Research on Productivity Detection Method of Gyratory Crusher based on Kinematic Characteristic Analysis

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Abstract: Crusher is an indispensable large-scale machinery in coal industry, construction industry and so on. In order to effectively improve the production efficiency of gyratory crusher and break the original detection method, this paper puts forward the research on productivity detection method of gyratory crusher based on kinematic characteristic analysis. The material critical time of the gyratory crusher is calculated by setting the structural parameters of the crushing chamber of the gyratory crusher. Taking the TBF0312 gyratory crusher as an example, the material critical time of the gyratory crusher is analyzed, and the productivity test of the gyratory crusher is made to determine the detection method of the productivity of the gyratory crusher.

Keywords: Gyratory crusher; Productivity; Kinematic characteristic; Detection method

1. Introduction

For some industrial sectors such as coal, mining, building materials, construction and so on, in order to effectively improve work efficiency and to dissociate and crush the material components, it is necessary to crush and process the original ore [1]. Nowadays, with the advancement of society and the development of science and technology, there are many latest crushing methods, such as electric power, thermal energy, magnetic force and sound wave. But for economic considerations, some enterprises still adopt the mechanical crushing method, which leads to the need to effectively improve the productivity of crushers. Therefore, we need to study the productivity detection method of crusher.

2 Design of Productivity Detection Method of Gyratory Crusher based on Kinematic Characteristic Analysis

2.1 Set the structural parameters of the crushing chamber of the gyratory crusher

Taking the TBF0312 gyratory crusher as an example, the moving cone lining busbar of this type of gyratory crusher is composed of many straight lines connected with each other, but the slope of each straight line is basically the same and the difference is very small. In order to facilitate the detection and research, the suspension point of the gyratory crusher is taken as the origin and the vertical direction is taken as the y-axis direction to establish a rectangular coordinate system, and the fitting point of the linear regression equation is established. The fitting point takes the endpoint of each line segment on the busbar of the conical liner plate, and the linear equation is obtained as follows:

$$y = 5.324x + 2097 \quad (1)$$

The slope of the equation is K=5.324. The movement distance of the TBF0312 gyratory crusher cone at the outlet and inlet are s_1 = 9 mm and s_2 =42 mm, respectively. From this, the critical swing speed of the material can be calculated as n_2 =135 r/min when pure sliding occurs in the crushing chamber. However, the recommended swing speed of the TBF0312 gyratory crusher is n=121 r/min. Therefore, the movement form of the material in the crushing chamber of the TBF0312 gyratory crusher is pure sliding movement. The pure sliding movement reduces the friction between the material inlet and outlet, and this parameter setting makes it easier to detect the productivity of the gyratory crusher [2].

2.2. Calculate the critical time of the gyratory crusher material

Under the kinematic characteristic, the movement form of the material in the crushing chamber of the gyratory crusher depends not only on the rotational speed of the moving cone, but also on the form and process of the moving cone at the inlet and outlet. There are three kinds of movements of the material in the crushing chamber: the free-falling movement in the natural state, the free sliding along the moving cone and the material group, and the existence of the two forms of movement.
The research in this paper shows that under the normal working conditions, if the movement form of the

material changes, the minimum and maximum rotating speeds are set to n_1 and n_2, respectively. If the swing speed of the moving cone is less than the minimum speed, the material will slide purely in the crushing chamber; if the swing speed of the moving cone is greater than the maximum speed, the material will occur free-falling movement in the crushing chamber; if the rotating speed of the moving cone is between the two limit speeds, the closer the material is to the inlet, the easier the sliding movement will occur; the closer the material is to the outlet, the easier the free-falling movement movement will occur. The functional relationship expression is as follows:

$$\frac{1}{2}gt_1^2 = \frac{1}{2}g\left(\frac{30}{n_1}\right)^2 = \frac{S_1}{\cos\ q_B} \quad (2)$$

$$\frac{1}{2}gt_2^2 = \frac{1}{2}g\left(\frac{30}{n_2}\right)^2 = \frac{S_2}{\cos\ q_B} \quad (3)$$

In the equation, the expression of material movement in the crushing chamber is deduced from the expression of free-falling movement. In the expression, s_1 represents the movement path of moving cone at the inlet. s_2 represents the movement path of moving cone at the outlet. t_1 represents the time of material free-falling in the crushing chamber. t_2 represents the time of material sliding in the crushing chamber. And q_B represents the critical time of material.

The critical time of the material of gyratory crusher is obtained by the above function expression, and the productivity of the gyratory crusher can be obtained by combining the outlet width and the energy conversion process.

2.3 Determine the width of the outlet

According to the experimental results, as shown in Table 1, the width of the outlet is usually expressed by the letter n. The empirical formula is generally used to calculate the productivity of the gyratory crusher, that is, n=175-50B (r/min). In the expression, B represents the width of the inlet of the crusher (see the reference width in Table 1). The width of the outlet of crusher has a great influence on productivity. Generally, the larger the width of the outlet of gyratory crusher, the higher the productivity will be. Therefore, in the actual production design, in order to effectively detect the productivity of the gyratory crusher, the width of the outlet of the gyratory crusher is usually adjusted to be larger than that under normal conditions.

Table 1. The productivity of the unit outlet width of the gyratory crusher

Specification	500/75	700/130	900/160	1200/180	1500/180
Productivity	2.5	3.0	4.5	6.0	10.5

The experimental results show that the width of the unit outlet of the gyratory crusher has a certain influence on the productivity. The larger the outlet width of the gyratory crusher, the higher the productivity, the smaller the outlet width of the gyratory crusher, the lower the productivity. Therefore, increasing the width of the outlet can effectively improve productivity.

2.4. Determine energy conversion

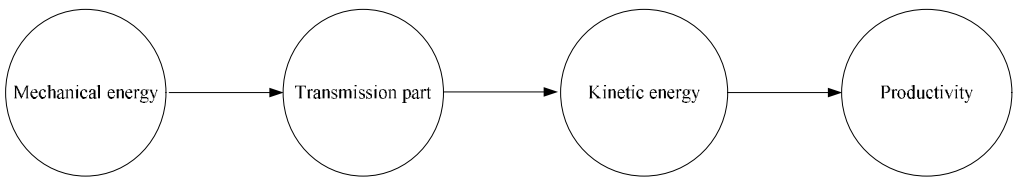

Figure 1. Energy transfer diagram of the gyratory crusher

In industrial machinery [3], the crusher is the most common and it is easy to understand. The structure of a crusher includes frame, spindle, liner, transmission part and eccentric sleeve, adjusting device and safety device. The simple crusher structure is composed of moving cone, fixed cone, eccentric sleeve shaft, bevel gear pair and triangular belt pulley.

The energy consumption of the gyratory crusher directly reflects the productivity. The higher the energy consumption, the lower the productivity of the gyratory crusher; the lower the energy consumption, the higher the productivity of the gyratory crusher. The use of gyratory crusher is to combine all parts of machinery, the productivity is studied from the perspective of

conversion of mechanical energy to kinetic energy, so as to achieve stable production.

According to the energy transfer diagram of the gyratory crusher, as shown in Figure 1, the energy transfer efficiency of the crusher is very high. When the material enters the crushing chamber and passes through the transmission part, the mechanical energy of the crusher is transformed into the kinetic energy of the material. Therefore, the energy conversion can effectively detect the productivity of the gyratory crusher.

2.5. Implement multi-factor detection

After the productivity is determined, in order to verify the credibility of the detection experiment of the gyratory crusher productivity, multi-factor detection is required [4].

First of all, we need to sort out the production workshop. Separate items that are frequently used from items that are not frequently used. Dispose and throw away the unwanted items directly, and distinguish among the items to be used, the items not needed temporarily and the items not used for a long time. When the production space is insufficient, we should immediately tidy up the chaotic areas, and do not consider increasing the workshop space.

Secondly, we need to reorganize the workshop. The production workshop should be divided into groups. Each group need to be arranged a team leader, and the whole production workshop need to be arranged a workshop director. In this way, we can investigate the responsibility for problems of different natures and ensure the orderliness of production.

Finally, the training of the workshop staff is also very important. We should make employees develop good work habits and working atmosphere, cultivate them team spirit and professionalism, make them have certain organizational discipline, strictly abide by rules and regulations, and create a united and friendly workplace to increase productivity.

The experimental method for measuring the productivity of the gyratory crusher can make reasonable production plan and control it properly according to market demand [5]. In today's fierce market competition, we must formulate a set of orderly methods for detecting productivity to reduce production costs, speed up the internal circulation of enterprises, and ensure that products produced according to production plan can be delivered on time. If a production workshop does not have a sound production plan, then the products produced will have a series of problems that break the productivity test process of the crusher. Therefore, the development of a perfect production plan has become an important part of the development and survival of enterprises [6]. Multi-factor detection effectively validated the detection method in this paper.

In the workshop production process, we should timely control. If the production speed of one department is faster than that of other departments, then we should control the production speed of this department and make it consistent with that of other departments. This can not only effectively improve productivity, but also facilitate the unified detection of productivity.

Some production workshops have traditional management systems, perfect detection processes and balanced productions, so shortening the manufacturing cycle. The detection method in this paper can can quickly and easily detect the productivity in production.

2.6. Results verification

The production and operation process can effectively verify the detection method of the productivity detection experiment of the gyratory crusher. Through the production operation flow chart, the critical time can be accurately calculated and the productivity can be detected. The production operation process needs to be constantly updated and improved. There is no one-step operation process, but we need to find a more economical and convenient way. The change of social environment leads to the continuous change of the market. Therefore, we should constantly improve the operation process and methods in the process of production and operation.

The production operation process can more clearly see the operation of each link and the critical time of each process, because the operation process involves every department and every level. If it can strengthen the product operation in production, it can not only save time, but also effectively improve productivity [7].

To improve the operation process, it is necessary to make a corresponding flow chart. The flow chart can clearly show which tasks are included in a production process, and the order relationship between each task. Therefore, after the improvement of operation process, the first thing is to make a new flow chart, which allows the various departments of a enterprise to exactly and clearly see how the enterprise operates, and what are the operating procedures. The flow chart can clearly see the content of each process. When problems arise, they can can be corrected immediately. And the flow chart is the basis of production.

The experimental results of the productivity detection of the gyratory crusher show that the experimental detection method of the productivity detection of the gyratory crusher in this paper can effectively detect the productivity of the gyratory crusher.

3. Experiments

After the detection method is determined, the effectiveness experiments are required. When the external environment is consistent, different outlet

widths are set to determine the critical time of the gyratory crusher, so as to detect the productivity. The shorter the critical time, the higher the productivity of the gyratory crusher. The higher the critical time, the lower the productivity of the gyratory crusher. The detection method in this paper is compared with the traditional method. The analysis results are shown in the figure below.

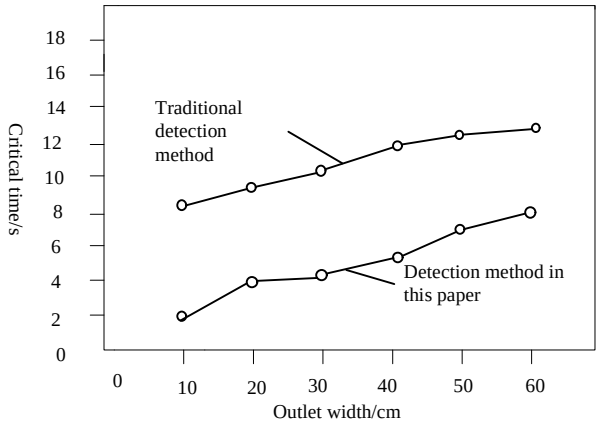

Figure 2. The relationship between critical time and outlet width

The conclusion of Figure 2 shows that the critical time detected by the method in this paper is significantly lower than that detected by traditional method. Therefore, the productivity detection experiment of gyratory crusher can verify that the method in this paper provides an effective basis for productivity detection.

4. Conclusion

In summary, the productivity detection experiment studies the productivity detection method, and determines the structural parameters of the crushing cavity and the energy consumption of the gyratory crusher from the perspective of the gyratory crusher itself. Through the experimental detection, the critical time of the material under different widths of the outlet is determined to determine the detection method of productivity. In this paper, the research on the productivity detection method of the gyratory crusher based on kinematic characteristic analysis provides an effective and reliable method and theoretical basis for the productivity detection, so as to determine the detection method of the gyratory crusher.

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