Matching Research on Filling Rate and Rotation Rate of Ball Mill

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Abstract

When the grinding medium (steel ball) of the ball mill is in the venting state, the inner steel ball close to the center of the cylinder is in the peristaltic core, and the grinding effect is small. When the movement state of the steel ball is changed from the discharge type to the drop type, the inner layer gradually appears hollow, and the void expands as the filling rate and the rotation rate increase, and when the matching of the filling rate and the rotation rate is optimal, The ball mill has the best grinding efficiency.

Keywords

Ball mill, filling rate, transfer rate, matching.

1. Introduction

Ball mill is widely used in non-ferrous metals, building materials, mining, electric power and other industries. In recent years, with the development of the equipment manufacturing industry, the specifications and installed power of the ball mill have gradually expanded, and the problem that comes with it is how to make these giant devices play their role. It is the key to ensure the grinding efficiency. According to the working theory of the ball mill, the best match between the filling rate and the transfer rate is the theoretical basis for ensuring the grinding efficiency.

2. Relationship between Grinding Efficiency and Filling Rate

The ball mill's production capacity is directly proportional to the grinding power

consumption, and the grinding power consumption increases with the filling rate. Therefore, the filling rate is within a certain range($\emptyset = 0.5$) The ball mill's production capacity is proportional to the filling rate. It can be seen from Fig. 1 that at the time, when $\emptyset = 0.45$,the maximum power consumption of the grinding was greater than the $\emptyset = 0.35$ and $\emptyset = 0.40$ maximum power consumption of the time.

When the transfer rate is different, the relationship between grinding efficiency

and filling rate is shown in Fig. 2. When the transfer rate is different, the optimal filling rate is also different. If $\varphi = 65\%\sim75\%$,Optimal fill rate can be selected in 0.40~0.45.

During the operation of the ball mill, the grinding media (steel balls) must wear out. After a certain period of operation, the filling rate of the steel ball will decrease. In order to ensure the best filling rate. The steel ball must be added regularly, and the amount of the ball can be calculated as follows.

$$\Delta G = \frac{\emptyset - \emptyset_0}{\emptyset} G \quad (1)$$

In the middle: $\emptyset$——Theoretical fill rate;

G——Theoretical ball loading;

$\emptyset_0$——Actual filling rate, Its value can be calculated by the following methods.

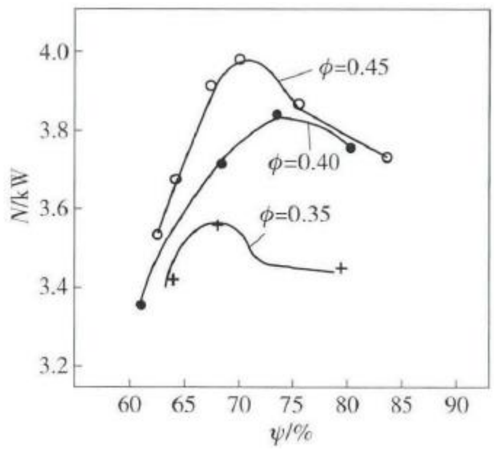

Fig.1 The relationship between power and transfer rate

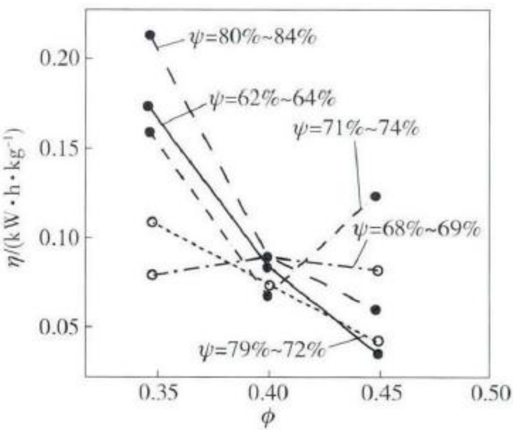

Fig.2 Relationship between grinding efficiency and filling rate

As shown in Fig.3, h indicates the height of the steel ball filling surface from the top of the mill. D_i indicates the effective inner diameter of the mill,The ratio is:

$$x = \frac{h}{D_i} \tag{2}$$

According to the size of the ratio x, the actual filling rate ϕ_0 can be found in Fig.3.Therefore, according to formula (2), the amount of steel balls that should be added can be calculated.

3. Relationship between Grinding Efficiency and Transfer Rate.

Rotating speed is one of the important parameters of the economic operation of

the ball mill.According to the experiment:When the filling rate is constant, the useful power consumption and production capacity have a maximum value.Therefore, the ball mill has the largest production capacity when it is operated at a speed where the maximum power consumption is reached.Fig.4 shows the relationship between grinding efficiency and turnover rate.The curve shows that when the filling rate is constant, the grinding efficiency is the best, and the corresponding one has the best transfer rate.

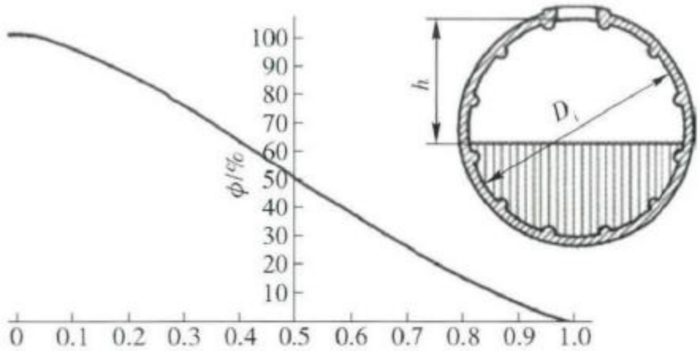

Fig.3 Ratio relationship of x and ϕ_0

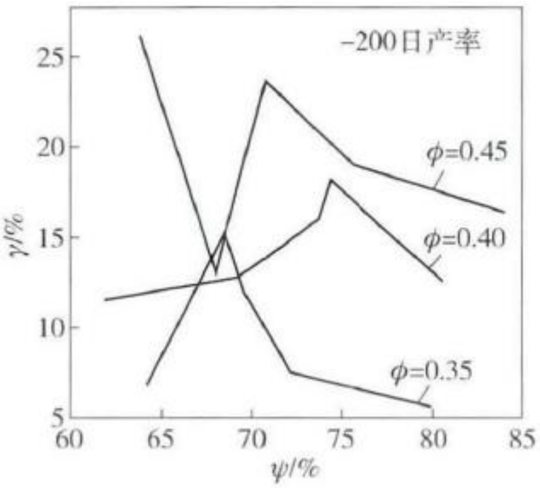

Fig.4 Relationship between grinding efficiency and transfer rate

In order for the ball mill to operate normally and effectively, the speed of the ball mill should ensure that the ball load is at the maximum height along the parabola.The drop of the ball is:

$$H = \frac{2\rho \sin^2\theta \sin\left(\theta - \alpha_\phi\right)}{\cos\alpha_\phi} \times [\cot\theta + \sqrt{\frac{\cos\alpha_\phi}{\sin\theta \sin(\theta - \alpha_\phi)}} - 1] \times [-\sqrt{\frac{\cos\alpha_\phi}{\sin\theta \sin(\theta - \alpha_\phi)}} - 1] + \frac{\rho \sin\left(\theta - \alpha_\phi\right)\cos^2\theta}{\cos\alpha} \quad (3)$$

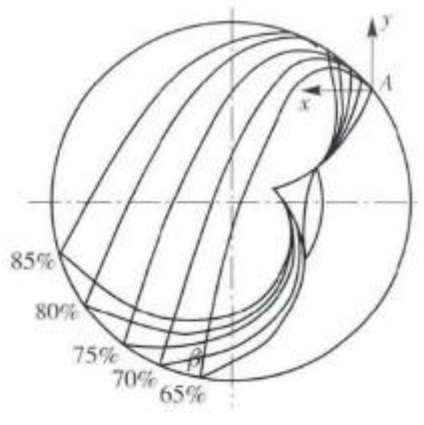

Fig. 5 Ball trajectory

Fig. 5 is a graph plotted under conditions where the filling rate is constant and the rotation rates are different.According to calculation,If φ = 65%~75% ,The falling of the steel ball is the highest speed.Therefore, it has been debatable to use the method of increasing the rotational speed to increase the output.Especially when the rotation rate is increased to 85%, not only the drop height is reduced, but also the energy consumption is on the collision between the steel ball and the side wall of the cylinder, which is very disadvantageous for the operation of the ball mill.

4. Conclusion

Whether the performance of the ball mill is reliable, the matching and selection of its performance parameters is extremely important. The matching of filling rate and transfer rate directly affects the processing capacity of the ball mill. With the continuous improvement of R&D design tools, the relationship between the parameters of the ball mill's motion state, power consumption, filling rate and transfer rate needs further research.

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