

On the Application of Grinding Technology for High-Speed Railway Rails

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Abstract:

At present, the high-speed railway is an important part of modern transportation infrastructure, and steel rail is one of the foundation and key components of the high-speed railway. With the high-speed train running faster, the quality requirements of the rail are getting higher, and the rail grinding technology has become one of the important means to ensure the safety and stability of the high-speed train. In this paper, the application of rail grinding technology in high-speed railways will be deeply discussed.

Keywords:

High-speed railway
Steel rail
Grinding technology
Application

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1. Cause analysis of EMU lateral amplitude overrun

1.1. Rail light strip

High-speed railway as a high-speed, high-quality means of transportation, the noise and vibration generated by the EMU when running will have an important impact on the comfort of passengers, the stability of running and the operating life of track equipment. The rail light strip is one of the important factors. Rail light strip refers to a bright strip on the side of the rail due to long-term friction, which is very common in high-speed railway operations. The existence of a rail light band will cause the lateral amplitude of the EMU to exceed the limit, which will affect the running stability of the train. Therefore, the application of rail grinding technology in

this aspect is particularly important. First of all, there are two main reasons for the formation of rail light strips: (1) The friction on the side of the rail causes the metal particles on the surface to compact under the impact between the wheel and rail, which increases the surface hardness and gradually forms a bright band on the raised part; (2) The rolling of the wheel-rail, the interaction between the tire and the track will cause wear on the rim, which will lead to the rise of the rim, and the friction heat will cause the surface hardness of part of the side edge of the rail to increase, forming a bright belt^[1]. The existence of the rail light belt will not only cause the transverse amplitude of the EMU to exceed the limit, but also increase the friction of the EMU on the track, and the wear of the track will be further aggravated, thus

affecting the operating life of the track equipment. In addition, the existence of rail light belts will also increase wheel-rail noise, which will cause trouble to residents along the line. In general, the rail grinding technology of high-speed railways has important application value in solving the rail light belt problem and is also an important means to ensure the safety of high-speed railway running and improve the operation efficiency.

1.2. Rail geometry

Rail geometry mainly refers to the size parameters such as the outline, height and width of the track. Its accuracy and stability directly affect the running state and safety of the vehicle on the track. First of all, the track geometry is one of the basic elements to ensure the safe and stable operation of the track ^[2]. In the process of high-speed railway design and construction, it is very important to accurately control and adjust the track geometry. When laying the track, once the track geometry is wrong, it is easy to lead to the lateral vibration of the train, the increase of noise and other problems, and even serious vehicle derailment accidents.

Secondly, the constant change of rail geometry is also one of the main reasons for the transverse vibration of the train. As an important component of high-speed railway, the rail will inevitably be subjected to a lot of use and wear, which will lead to the constant change of the rail geometry. The greater the change of rail geometry, the more obvious the lateral vibration of the train will be during running. To ensure the stability and safety of the track, rail grinding technology came into being ^[3]. By optimizing the geometry of the rail, the grinding technology can strengthen the structure and performance of the railway, thereby reducing the transverse vibration and noise of the vehicle during the running process, and improving the running speed and efficiency of the railway.

2. The function and characteristics of the rail

2.1. The basic structure and composition of the rail

The steel rail is one of the main components used to support the train wheels and transfer the wheel load on

the railway. It is composed of the upper pedal, the side plate, the rail head, the rail waist, the base and other parts. Among them, the upper pedal is the part that bears the train load, the side plate plays the role of anti-slip and lateral stability, and the rail head and the rail waist play the role of bearing the load and transferring the wheel load. The rail is mainly composed of high-quality steel and some other alloying elements, which can increase the strength and wear resistance of the rail. In addition, the rail also needs to be processed by heat treatment and other processes to ensure its quality and performance ^[4].

2.2. The function and characteristics of the rail

2.2.1. The function of the rail

(1) Bearing load: The rail is one of the main components of the railway to bear the load of the train, it can effectively transfer the wheel load and disperse it to the railway foundation, but also can withstand the longitudinal and lateral load of the train.

(2) Maintain the stability of the vehicle: As a supporting component of the train, the rail can play a role in maintaining the stability of the vehicle when the train is running, reducing the possibility of the train rollover or out of control ^[5].

(3) Ensure smooth running: The rail can directly affect the running stability of the train. For high-speed trains, the smoothness of the rail has a great impact on the operating efficiency and safety of the train.

2.2.2. Characteristics of the rail

(1) High strength: The rail needs to bear the huge load of the train, so it needs to have high strength and toughness, and can maintain its stability and performance for a long time.

(2) Strong wear resistance: Long-term running of the train will produce greater wear on the rail, so the rail needs to have strong wear resistance, and can maintain the smoothness of its surface for a long time.

(3) Good corrosion resistance: The rail has been in an open environment on the railway for a long time, and it needs to resist the influence of natural factors such as wind, sun, and rain erosion, so it needs to have good corrosion resistance to maintain its design life for a long time.

(4) High accuracy: The geometric shape and

dimensional accuracy of the rail have a very important impact on the running stability and operating efficiency of the train, so the processing and installation of the rail should ensure accuracy and rail size ^[6].

In general, the application of high-speed railway rail grinding technology is to ensure the smoothness and smoothness of the rail, so as to improve the operation efficiency and safety of the train. As an important component of the railway, the rail needs to have the characteristics of high strength, high wear resistance, and high precision to ensure its stability and long service life.

3. The advantages and problems of rail grinding technology

3.1. The advantages and limitations of rail grinding

High-speed railway trains travel at a high speed, and the train needs to brake frequently to accelerate, which leads to the friction between the train wheelset and the rail being very large, easy to make the rail surface wear and fatigue cracks, thus affecting the safety of operation. The rail grinding technology is to polish the rail surface and remove the surface of the pit, marks, and oxide layer, to extend the service life of the rail and improve traffic safety ^[7]. Specifically, the advantages of rail grinding technology are as follows:

- (1) Improve the finish and smoothness of the rail surface, reduce friction resistance, reduce energy consumption and save energy;
- (2) Optimize the shape of the wheel-rail contact surface, reduce friction and wear, and extend the service life of the rail;
- (3) Shorten the braking distance of the train to improve safety;
- (4) Reduce the noise emitted by the rail and improve the operating environment.

3.2. Existing problems and improvement directions of rail grinding

Although rail grinding has significant advantages, there are also some problems:

- (1) Grinding efficiency is low, and cannot meet the needs of high-speed railways. At present, the speed of manual grinding is relatively slow, and the working time

of each shift is long, which cannot meet the requirements of the actual working speed.

(2) It is difficult to ensure the quality of grinding. Due to the manufacturing of machinery and equipment and the technical reasons of the operator, it is still difficult to ensure the quality of grinding, and it is easy to have differences and compound errors between different positions ^[8].

(3) Grinding work will have adverse effects on the operation of passenger trains. At present, the grinding work can only be carried out at night, but this operation will still have some impact on the normal operation of the train, such as the train cannot overpass in the grinding section.

To solve these problems, improvements can be done on the following aspects:

- (1) Improve the machine and equipment to improve the grinding efficiency. At present, there is no targeted automatic grinding equipment for high-speed railway, it is necessary to improve the accuracy and speed of equipment while ensuring the grinding quality to meet the needs of high-speed railway operation.
- (2) Improve the grinding process and improve the quality of grinding. The precision and quality of grinding can be improved by introducing new processing technologies, such as laser grinding and plasma grinding and other methods.
- (3) Use more advanced materials. Develop more wear-resistant materials to make the rail ^[9], thus reducing the number of grinding and increasing the service life.
- (4) Achieve unmanned grinding. Through the introduction of intelligent technologies, such as artificial intelligence and machine vision, the automation and precision of rail grinding can be achieved, and the grinding efficiency and quality can be improved.

4. Rail grinding

4.1. Interpolation principle of the rail profile grinding mode application

High-speed rail is one of the main ways for modern people to travel, and it is the infrastructure for high-speed rail operation. Therefore, the quality and maintenance of the rail are of great importance. Rail grinding technology is one of the important links to ensure the safe and

smooth operation of high-speed rail. The rail profile grinding mode based on the interpolation principle is a common grinding technology.

4.1.1. Introduction of the principle

The interpolation principle is a method to obtain unknown data by interpolating known data, which can be used to grind the profile of the rail surface. Specifically, according to the preset rail profile curve^[10], the height difference of the rail surface is measured, and then the corresponding grinding height is obtained by the interpolation algorithm. Finally, the rail grinding equipment is used to perform the actual grinding operation, so that the rail can reach the preset profile curve. This grinding method has the advantages of high precision, high efficiency and wide application range.

4.1.2. Application scenario

The rail profile grinding mode of the interpolation principle is suitable for the situation where the rail surface height difference is large and the overall grinding is needed. For example, the newly installed rail has irregular height difference on the surface due to the processing accuracy and the reasons in the laying process; Or the old rail, in the long-term use of the surface is worn or scratched^[11] by foreign bodies, resulting in a large difference between the height and the height, the need for overall grinding.

4.1.3. Operation steps

- (1) Rail surface scanning: The use of professional scanning equipment to scan the rail surface;
- (2) Data processing: The scanning data is processed to obtain the height distribution map of the rail surface;
- (3) Profile curve setting: According to the actual situation, set the profile curve of the rail;
- (4) Interpolation algorithm calculation: The interpolation principle is used to calculate the grinding height of each point;
- (5) Grinding operation: According to the calculation results, the actual rail grinding operation;
- (6) Testing and verification: The surface of the polished rail is tested and verified to confirm that its profile curve meets the requirements^[12].

4.2. Application of rail rapid grinding mode

The rail is the core component of a high-speed railway, and its state is directly related to the smoothness and safety of the train. Therefore, the timely application of rail grinding technology is very important. Rail rapid grinding mode is an efficient rail grinding method, it uses professional equipment, and can quickly fix the rail surface defects and uneven grinding. The advantage of this grinding method is that it can not only improve the safety of the railway but also improve the ride experience of passengers and ensure the high-speed and smooth operation of the train. Specifically, the rail rapid grinding mode can be achieved through the following steps:

- (1) Equipment preparation: Rail rapid grinding requires professional equipment, including a grinding machine, grinding head, swing arm, etc., to carry out comprehensive inspection and maintenance to ensure that the equipment is in normal working condition.
- (2) Rail cleaning: Before grinding, the surface of the rail needs to be cleaned to better detect the surface condition and determine the part of the grinding.
- (3) Detection: Use professional testing equipment to detect the height difference and unevenness of the rail surface to determine the parts and depth that need to be smoothed^[13].
- (4) Grinding: According to the test results, select the appropriate grinding head, quickly grinding the rail surface, and grinding away the raised part and uneven part of the surface, so that the rail surface is smoother.
- (5) Inspection: After grinding is completed, it is necessary to carry out a comprehensive inspection to ensure that the rail surface has been completely polished without any defects or raised parts.

Through the rail rapid grinding mode, the smoothness of the rail surface can be significantly improved, and problems such as trains running stuck and bouncing caused by rail surface defects can be avoided. In addition, this grinding mode can be carried out quickly and efficiently, saving the time and energy of maintenance personnel. However, there are some problems and limitations with the rapid rail grinding mode. For example, this method is only suitable for rail with small surface defects, and for some dimples or raised parts with greater depth, other more professional grinding methods are needed. In addition, the rail

rapid grinding mode requires the use of professional equipment and operating skills, which also increases the maintenance cost and the professional skill requirements of maintenance personnel. The application of the rail rapid grinding mode is very wide and can be used not only for the maintenance and maintenance of high-speed railways but also for the maintenance of other types of railway equipment^[14].

4.3. Application of rail profile grinding technology

(1) In the grinding operation, the rail grinding profile template should be used in time to check the grinding profile, and the portable profile instrument or vehicle profile detector should be used to detect the rail grinding profile. When the portable profile instrument is used, the top surface of the left and right strand rail is used as the positioning reference.

(2) Rail grinding profile detection: Data are processed every 1 km during on-board detection; while manual detection was conducted every 50–100 km with randomly selected lines and curves of 100 m each to detect the left and right strands of rail three places each.

Rail profile grinding technology is an important part of the field of high-speed railway maintenance. It refers to the processing of railway rail surface to make its profile meet the corresponding requirements. This technology can effectively extend the service life of the railway and improve the safety performance of the train. However, there are still some problems in the application of rail grinding technology. The advantages of rail profile grinding technology are mainly shown in the following aspects. First of all, it can effectively prevent the gap between the wheel and the rail from being too large, to avoid the risk of the train jumping during high-speed operation.

Secondly, rail grinding technology can also extend the service life of the railway and reduce maintenance costs. In addition, it can also shorten train operation time, and improve operation efficiency and safety^[15].

However, there are still some problems in the application of rail grinding technology.

(1) The current rail grinding technology lacks precision and automation. On high-speed rail, vehicles move at very high speeds, so any slight deviation can pose a threat to driving safety.

(2) The cost of rail grinding technology is high, and the maintenance cost is large.

(3) The rail grinding technology also has the problem of low efficiency.

To solve these problems, the rail profile grinding technology applied now is divided into rail profile grinding mode application of interpolation principle, rail rapid grinding mode application, rail profile grinding technology application, and switch rail welding joint grinding technology application. The application of rail profile grinding technology can help us solve the problem that the railway rail shape accuracy is not high. After the application of rail profile grinding technology, the railway rail shape can be accurately treated. With the rail grinding equipment controlled by a computer, the rail can achieve higher precision and automation in operation, thus significantly improving the safety and stability of the train.

5. Conclusion

The development of high-speed railways is inseparable from rail quality assurance, and rail grinding technology is one of the important means to achieve rail quality assurance. Through the research of rail grinding technology, it can not only effectively reduce the transverse amplitude of EMU, but also extend the service life of rail and ensure the safe and stable operation of high-speed railway. Although there are some problems in rail grinding technology, it is believed that rail grinding technology will play a more important role in the construction of high-speed railways in the future by further strengthening technical research and improvement.

Disclosure statement

The author declares no conflict of interest.

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