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Effect of Microstructural Attributes On Wheel and Rail Studying the Wear and Damage

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Abstract- The assistance life of rails would be strikingly diminished owing to the increment of hub load, which can incite the occurrence of damages like breaks, collapse, fat edges, and so on Laser cladding, which can upgrade the mechanical properties of the rail by making a coating, has gotten extraordinary attention in the space of the rails because of the appealing benefits like low input heat, little heat-impacted zone, and little deformation.

An increment in the hardness of the wheel material outcomes in the damage system of the wheel roller changing from little pitting and adhesion wear to delamination wear. Then, at that point, the rail roller shows serious shelling damage. Basically, the matching of the hardness of wheel and rail materials shows huge potential for reducing wear and surface damage. An increment in the contact stress brings about the wear of wheel and rail rollers becoming more extreme. The current study highlights the effect of micro structural attributes on wheel and rail studying the wear and damage.

***Keywords* -** Rail/wheel tribology, rolling-sliding tests, hardness, contact mechanics, surface topography

I. INTRODUCTION

The rail, which is a major component to support the running of trains, significantly affects the stationarity and security during the train working. With the quick development of rapid and substantial take trains which implies the rail will convey heavier frictional loads, the surface damages of rail, i.e., wear and rolling contact fatigue (RCF), and so on, have become seriously extreme.

The surface damages often occur and amass at the contact surface between the rail–wheel components during the assistance lives, which also are the principle reasons for safeguard support in the modern railway framework. Therefore, to promote the development of transportation industry and the wellbeing of the train running, how to prolong the help life of the rail and repair the damaged rail have become a critical assignment.

The damage instrument changes from little shelling to serious delamination damage and oxidation wear. The primary compositions of wear garbage are the oxide Fe_2O_3 and martensite. Accordingly, diminishing the contact stress is a viable measure for lightening wear and damage of substantial take wheel and rail materials.

To obtain superior wear and RCF resistance, heat treatment is typically utilized in the manufacturing process of the rails. However, this additional progression would prompt an expanded cost. The traditional techniques, for example, case solidifying and peening are selectable solutions to improve the wear and RCF performance of many engineering materials. However, the length of rail is normally beyond 100 m, which implies it is illogical and costly to adopt those traditional techniques into the manufacturing of rails.

The repairing of the damaged rail implies repairing online utilizing sorts of technology without extracting the damaged rail. Repairing can abolish the process of the excision of damaged rail and welding of join that can lessen the waste of resource and energy. In addition, the "window" time can be deflected that guarantees the normal running of the train.

A proper repair contributes to the improvement of the surface nature of the rail, the prolonging of the assistance life, just as the increment of its economic worth and social advantages. As of now, the technology for repairing the damaged rail contains wheel–rail lubrication, rail crushing, rail mailing, surface coating, and so on

The surface coating technology, like thermal splashing, plasma circular segment surfacing, and laser cladding not only can repair the local damage yet additionally improve the mechanical properties and prolong the help life. Compared to the conventional technology, the laser cladding becomes more and more noticeable for the rail repairing, owing to the benefits like low input heat, little heat-impacted zone, little deformation, and the capacity to make the metallurgical bonding between the clad and substrate.

The interface between the wheel and rail assumes a crucial part in deciding the unwavering quality of railways.

However, various damage types can occur on wheel and rail surfaces, a consequence of serious side wear, fatigue breaks, wheel polygon wear, rail corrugation, etc. Furthermore, these deformities can cause the complete disappointment of wheel/rail contact bringing about the potential for a derailment. Therefore, the damage instrument of the wheel/rail system and corresponding preventive measures have been widely researched utilizing various experimental methods and theoretical models.

The wear and rolling contact fatigue observed on wheels and rails are primarily brought about by rehashed stress between the wheel and rail. The rail of a high velocity line shows an enormous number of fatigue breaks. The continuous propagation of these breaks can bring about rail crack that might possibly prompt a derailment. Truth be told, decreasing wear problems can bring about more rolling contact fatigue or other kinds of wheel/rail damage. Therefore, there is a competing and prohibitive relationship between fatigue breaks and wear.

II. EXPERIMENTAL DETAILS

Rolling-sliding testing machine

Rolling-sliding tests were completed utilizing a MMS2A rolling-sliding testing machine. The tester consisted of two rollers with a measurement of 40 mm that filled in as the rail roller (lower example) and the wheel roller (upper example). The rollers were powered by a DC motor. The geometric sizes of the still up in the air utilizing the Hertzian simulation rule; a schematic representation of the wheel and rail rollers is shown in Figure 1. The wear debris that accumulated on the rollers during the rolling-sliding wear process was collected and analyzed.

Experimental parameters and materials

The normal force was determined using the Hertzian simulation rule.16 Normal forces of 110, 150, 156 and 170 N were used in the laboratory to represent nominal contact stresses in the field of 1150, 1300, 1350 and 1500 MPa, respectively. The rotational speed of the upper roller (wheel specimen) and lower roller (rail specimen) were 180 and 200 r/m, respectively. Therefore, the slippage ratio of the rollers was 10%. The number of cycles of the rail roller was 4.8 105.

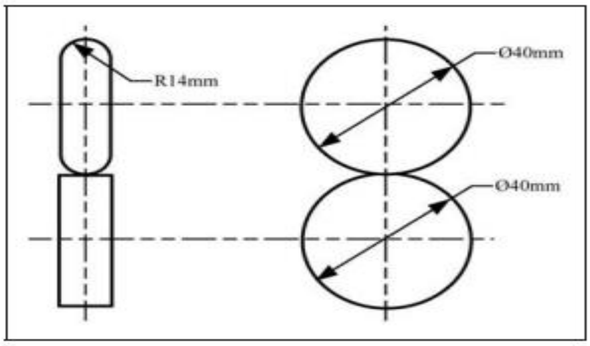

Figure 1. Schematic representation of the wheel and rail rollers.

The wheel and rail rollers were produced from wheel and rail tracks utilized in the field. The substance compositions in weight rate and mechanical properties of the examples are given in Table 1. The wheel rollers went through heat treatments at various temperatures to obtain various upsides of hardness. The metallographic constructions of the wheel and rail examples are shown in Figure 2.

Unmistakably the microstructure of the wheel examples is composed of ferrite and pearlite microstructures. The ferrite content of the four wheel examples is obviously unique (Figure 2(a)). The primary microstructure of the rail example is pearlite (Figure 2(b)). In this review, four heat-treated wheel examples were contemplated. In addition, wheel and rail materials that didn't encounter any heat treatment were utilized in tests that differed the contact stress level.

Table 1. Chemical compositions and mechanical properties of specimens from TB/T 2817-1997.

Specimen	C (%wt)	Si (%wt)	Mn (%wt)	P (%wt)	S (%wt)	σ_b (MPa)	δ_5 (%)
Wheel	0.56	0.40	0.80	0.020	0.015	910	10
Rail	0.65–0.76	0.15–0.35	1.10–1.40	⩽0.030	⩽0.030	880	9

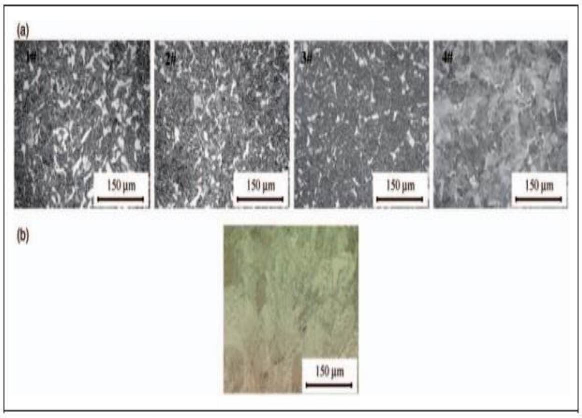

Figure 2. Metallographic structure of (a) wheel and (b) rail specimens.

III. RESULTS

The surface hardness of the wheel examples (Vickers hardness, load: 200 g) is shown in Figure 3. Obviously the hardness of the wheel rollers continuously increments from roller no. 1 to roller no. 4 because of changes in the temperature utilized in the heat treatment (roller no. 1: extinguishing: 830 C þ treating: 500 C; roller no. 2: extinguishing: 845 C þ treating: 500 C; roller no. 3: extinguishing: 865 C þ treating: 500 C; roller no. 4: extinguishing: 890 C þ treating: 500 C). The hardness of the rail material is about 314 HV. Therefore, the hardness ratios of the rail and wheel rollers are 1.25, 1.15, 1.10 and 0.95, individually.

As shown in Figure 4, the friction coefficient quickly increments and afterward stays constant as the quantity of patterns of rail roller increments. It was concluded that the friction coefficients of the wheel and rail examples do not huge change under various wheel and rail hardness conditions. These outcomes demonstrate that the hardness of the wheel material has no apparent impact on rolling friction coefficients of the wheel and rail rollers.

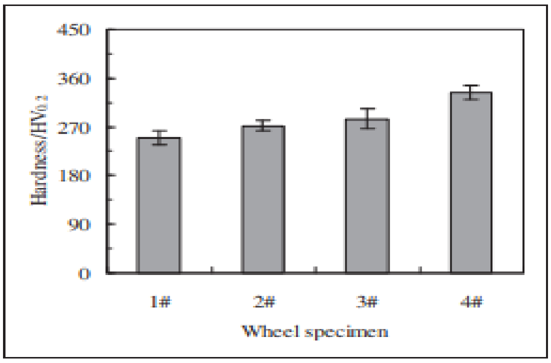

Figure 3. The surface hardness of the wheel specimens.

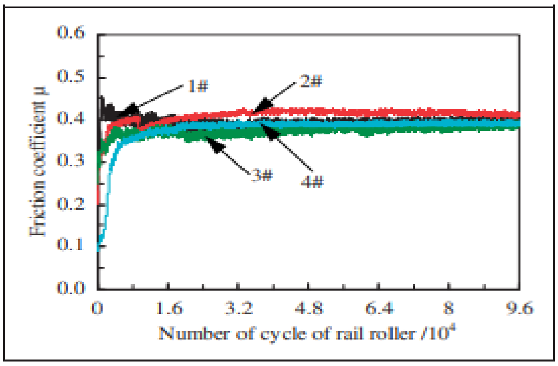

Figure 4. Friction coefficients of the wheel and rail specimens (contact stress 1300 MPa).

It is notable that wheel/rail contact is a complicated tribological process. Many factors can impact the wear and damage behavior of the wheel and rail, for example, hub load, wheel and rail materials, wheel and rail profiles, speed, third medium in the wheel/rail interface, and so on The experimental outcomes show that the hardness of the wheel material substantially impacts wear and damage of the wheel and rail rollers.

The relation between wear weight and hardness ratio of the rail and wheel rollers shows that the wear weight of the wheel rollers has an almost direct ascent. However, the wear weight of the rail rollers has a direct fall with an expansion in the hardness ratio of the rail and wheel materials. In addition, various upsides of the hardness ratio of the rail and wheel materials cause changes in the damage system of the wheel and rail rollers.

With an expansion in the contact stress, the wear and fatigue damage experienced by the wheel/rail system becomes progressively serious. The experimental outcomes demonstrate that the increment in the rate of wear weight of wheel and rail rollers is 165% and 108%, separately, when the contact stress increments from 1150 to 1500 MPa.

Furthermore, the damage component of the wheel and rail rollers obviously changes as the contact stress conditions are shifted. Therefore, it is confirmed that wear is the conclusive factor that decides the substitution of weighty take wheel/rail materials. The size of the wear trash shows no huge contrast under various contract stress conditions because of rehashing roller compaction at the wheel/rail interface.

IV. CONCLUSION

The hardness of the wheel material has no obvious impact on the friction coefficient of wheel and rail rollers. The wear weight of wheel rollers has an almost straight ascent; however, the wear weight of rail rollers has a direct fall, with an increment in the hardness ratio of the rail and wheel materials.

With an expansion in wheel hardness, the damage component of the wheel roller changes from little pitting to delamination wear. The shelling damage of the rail roller is the dominant impact.

An expansion in the degree of contact stress irritates the wear of the wheel/rail system and cause enormous mass shelling, serious delamination and oxidation wear. The principle compositions of the wear flotsam and jetsam are the oxide Fe_2O_3 and martensite.
To mitigate the wear and damage of wheel/rail systems on a weighty take railway, a powerful measure is to diminish the contact stress by optimal plan of the wheel/rail interaction.

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