Other   |           |                  |                |                |

3. Analysis of algorithms

In business management, we often encounter the problem of how to effectively use existing manpower and material resources to complete more tasks, or how to use the minimum manpower and material resources to achieve the goals under the predetermined task objectives. Such problems are expressed in mathematical language. First, appropriate variables are selected according to the goal of the problem. The function form of the variable (called the objective function) expresses the goal of the problem. The constraints on the problem are expressed by the equation or inequality of the variable. Expressions (called constraints). When the variables take continuous values and the objective function and constraints are both linear, this type of problem is called a linear programming problem.

The research on modeling, solving and application of linear programming problems constitutes the branch of linear programming in operations research. Linear programming modeling is relatively simple and has general algorithms. It is the most widely used branch in operations research. Typical problems solved by linear programming include transportation problems, production-planning problems, cutting problems, and mixing ingredients problems. The blast furnace batching problem can be regarded as a more complex mixed batching problem. As long as the traditional blast furnace batching problem can be modeled according to linear programming, the calculation equations can be converted into linear equations about decision variables, and an optimization direction can be determined, the linear programming method can be used to solve the blast furnace batching problem.

The simplex method is a general method for solving linear programming problems. Its theoretical basis is that the feasible region of a linear programming problem is a polyhedral convex set in a dimensional vector space, and its optimal value must be reached at a certain vertex of the convex set if it exists. The feasible solution corresponding to the vertex is called the basic feasible solution. The basic idea of the simplex method is: first find a basic feasible solution, identify it to see if it is the optimal solution; if not, then switch to another improved basic feasible solution according to a certain rule, and then identify; If not, then convert again and repeat the process. Because the number of basic feasible solutions is limited, the optimal solution to the problem must be obtained after a limited number of transformations. If the problem does not have an optimal solution, you can also use this method to determine. The calculation process is shown in table 2.
Table 2. Saving attribute information for each calculation

| Serial number | Field description         | Field number   | Data type     | Length | NOT NULL | PK | FK |
|---------------|---------------------------|----------------|---------------|--------|----------|----|----|
| 1             | project number            | ITEMID         | Number        | 4      | Y        | Y  | Y  |
| 2             | keyword                   | KEYNAME        | Varchar2      | 64     |           |    |    |
| 3             | Note                      | REMARK         | Varchar2      | 64     |           |    |    |
| 4             | Screen display logo       | DISPLAYFLAG    | Number        |        |          |    |    |

4. Conclusions
First of all, in terms of quantity, the majority of blast furnaces are small and medium-sized. It is important to optimize the algorithm for blast furnaces with small furnace capacity and incomplete detection conditions. It will make the calculation results more consistent with actual data. Means are also the primary goal of the next research. Second, according to the operating habits of different blast furnaces, the currently considered objective functions and constraints may not include all possibilities. Therefore, the development of analyzable objective functions and constraint rules, and configuration using a visual human interface, can be customized and maintained by the on-site operators of each blast furnace to meet all potential process requirements. Third, the use of commercial software can achieve much more complicated extreme value analysis under non-linear constraint conditions and complete constraints such as the lowest cost per ton of iron.

Upgrade is considered in the next version. Finally, it can be better combined with the process control system. Using this software as a module of the process control system can make the theoretical calculation result correspond to the actual slag composition analysis, and consider the deviation value of the two as a constraint condition. It can increase the calculation accuracy of this software and increase the competitiveness of the process control system.

References
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