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Research on High Reliability Guide Shoe Based on Laser Cladding Technology

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Abstract

In this research, in order to ensure the guiding effect of the guide shoe on the engagement of the walking wheel and the pin row, the theoretical wearable amount of the upper and lower wear-resistant layers during the validity period of the guide shoe was studied, and the effect of the laser cladding process parameters on the cladding On the basis, determine the optimal process parameters of the guide surface of the laser cladding guide shoe, improve the wear resistance of the guide surface, and increase the service life of the guide shoe by more than 20%.

Keywords

Shearer; guide shoe; laser cladding; process parameters.

1. Introduction

The guide shoe is an important part of the walking system of the chainless haulage shearer. Its main role is to guide the shearer to travel, to ensure the normal engagement of the travel wheels, and to withstand the gravity of most shearers and some cutting reaction forces. Due to the influence of unfavorable factors such as inclination Angle of fully mechanized mining face, overcast mining, floor fluctuation and non-standard operation of workers' moving, the guide shoe has bad working condition, complicated force, frequent wear failure and fracture failure, which greatly affects the reliability and service life of the shearer[1]. In recent years, some domestic universities and coal machinery companies have done a lot of research on the wear resistance of guide shoes and have achieved staged results. The guide shoe overhaul cycle has been increased from 1 million tons of coal to 1.5 million tons of coal.

With the construction of high-yield and high-efficiency mines, the development of high-reliability shearers requires that the guide shoe must be suitable for high-speed traction, high reliability, and high wear resistance [2]. At present, domestic guide shoes cannot have these capabilities, and it is bound to require research on a new type of guide shoe suitable for high reliability.

2. Theoretical Analysis

2.1. Analysis of the Wearable Amount of the Guide Shoe Wear Layer Theory

As a bearing part of a coal winning machine, a guide shoe is required to have high strength and toughness; as a sliding surface in contact with a guide rail, it is required to have high wear resistance. When the shearer works, the friction between the guide shoe and the pin row is sliding dry friction, so it will cause severe wear during work. At present, the guide shoe generally adopts a method of welding a wear-resistant layer on the guide surface body material to increase the wear resistance of the entire guide shoe. Therefore, the wear resistance of the

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wear-resistant material is extremely important. Insufficient wear resistance of the wear-resistant material will cause the wear of the wear-resistant material to accelerate, thereby accelerating the wear of the body and greatly shortening the service life of the guide shoe [3]. By analyzing and researching the theoretical wear of the guide shoe, the wear of the guide shoe of the shearer is reduced.

The wear-resistant layer of guide shoe is closely related to the range of driving center distance between travel wheel and pin row, the vertical distance from the center of connecting hole of new guide shoe to the upper wear-resistant layer, and the vertical dimension of guide hole of new guide shoe[4].

As shown in Figure 1, P is the installation center distance between the walking wheel and the pin row, and its value is the radius of the indexing circle of the walking wheel. Assuming that the floating range of P can be obtained from the figure and size relation, the maximum wear amount of the upper wear layer of guide hole of guide shoe is:

$$\delta_1 = (A + C_1) - P_1 \tag{1}$$

The maximum wear amount of the lower wear-resistant layer of the guide groove is

$$\delta_2 = (P_2 - C_2) - (A + B) \tag{2}$$

In the formula, A is the vertical distance from the center of the connecting hole of the guide shoe to the surface under the upper wear resistance layer;

C_1, C_2 are the distance between the pin nodal line and the upper and lower end of the vertical plate;

B is the vertical distance of the guide hole;

Above, the allowable wear amount is analyzed theoretically from the geometric dimension, and then the allowable wear amount of wear layer is calculated based on the structural parameters of guide shoe.

For the determination of the maximum allowable wear of the upper and lower guide surfaces of the guide groove, $\delta_1$andδ_2. According to Fig. 1, it is necessary to ensure that the meshing center distance between the walking wheel and the pin row is within the allowed range, that is, the guide shoe is allowed to sink 10mm and lift 15mm. The pin row allows a vertical deflection angle $\beta_0 = 3^{\circ}$, The guide shoe guide length$L_1 = 990$mm, pin row height $h = 108$mm, The total clearance in the height direction of the guide groove and the pin row is $2\Delta h = 12.9$mm, However, the actual design dimension of the guide groove height of the guide shoe is 118mm, so it is necessary to ensure that the clearance between the guide groove and the pin row is not less than 12.9mm, and the meshing center distance between the walking wheel and the pin row is within the allowable range, so it can be known that $\delta_1 \leq 10$mm, $\delta_2 \leq 5$mm.

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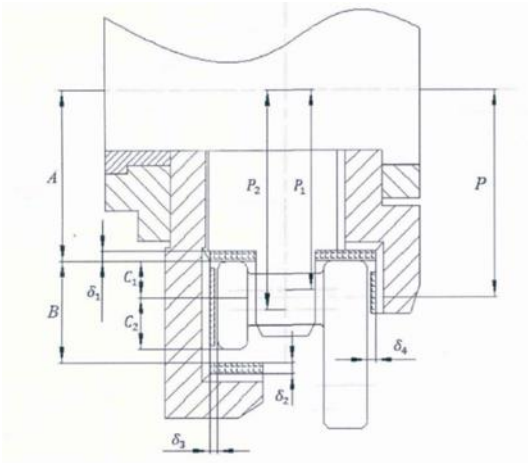

Fig 1. Installation diagram of traveling wheel and pin row guide shoe

For the determination of the maximum allowable wear of the left and right guide surfaces of the guide groove, $\delta_3$and δ_4, according to Fig. 1, it is necessary to ensure that the cross section of the walking wheel does not interfere with the two parallel plates of the pin row. In this routine, the width of the walking wheel is 75mm, and the distance between the two parallel plates of the pin row is 96mm, so the maximum axial displacement of the walking wheel is 10.5mm, and the gap between the guide groove and the pin row is not less than 8.2mm, and the row When the axial movement of the walking wheel does not exceed 10.5mm, it can be seen that $\delta_3, \delta_4 \leq 6.5$mm.

In theory, when wear more than allowable value, coal winning machine guide sliding boots will need to repair or replace, at this time if not timely replacement of new guided sliding boots or to rethink its wear-resisting layer surfacing welding wear-resisting material, the walking wheel and pin row will not mesh properly, sliding boots also cannot have the effect of normal direction, it is easy to cause damage to walk wheel, reduces the production of coal mine.

2.2. Laser Cladding Technology and Its Process Parameters

Laser cladding technology is a surface treatment technology developed in recent years. It has been widely used because of its high metallurgical bonding strength between cladding layer and substrate. Laser cladding is a complicated physical and chemical metallurgy process. The traditional cladding technology is faced with the problems of high sensitivity to crack, easy to produce porosity and low efficiency. The crack phenomenon and behavior involve many aspects of laser cladding, and cladding technology is the key factor to determine cladding quality and efficiency [5].

The process parameters of laser cladding mainly include laser power, cladding speed, powder feed rate, etc., study the effect of laser cladding process parameters on the cladding layer, analyze the cause of quality defects, and determine the optimal process parameters during laser cladding Therefore, effectively controlling the quality of the cladding layer is of great significance to the realization of industrialization [6].

It is suitable for the wear and tear repair of common wear parts in coal mine. Such as shearer guide shoe, scraper conveyor, shearer cutting head.

3. Experiment and Discovery

At present, $ZG25CrNiMo$、$ZG35CrMnSi$ and other cast steel alloys are generally used as guide shoe materials in China. Q460 and Q450 are generally used as frame welding materials for shearer traction box and electric control box. Their mechanical properties can not fully meet

the requirements of high reliable wear-resistant guide shoes. Based on the analysis of the materials of the guide shoes of foreign advanced coal machines, a large number of relevant materials are consulted. In this paper, CrNiMo series low carbon alloy steel is selected as the welding plate of the new type of slide shoes. The main chemical composition is shown in Table 1.

Table 1. Three Scheme comparing

Element	C	Cr	Mn	Si	Mo	P	S
Content/%	0.13~0.19	0.40~0.70	0.60~0.95	0.17~0.37	0.30~0.41	< 0.025	< 0.025

The CrNiMo material was used to make the test sample, and the sample was tempered with a hardness of 260~300 HB. The electronic universal testing machine, high frequency fatigue testing machine and pendulum impact testing machine were used to test the tensile, fracture and impact properties of the samples. The tensile ultimate strength, yield strength and impact toughness of the CrNiMo series materials obtained after the tempering treatment reached 1030 MPa , 815 MPa and 97 J/cm^2 . The fracture toughness $KIC = 245.6\ kg/mm^{3/2}$ was calculated from the sample data.The test results show that the material has good mechanical properties and can meet the requirements of high strength guide shoe.

The main failure mode of guide shoe is wear failure. At present, the contact surface of guide shoe and pin row generally adopts wear-resistant welding rod surfacing 5mm wear-resistant layer to improve the wear resistance of guide shoe and extend the service life. After consulting a large number of relevant data and matching tests, the research group finally selected a Fe-Cr-Mn iron base alloy powder as the new type of wear resistant cladding material for the shoe.

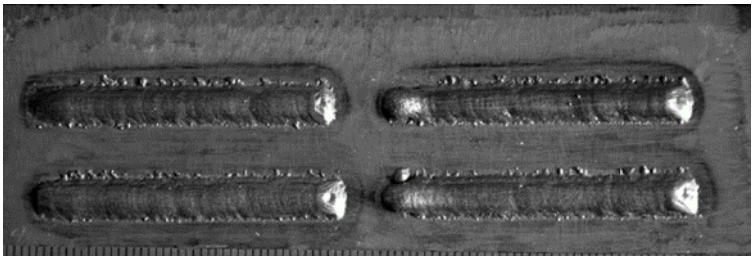

Fig 2. Laser cladding after optimizing process parameters

Optimized process parameters: laser power 5000W, scanning speed 10mm/s, defocus amount 15mm, preset layer thickness 0.4mm, powder feed 5g/min for laser cladding Fe-Cr-Mn iron-based alloy powder, the resulting coating The macro morphology of the layer is shown in Fig. 2. The surface of the cladding layer is white and bright, the surface is smooth and smooth, and there are no cracks and pores. The traces of impact on the substrate are slight and the appearance and forming quality are stable.

4. Conclusion

The currently developed guide shoe is cladding Fe-Cr-Mn iron-based alloy powder on the guide surface of the shoe to form a wear-resistant and corrosion-resistant strengthening layer. After several dry friction life verification tests, various properties such as abrasion resistance have reached the standard, and the service life of the guide shoe has been increased by more than 20%. It has been successfully applied to MG500/1200-WD series coal mining machine and MG500/1330-WD series coal mining machine, reducing the time for guide shoe replacement

and maintenance, improving production efficiency, and at the same time saving a lot of money, which has a huge social economy Meaning and promotion value.

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