Prediction of Sinter Quality Based on Population Genetic Algorithms and Fuzzy Reasoning

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Abstract: In view of the characteristics of non-linearity, strong coupling and large time delay in sintering process, the sintering process was analyzed from the point of view of process parameter control, and the evaluation index of sinter performance and its main influencing parameters were determined. On this basis, a sinter quality prediction method based on population genetic algorithm and fuzzy reasoning was proposed. Firstly, the pheromone-based ant colony algorithm is used to generate an optimal solution as the initial population of genetic algorithm, which is conducive to improving the convergence performance. Then, by making full use of random numbers and increasing the number of cycles, the roulette-based selection algorithm in traditional genetic algorithm is improved, so as to ensure the diversity of the next generation population and improve the chance of the best chromosome being selected. The method is applied to the prediction of sinter quality. The experimental results show that this method can predict the iron content of ore by quantifying the sinter quality, which has a positive effect on the beneficiation and output prediction of related enterprises.

1. Introduction

After entering the 21st century, China's iron and steel industry has been unprecedented development, and steel is the most important structural and engineering materials in modern construction projects, its quality directly related to the quality and safety of the structure of the project. Sinter is one of the main raw materials for blast furnace ironmaking. Its quality directly affects the quality of iron and steel. The composition and structure of minerals in sinter vary with sintering raw materials and sintering properties, and the composition and structure of sinter are the main factors affecting its quality. Therefore, it is of great practical significance to study the influence of sinter composition and structure on its quality. Aiming at the shortcomings of traditional genetic algorithm, such as easily falling into local optimal solution and slow convergence, in the process of function optimization.

2. Population Genetic Algorithm

Genetic algorithm has many advantages, such as only the information of objective function, not limited by the continuity or differentiability of search space, and it is suitable for solving complex problems in non-linear and multi-dimensional space. However, the basic genetic algorithm has great limitations, and it is not convergent in any case, that is, it can not find the global optimal solution. When establishing the initial population, the population genetic algorithm establishes several initial populations. Each population carries out the running program of genetic algorithm such as crossover and mutation independently, and carries out gene transformation among populations after fixed generational evolution, thus realizing the optimal search of the problem in different ways. Population genetic algorithm uses multi-population to purchase goods at the same time, and constantly exchanges excellent individuals among populations to solve the extremum problem of basic genetic algorithm. The basic steps of population genetic algorithm are as follows:

1) Determine the encoding and decoding method, determine the decision variables and constraints

2) Constructing chromosomes, generating initial population and setting basic parameters of

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genetic algorithm;

3) Calculate the support and credibility of all rules;

4) To determine individual evaluation methods;

5) Basic genetic algorithm operations, such as selection operator, crossover algorithm, mutation operator, etc.

6) High-level operators of genetic algorithm such as population crossover and re-insertion;

7) Judging the condition of stopping evolution, if it does not meet the condition of stopping evolution, return to step 5. If the condition of stopping evolution is met, the optimal chromosome is selected and decoded, and the operation of the algorithm is terminated.

3. Establishment of Fuzzy Reasoning Based on Population Genetic Algorithms

In this paper, genetic algorithm is used to train the weights and thresholds of fuzzy reasoning. Through a lot of analysis and comparison, population genetic algorithm is used instead of traditional basic genetic algorithm to solve the premature and pole problems of the model. The weights and thresholds of fuzzy reasoning obtained by population genetic algorithm are obtained. Firstly, the data is predicted and processed, and its average value is calculated to weaken the randomness of the data. Then the corresponding fuzzy reasoning model is established. Each successive six data is a training mode, the first five data are input, and the last data is output. Population genetic algorithm is used to train the fuzzy reasoning to solve the training extremum problem in classical fuzzy reasoning. At the same time, in order to solve the problem of swaying around the optimal solution when the genetic algorithm is approaching the optimal solution, when the training result of the population genetic algorithm achieves a certain precision, the standard fuzzy reasoning model is trained again to get a high-precision prediction model by taking the training result of the population genetic algorithm as the initial value. The specific steps are as follows:

1) Pre-process the selected 180-day network security situation data, normalize it, and calculate the average value of the data in the next five days, and get 36 continuous data.

2) Processing the first 24 data, 6 data in succession are a set of training modes, the first 5 data are input sample values, and the sixth data are output sample values. A total of 19 training modes are obtained.

3) Establish the corresponding fuzzy reasoning model, that is, there are five input neurons and one output neurons. Using empirical formulas, the number of middle layer neurons is determined to be three.

4) The population genetic algorithm is used to train the fuzzy reasoning model, and the insertion rate, generation gap, mobility and iteration times of the population genetic algorithm are determined. The total chromosome number of the population genetic algorithm is 1000 and the population number is 10.

5) Determine the objective function of genetic algorithm. Each chromosome corresponds to a fuzzy inference, and the objective function is the average value of the prediction error of the fuzzy inference model corresponding to all chromosomes.

6) According to step 3, 22 weights and thresholds are needed for each fuzzy reasoning. The initial population of genetic algorithm is established by using floating-point coding method. There are 1000 individuals in the initial population, 22 floating-point coding for each chromosome, corresponding to 22 weights and thresholds respectively. The model of fuzzy reasoning is optimized by using population genetic algorithm.

7) The weights and thresholds of the fuzzy reasoning obtained from the optimization model of population genetic algorithm are the initial weights and thresholds of the fuzzy reasoning, and the classical fuzzy reasoning model is trained to obtain the final prediction model.

8) Take the 20th to 24th data of the 36 data processed as input, and get the output. Then the last four data in the previous input are used as the first four data of this input, and the last output data is used as the fifth data of the input. The output is obtained continuously until the 36th prediction data is obtained.

9) The accuracy of the model is analyzed by comparing 12 data of simulation and prediction with their corresponding actual values.

4. Sinter Quality Index

Softening properties include the following two aspects: (1) softening properties. Sinter is not pure material, there is no fixed melting point, its melting range is an interval. There is no uniform standard for softening range in China, which is usually 0.5 *105-1.0 *105 Pa. (2) Droplet performance. After sinter softening, burden is heated and reduced in blast furnace, and ore is melted gradually. At this time, the permeability of the soft melt layer is very poor, and there is a large pressure drop. Pressure drop is the main index for evaluating the properties of ore droplets. There is no uniform standard for the performance index and determination method of ore droplets in our country. Usually, the temperature is raised to 1500 C for determination. Low temperature reduction pulverization rate is one of the important indexes for evaluating sinter quality. The increase or decrease of the index value will affect the blowing out amount of dust from the top of blast furnace and the permeability of charge column, which will lead to the increase of coke ratio and the decrease of output. In order to effectively solve the problem of low temperature reduction and pulverization, three measures should be taken as follows: (1) adding appropriate calcium chloride additives in sinter mixture or applying calcium chloride solution on sinter surface; (2) increasing the content of FeO in sinter; (3) reducing the content of Na2O, K2O and titanium dioxide in sinter. Reduction performance is one of the important indicators reflecting high temperature metallurgical properties. It refers to the difficulty of removing oxygen combined with iron from iron ore by reducing gas. The more reducible sinter is, the easier it is to remove oxygen from iron. Usually, Fe3O4 is difficult to be reduced, Fe2O3 is easy to be reduced, and limonite is the best in natural iron ore, followed by hematite. Cold mechanical strength refers to the strength of the burden before it enters the stage of smelting in the process of transportation and inversion. The higher the cold mechanical strength is. The better the technical and economic indicators of furnace charge are.

5. Influencing Factors of Sinter Quality Index

Under the conditions of moisture, fuel consumption, basicity and iron mixing, the influence of sinter composition and structure on sinter quality index under different conditions was studied by sintering cup experiment, orthogonal test range analysis, optical microscope and_-ray diffraction. The moisture content in sinter mixture has a vital influence on sinter quality. If the surface moisture of sintered mixture is sufficient, the air friction resistance can be effectively reduced. At the same time, the surface tension of water can ensure that the sintered mixture has sufficient strength. Moisture content has a certain influence on the return rate and vertical sintering speed. Increasing the moisture content of sintering mixture can improve the permeability and average vertical sintering speed of the mixture. When the moisture content is 7.2%, the average return rate is the lowest, which is 25%. In addition, the moisture content also has some influence on the yield and firing rate. When the moisture content is 7.2%, the yield of sinter is as high as 78%, and the firing rate does not change significantly, and with the increase of moisture content, the yield and sintering rate are gradually reduced. Sinter depends on the high temperature produced by fuel combustion to carry out solid and liquid phase reactions, and form agglomerates. In order to ensure the quality and output of sinter, the fuel consumption should be reasonably selected, not only to ensure that the sinter has good air permeability, but also to ensure full combustion of fuel. The main effects of burnup on the return rate and vertical sintering speed are as follows: increasing fuel content, sintering temperature increases, the permeability of mixtures decreases, vertical sintering speed decreases, the content of unburned bulk mixtures decreases, and the return rate of sinter decreases; the main effects of burnup on the firing rate and yield are as follows: fuel consumption on average firing rate and average yield The effect is relatively small. With the decrease of fuel consumption, the firing rate increases and the yield decreases. Alkalinity is one of the main factors affecting sinter quality. The higher the basicity of sinter, the better its metallurgical and physical properties.

Alkalinity plays an important role in improving the composition and structure of blast furnace sinter. The effect of basicity on sinter yield and return rate is as follows: when basicity is about 2.0 and there is segregation between flux and iron ore, sinter yield decreases and return rate increases; when basicity is between 1.8 and 2.2, adding appropriate limestone into the mixture, limestone decomposes at high temperature, which reduces the moving speed of combustion zone and improves the utilization of fuel. Rate, and when water is combined with limestone, mud is formed. The sludge has a high viscosity, which can accelerate the moving speed of combustion zone and ensure the smooth sintering process. The effect of basicity on sinter strength is as follows: properly increasing sinter basicity can improve sinter strength. The quality of iron ore in China is low. Domestic iron and steel factories usually purchase high quality iron ore sintering from abroad. This can change the structure of sintering raw materials, optimize the proportion of iron ore resources, and effectively improve the quality of sinter. The effect of iron mixing on the return rate and vertical sintering speed: when the iron mixing level is below 4, the return rate is relatively low; when the iron mixing level is 5, the vertical sintering speed is relatively high; when the iron mixing level is between 1 and 4, the return rate is relatively low. Influences of iron mixing on firing rate and finished product rate: With the improvement of iron mixing level, firing rate decreases gradually. When the mixing level is between 1 and 4, the sintering rate decreases slowly; when the mixing level is between 4 and 6, the sintering rate decreases significantly. With the improvement of iron mixing level, the finished product first rises and then decreases.

6. Conclusions

In view of the characteristics of long process flow, many influencing factors and complex mechanism in iron ore sintering process, a method of sinter quality prediction based on population genetic algorithm and fuzzy inference is proposed, which can provide accurate sinter quality information for production. According to the principle of grey theory model, the reference sequence and comparison sequence are determined, and the reasonableness of reference sequence and comparison sequence is evaluated by grey relational analysis method, so as to guide the actual production operation. The results show that the model can accurately predict the quality information of sinter under the condition of poor information and small samples. The advantage of the model is that it can calculate the sinter quality information with simple EXCEL program under the condition of less sample data, and predict the results with higher accuracy and better satisfaction. Compared with the traditional prediction model, population genetic algorithm and fuzzy reasoning are worthy of vigorous application and promotion in sinter quality prediction.

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