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Research status and prospect of rail grinding technology

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Abstract: *The research and application of rail grinding technology not only improves the safety and stability of railroad trains in the process of driving, but also improves the comfort of passengers. The paper firstly generalizes and summarizes the research status of rail grinding technology in the past ten years. Secondly, it discusses the key technology of rail grinding from four aspects: turnout grinding, personalized contour grinding, rail grinding car and abrasive belt grinding, and explores the evaluation factors of grinding quality after the completion of rail grinding. Finally, the prospect of rail grinding technology is made.*

Keywords: *Rail grinding; Personalized profile grinding; Preventive grinding; Wave mill*

1. Introduction

With the increasing level of development of rail transportation, the research and development of rail grinding technology has also received more and more attention [1-3].In this paper, the classification of rail grinding technology and its key core technology will be discussed and analyzed, and the assessment index of rail grinding quality will be pointed out.

2. Current Status Of Research

Grinding of rails is essential for better interaction between train wheels and rails. The original rail polishing technology is a restorative polishing of rail head and section dimensions after cracks, defects or even fractures occur on the rail surface[4] Such grinding method not only has low efficiency, but also costs a lot of money, and can not eliminate or control the source of rail disease in time, before the rail repair has a huge potential threat to the train operation. In the 1990s, the United States, Australia, India, Sweden and other regions adopted pre-polishing technology for rails,That is, before the rail is used as a track, it is pretreated and polished. Railroad maintenance practice proves that the rail using pre-polishing technology to prevent rail wear, wave wear, crack expansion, noise and release fatigue of wheel and rail have a better control effect[5-8] . At present, the rail wear mainly adopts preventive polishing, supplemented by restorative polishing, before the rail is put into use for pre-polishing. When the surface of the rail in use produces wave wear and cracks, then the rail for restorative polishing[9-10] .

3. Key Technologies

3.1. Turnout Grinding

Turnout is an important equipment for train conversion route, in recent years, with the extension of high-speed train operation time, Rail wear is getting worse, turnout disease is particularly prominent, resulting in train operation safety and equipment use and other problems [11]. Kai Ren et al [12],Graduate Department of Chinese Academy of Railway Sciences have used the combination of large machine grinding and small machine fine grinding to grind the turnouts, which greatly improved the fit between the measured and designed profile of the turnouts, with significant benefits. Zong Congcong et al [13], Institute of Railway and Urban Rail Transportation of Tongji University ,used the optimized wheel-rail minimum clearance method to optimize the design of the turnout tip rail section, and the optimization results show that the contact plate area between wheels and rails increases and the contact stress peak decreases, which effectively reduces the wear between rails and prolongs the service life of rails, as shown in Figure 1.

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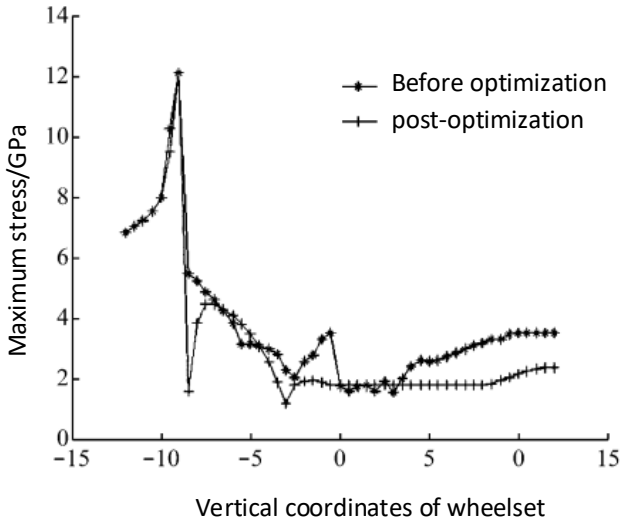

Figure 1: Maximum positive stress at the middle end.

3.2. Individualized Contour Grinding

Individualized contour grinding is to set different grinding parameters in straight and curved sections to ensure that the grinding mechanism will change during the grinding process of the rails, enabling Individualized grinding of different sections and parameters [14] . At present, the public service of the railroad bureau has approved the scheme and concept based on individualized contour grinding. The researchers of the State Railway Design Group Co.,Ltd. have proposed a rail profile grinding solution based on wheel-rail contact relations for high-speed turnouts during the rutting period [15] , the effect of turnout rail grinding was carried out, the results show that, as shown in Figure 2, the transverse vibration acceleration of the car body was reduced after grinding, the transverse acceleration of the car body was reduced by 7.4%, which greatly improved the smoothness of wheel-rail contact.

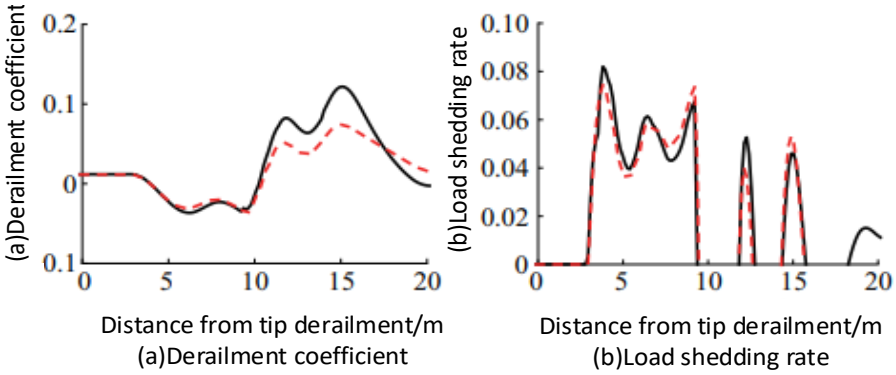

Figure 2: Operating safety factor of the car body before and after grinding.

3.3. Individualized Contour Grinding

Due to the increasingly high quality requirements for rail grinding, the conventional rail grinding car gradually can not meet the grinding needs, so improve the work quality and efficiency of the rail grinding car to reach grinding car refinement operation has become an urgent problem in the rail grinding car operation [16] . Wengang Fan et al [17], Beijing Jiaotong University, designed a high-speed railroad corrugation processing fast rail grinding car based on open belt grinding technology, as shown in Figure 3, this new rail grinding car can eliminate the corrugation produced to the rail profile in the grinding angle range of -20 degrees to +20 degrees, to meet the purpose that the traditional technology of rail repair with grinding wheels or milling cutters is increasingly difficult to meet people's requirements for high-speed and high efficiency.

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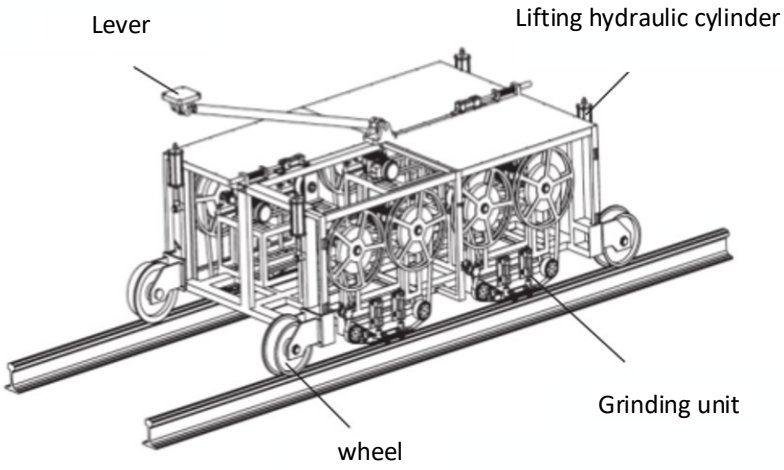

Figure 3: Numerical model of grinding car with open abrasive belt.

3.4. Belt Grinding

In the process of rail grinding, because abrasive belt grinding has the advantage of elastic contact processing, and the grinding temperature is lower, now the domestic and foreign have begun to use abrasive belt for rail grinding operations [18] . Meng Nie et al [19], School of Mechatronics and Control, Beijing Jiaotong University, proposed to use the force ratio parameters of abrasive belts to detect the local grinding process and then calculate the abrasive belt wear in response to the current problems of poor consistency and short life of abrasive belt grinding, and the conclusion showed that the force ratio information in the grinding process could be used to describe the wear state and parameters of abrasive belts. The conclusion has important reference significance for evaluating means to improve the grinding performance of abrasive belts. The effect of grinding on the surface roughness of abrasive belts during abrasive belt rail grinding was investigated by Chaoyue ZHUO et al [20] of Chongqing University, the data results showed that the increase of contact force Fn promotes the increase of Rsm as shown in Fig. 4, and the contact pressure is a sensitive factor affecting the surface roughness Rsm of the Belt grinding with a significant positive correlation.

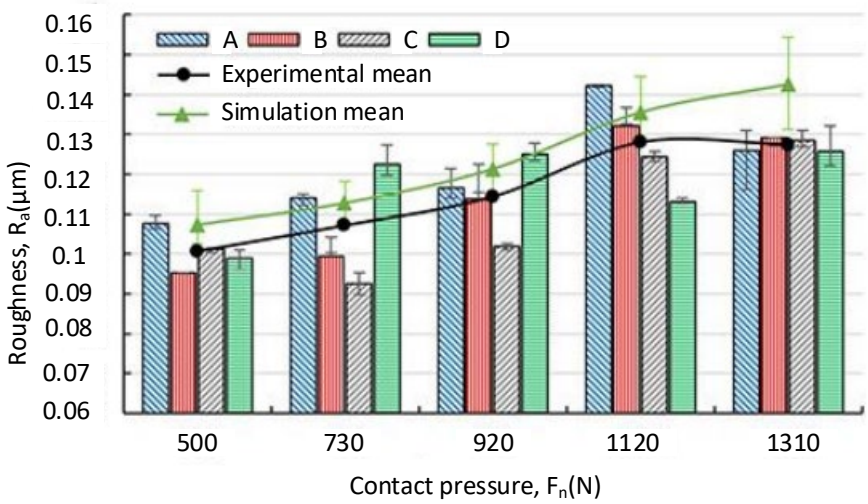

Figure 4: Trend of roughness RSm along the contact force Fn.

4. Quality assessment

The purpose of rail polishing is mainly to eliminate the noise between wheel and rail, enhance the stability between train and rail, and eliminate the corrugated wear of rail. Next, the grinding quality of rail is evaluated from three aspects, namely noise, wavy wear and smoothness, and the relevant work

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made by current researchers to solve these problems is listed.

4.1. Noise

During the operation of the train, due to the friction between the wheels and rails all the time, the wheels and rails wear each other, and if the rails are not polished in time, the noise between the wheels and rails will become louder and louder. In normal train operation, the noise and vibration generated by external sources such as rolling noise of wheel rails and braking noise is the main problems. Li Zhiqiang et al [21-22], China Academy of Railway Science , compared the radiation noise source intensity of the train passing through the test point before and after the pre-polishing of the rails during the linkage of a high-speed railroad in China, and the results showed that, as shown in Figure 5, the noise of the rails after the test rolling stock passing through the pre-polishing was reduced compared with that before the pre-polishing, and the radiation noise source intensity was reduced by about 1.4 dB (A).

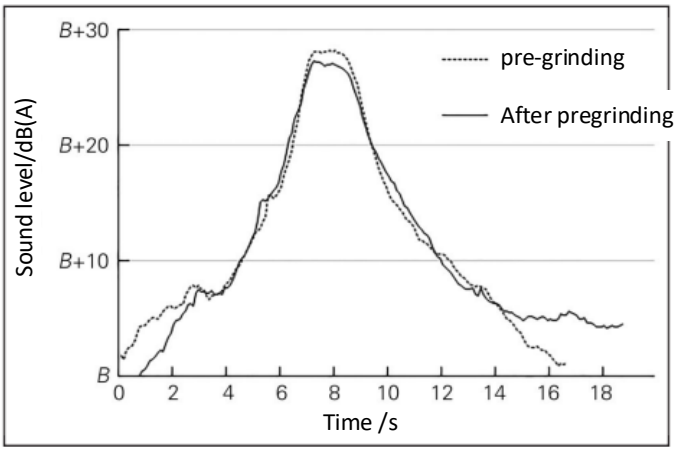

Figure 5: Comparison of noise time domain curves before and after pre-sanding of steel rails.

4.2. Wave Wear

Rail wave wear is referred to as rail wave wear, is a major type of rail damage. Wave abrasion refers to the periodic uneven plastic deformation and abrasion of the rail head tread along the length direction, so that the whole length of the rail presents the wave shape of unevenness. The formation of rail wave wear is mainly divided into power class causes and non-power class causes, as shown in Table 1.

Table 1: Theory of wave mill genesis

Genesis theory of wave grinding	classification
Dynamic causation	Wheel-rail contact resonance theory
	Wheel-rail vertical resonance theory
	Wheelset vibration
	ave theory of wear work
Non-dynamic causes	Theory of metallurgical properties of rail
	Residual stress theory
	Theory of wear and corrosion
	Theory of uneven plastic flow
	Contact fatigue theory

When the train passes through the rail wave grinding section, there will be violent impact vibration between the wheels and rails, and it will lead to the fatigue damage of the components of the rail structure, which will seriously endanger the normows that the grinding machine can achieve better treatment effect for the wave grinding of the rails in the curve section, and the grinding effect is better and faster than the traditional grinding method, as shown in Figure 6.

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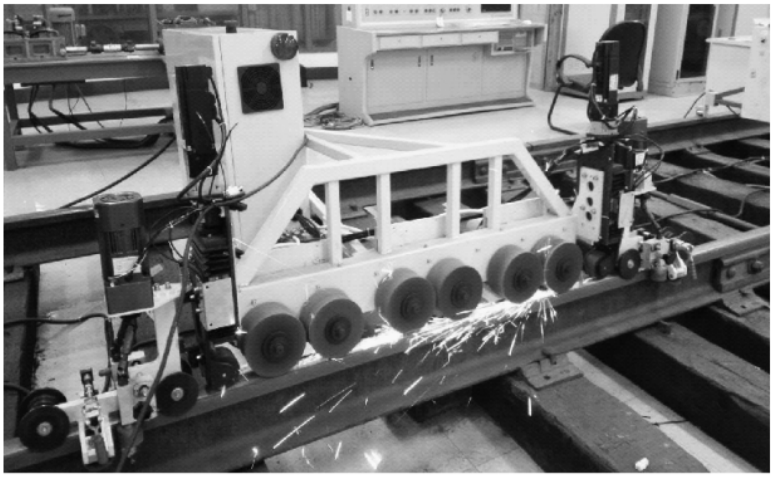

Figure 6: Multi-wheel group rail wave grinding machine physical.

4.3. Stability

With the increase of the train running speed, its dynamic operating environment has changed qualitatively, the safety and smoothness of the traffic has put forward more demanding requirements. And due to the increase of the impact vibration of the rail, resulting in the increase of the force of the foundation under the rail, and then produce uneven deformation and other damage or damage, so these damage must be grinding treatment, in order to increase the smoothness of the train running on the rail. Personalized contour grinding of rails by Li Wei et al [23] of Shenzhen Metro Operations Group Co, compared with before and after grinding, the derailment coefficient of the rails after the implementation of grinding is reduced compared with that before grinding, as shown in Figure 7, and the wheel-rail contact geometry is more uniformly distributed, which effectively improves the smoothness of the train running on the rails.

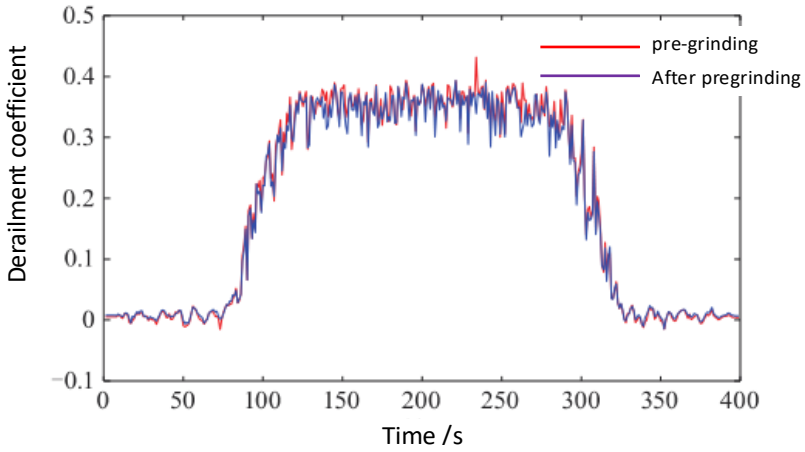

Figure 7: Derailment factor before and after rail grinding.

5. Conclusion

With the continuous in-depth research on rail grinding technology, the efficiency and quality of rail grinding has also been improved. Now the rail grinding technology research is mainly reflected in the rail turnout grinding, contour grinding, rail grinding car and abrasive belt grinding, after grinding the rail evaluation index is divided into train running noise, wavy wear and smoothness. In order to further improve the rail grinding technology, reduce the impact of the grinding process, as well as optimize the grinding of the rail evaluation index, the future rail grinding technology should be from the above two aspects of in-depth research and discussion.

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