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System dynamics model of output of ball mill

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Abstract

At present, the economic benefits of double inlet and double outlet ball mills, which are commonly used in coal-fired power plants, need to be improved. Based on this, this paper explores the factors influencing the output of double inlet and double outlet ball mill by establishing the output system of double inlet and double outlet ball mill. By analyzing the influence factors of the output of double inlet and double outlet ball mill, and combining with system dynamics, the dynamic model of double inlet and double outlet ball mill output system is established, and SPSS is used to fit the model data with the real data. The fitting degree is above 0.8, and the authenticity is high. The simulation results show that the impact energy of barrel grinding, the grinding powder fineness, and the pressure ratio in the ball mill affect the output of double inlet and double outlet ball mill according to certain relations. Finally, the research in this paper provides theoretical and technical support for improving the economic benefits of double inlet and double outlet ball mills.

Keywords: Ball Mill Output; Double in and double out; system dynamics; spss

1 Introduction

At present, the main power generation mode in China is thermal power generation. The grinding and pulverizing device of thermal power generation is mainly a double-in and double-out ball grinder, and the output

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of double-in and double-out ball grinder is an important indicator to measure the performance of double-in and double-out ball grinder. Due to the disadvantages of large time delay, time-varying characteristics, multi-variable and strong coupling, high power consumption, and serious noise and dust pollution, the double-in and double-out ball mill in China has reduced the economy of the unit, thus unable to meet the requirements of the contemporary era [1]. Therefore, it is of great theoretical significance and practical value to study the factors affecting the output of the double-in and double-out ball grinder for improving the economic performance of the unit.

1.1 Research on the output of double inlet and double outlet ball mill

In 2016, Gao Xuewei and Fu Zhongguang proposed a modeling method of double inlet and double outlet ball mill based on big data analysis [2]. By extracting the required information from the actual data, the K-means clustering algorithm and principal component analysis method were used to analyze the data, and a distributed support vector was adopted to establish the model. T.Tanno et al. applied a reflective terahertz spectrum respectively in coal moisture measurement [3]. WenJun Wan et al. studied the dynamic balance of the coal level of the coal mill by analyzing the pulverizing mechanism of the coal mill, and established the mathematical model of the filling level of the coal mill by using the mathematical equation [4]. Wan Wenjun, Liu Hao, Huang Weijian, and Chen Shihe established the dynamic characteristic mathematical model of process parameters by analyzing the process parameters such as material level, outlet temperature, and coal quantity of double inlet and outlet coal mills [5].

1.2 Main problems existing in current research

(1) The output of double inlet and double outlet ball mill is an important index to evaluate the performance of double inlet and double outlet ball mill. However, the existing research on the output of double inlet and double outlet ball mill mainly obtains the main performance parameters through the analysis of experimental results and establishes the mathematical expression based on this, which often has certain limitations.

(2) Although many countries, including China, have recognized that many factors are affecting the output of double-in and double-out ball mills. But what are the key factors to improve the output of the double-in and double-out ball mill and what dynamic relationship do they show during the output process of the double-in and double-out ball mill? What are their roles? The exact answer is not yet given. However, the solution to these problems is of great practical significance to improve the output of double-in and double-out ball grinder.

Therefore, this paper firstly establishes the conceptual frame about the output of double-in and double-out ball grinder, researches the influencing factors of double-in and double-out ball grinder employing system dynamics, and provides strong theoretical support for improving the output of double-in and double-out ball grinder.

2 Analysis Method and Model Construction

2.1 Analysis method

In this paper, by using the research method of system dynamics, the complex network of various factors that affect the output of double inlet and double outlet ball mill is established by establishing multiple causal feedback loops, and the influence factors affecting the output of double inlet and double outlet ball mill are found out by constructing system dynamics flow diagram, to improve the economic benefits of double inlet and double outlet ball mill.

2.2 Model Construction

2.2.1 Conceptual Framework for Output of Double-in and Double-out Ball Mills

One of the important links in establishing a system dynamic model is to draw the cause and effect diagram of the output of double-in and double-out ball grinder. In this paper, the components of the output system of double-in and double-out ball grinder are divided into four modules: impact energy of grinding in barrel, grinding fineness after grinding, pressure ratio and output of grinding in barrel: impact energy module of grinding in barrel includes lifting height of steel ball in raw coal cylinder, barrel diameter, quality of steel ball, a rotational speed of the cylinder, filling rate and breakage degree of steel ball; grinding fineness after grinding the module includes raw coal quality, water content and coal residence time in the drum; pressure ratio module in ball mill includes ventilation and air leakage; output module includes the output of double-in and double-out ball mill.

2.2.2 Basic assumptions and determination of general causal relationships

Based on the conceptual model, the interaction of the influencing factors is analyzed, and two groups of basic assumptions (Fig. 1) between the output of double inlet and double outlet ball mills are put forward. The first group is about the interaction between the modules, that is, the interaction between the impact energy of the barrel grinding, the grinding powder fineness, the pressure ratio in the ball mill, and the ball mill output. The second group is the hypothesis of interaction among the influencing factors, that is, the impact energy of grinding in barrel, the fineness of grinding powder after grinding, and the pressure ratio in the ball mill.

Based on the above assumptions, a general cause and effect diagram of the output system of double-in and double-out ball mill is established [6–10], As shown in Figure 2

Fig. 1 Two sets of basic assumptions between the output of a double-in and double-out ball grinder

2.2.3 Establishment of Flow Chart

System dynamics modeling needs to clarify the purpose of modeling, different purposes even if the same system, the model may be different. The purpose of this paper is to study the factors affecting the output of double inlet and double outlet ball mill.

Fig. 2 General Cause and Effect Diagram of Output System of Double-in and Double-out Ball Mill

Based on the general causality diagram of the double inlet and double outlet ball mill output system shown in Figure 2, the data are statistically analyzed, and the factors that have little influence on the output of double inlet and double outlet ball mill are removed from the general causality diagram, and the system dynamic flow diagram of double inlet and double outlet ball mill output is established (Fig. 3).

2.3 Model Test

Fit test: Fit test between the actual value and simulated value by calculating the correlation coefficient with spss [11] software. After checking, the fitting degree of actual value and simulation value of coal reserves, ventilation volume, and material level differences are above 0.8, which is better.

3 Model Application

In this paper, by adding functions [6], [9] to the system, the influence of some factors on the output of double inlet and double outlet ball mill is analyzed by changing some variables in the model.

Taking 168 hours as an example, the variation of ball grinder output as shown in Fig. 4 is obtained by adjusting the factors in three modules: impact energy of grinding in the drum, grinding fineness after grinding, and pressure ratio in ball grinder.

The changes of grinding fineness, impact energy of grinding in the drum, and pressure ratio in ball grinder are as follows:

Fig. 7 Pressure ratio in coal mill 1

It can be seen from Figure 4 that the output of the ball grinder first increases and then decreases, and the maximum value appears in about 80 hours. The fineness of the pulverized coal ground in Figure 5 increases with time, the impact energy in the barrel in Figure 6 increases with time, and the pressure ratio in the pulverizer in Figure 7 decrease with time. In conclusion, before the maximum output of the ball grinder is reached, the fineness of coal ground and the impact energy of grinding in the barrel are the main factors affecting the output of the ball grinder. When the output of the ball grinder reaches the maximum value, the pressure ratio in the coal grinder replaces the fineness of coal ground, and the impact energy of grinding in barrel becomes the main factor affecting the output of the ball grinder.

4 Conclusion

In this paper, a process-oriented conceptual framework of the output of double-in and double-out ball mill is constructed, and a system dynamic model is constructed. By adding a function to the system dynamic model, the following conclusions are obtained:

(1) The impact energy of grinding in the barrel, grinding fineness after grinding and pressure ratio in the ball grinder are the main factors affecting the output of the ball grinder. When the output of the ball grinder does not reach the maximum, the impact energy of grinding in the barrel and the grinding fineness after grinding have a greater influence on the output of the ball grinder. When the output of the ball grinder reaches the maximum, the pressure ratio in the ball grinder has a greater influence than the impact energy of grinding in the barrel and the grinding fineness after grinding.

(2) If the output of the ball mill does not reach the expected value, the pressure ratio in the ball mill and the change of the ball mill output are used to judge whether the maximum output of the ball mill is exceeded. If there is a positive correlation between the pressure in the ball mill and the output of the ball mill, it exceeds the maximum output of the ball mill. It is necessary to increase the output of the ball mill by increasing the pressure ratio in the ball mill, such as changing the opening of the inlet baffle of the discharge mill. If there is a negative correlation between the pressure in the ball mill and the output of the ball mill, the maximum output of the ball mill is not exceeded. The output level of the ball mill can be improved by increasing the impact energy of grinding in the barrel and the fineness of the grinding powder. If we want to improve the impact energy of grinding in the cylinder, we can improve the filling rate of the steel ball and reduce the friction between the steel ball and cylinder; if we want to improve the fineness of grinding powder, we can use raw coal with better quality and more suitable moisture.

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