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RESEARCH ARTICLE OPEN ACCESS

Effect Of Micro Structural Attributes On Wheel And Rail

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Abstract:

Nowadays, the railway is regarded as a fast, efficient, and secure mode of transportation. The issue of rail and wheel contact is one of the most fundamental aspects of the railway system because improper interactions cause problems such as wear and have a negative effect on the train's dynamic functioning. Trains operate within the constraints imposed by friction between railway wheels and rail surfaces. Inadequate friction causes poor adhesion during braking, which is dangerous because it results in longer stopping distances. Inadequate friction is also a performance issue because it affects traction, limiting the amount of tangential force that can be developed when curving. Delays occur when a train travels through areas with poor adhesion while in service. Rail flaws are commonly referred to as'squats' when they resulted from rolling contact fatigue damage, and as'studs' when they were associated with a white etching layer caused by the transformation from pearlitic steel due to friction heat generated by wheel sliding or excessive traction. This type of rail surface flaw causes wheel/rail impact, large amplitude vibration of the track structure, and poor ride quality. From the fracture mechanical and material scientific standpoints, the root cause and preventive solution to this defect are still being investigated. The dynamic interactions between the vehicle and the track impose vibrations and acoustic radiations, transforming the railway corridor into a moving vibro-acoustic source. The dynamic amplification of loading conditions and reflected vibration effects on infrastructure and rolling stocks is significantly increased when either the wheel or rail is imperfect.

***Keywords* — Wear, Wheel–rail contact, Railway system, Surface roughness, Transportation, Inappropriate interaction.**

INTRODUCTION

The railway system has been regarded as a fast, aggregate, and secure mode of transportation, as well as a serious competitor for air transportation in terms of security and speed. Lower energy consumption, aggregate transportation, increased security, and environmental preservation are the most significant advantages of railway transportation. The issue of rail and wheel contact is one of the most fundamental aspects of the railway system, and for many years, the interaction of the wheel and rail in the railway transportation system has been taken into account. The study of the wear phenomenon between the rail and the wheel resulted in the design of a suspension system and wheel profile that is proportionate to the wear process, because using the optimum wheel profile will result in dynamic stability, comfort in expedition, and security against emersion from the rail, particularly in arched paths. [1]

The properties of the wheel material influence the susceptibility of railway wheels to wear and rolling contact fatigue damage. The steel composition, wheel manufacturing process, and thermal and mechanical loading during operation all have an impact on these. As a result, the in-service properties vary with depth below the surface and position across the wheel tread. The stress history at the wheel/rail contact (derived from dynamic simulations) and observed variations in hardness and microstructure are discussed in this paper. The hardness of an "in-service" wheel rim is shown to vary significantly, with three distinct effects. The underlying hardness trend with depth can be attributed to manufacturing microstructural changes (proeutectoid ferrite fraction and pearlite lamellae spacing). The near-surface layer exhibits plastic flow and microstructural shear, particularly in regions subjected to high tangential forces when curving, resulting in higher hardness values. The wheel/rail contacts cause stresses that exceed the material yield stress between 1 mm and 7 mm depth, resulting in work hardening without a macroscopic change in microstructure. [2] These changes in material properties as the wheel rim depth increases the likelihood of crack initiation on wheels nearing the end of their life.

Rail defects have become a widespread problem in many countries, affecting both passenger and freight rail networks. Rail squat/stud defects were observed in all types of track structures, all arrays of track geometries and gradients, and all operational traffics, as shown in Fig. 1. Inside the dry tunnels, however, there was almost no squat to be seen. However, according to a recent collaborative study, some rail studs appear in the London Underground due to wheel traction issues [3]. Stud cracks begin in the WEL and grow horizontally at a depth of 3-6mm below the rail surface. The rail surface depresses, causing vibration impact and noise. Squat cracks propagate from surface cracks caused by rolling contact fatigue (RCF) and grow at a depth of 3-6mm below the rail surface. Squats are commonly found in tangent tracks and high rails of moderate radius curves; squats caused in high rails of moderate radius curves are known as gauge corner cracks, and in turnouts with vertical, unground rails.

a) WEL-related stud (multiple squats)

b) RCF-related squat (single squats)

Fig 1 Rail squats in railway tracks based on their initiation types

With heavier and faster trains, the dynamic load transferring on to track and its components such as rails, sleepers, ballast, and formations is increasing, which is exacerbated by traffic speeds and rail surface defects. These dynamic impact loading conditions frequently cause rack support damage and initial differential settlement as well as plastic deformation. [4] The track problem does not end here. Plastic deformation and initial differential settlement combine to form and couple with short wavelength defects (if present) to exponentially aggravate the dynamic loading condition.

REVIEW OF LITERATURE

Through a parametric study, Jabbar-Ali Zakeri et al [5] investigated the effect of geometrical parameters on the behaviour of dynamic interaction of wheel rail. Zong et al [6] investigated a three-dimensional wheel-rail contact model in the finite element framework for the analysis of rail ends subjected to wheel contact loading. J. J. Zhu et al. [7] developed an adaptive wheel-rail contact model with a radial spring to predict the normal contact force of a wheel-rail.

Monfared and Khalili [8] presented the mechanical behaviour of a single Lead-Zirconate-Titanate by atomic number, and its specific mechanical behaviour is simulated by mathematical modelling and ABAQUS software for smart materials, as well as mechanical behaviour prediction. The wheel and rail contact analysis detail review highlighted the wear calculation, failure analysis, and so on. The literature review does not mention the material dependency analysis.

OBJECTIVES

The purpose of this paper is to look into the effect of as-manufactured steel microstructure and hardness, as well as wheel/rail contact conditions, on the observed damage (such as rolling contact fatigue (RCF) cracks and plastic flow) on the tread of railway wheels.

RESEARCH METHODOLOGY

Methodology is the systematic, theoretical examination of the methods used in a particular field of study. It consists of a theoretical examination of the body of methods and principles associated with a particular field of knowledge. It usually includes terms like paradigm, theoretical model, phases, and quantitative or qualitative techniques. A close reading and detailed analysis of secondary sources is required in order to apply the analytical and descriptive methods to the research. It is critical to obtain additional perspectives in order to expand on the textual analysis, which would necessitate close reading analysis of a few secondary materials.

RESULT AND DISCUSSION

Figure 2 shows an ideal sample design for the rail and wheel profiles. There are three points of contact. The first area is for straight-line motion, and the conical coefficient, which is defined as the ratio of half the difference between the left and right wheel rolling radius of an axis to transverse axis movement, is often designed from 0.15 to 0.2 for passenger trains. [9-10]

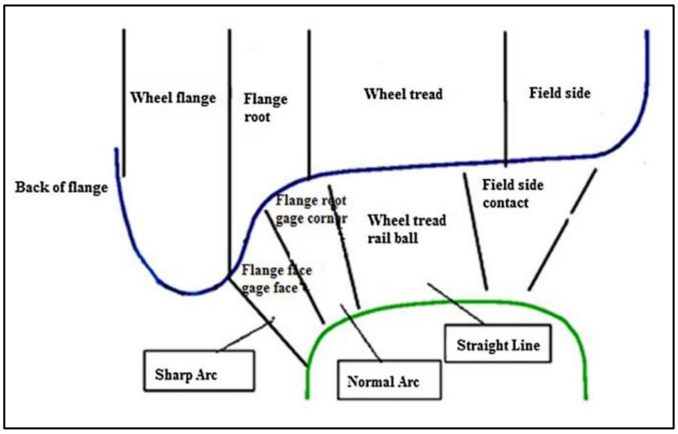

Fig.2: Contact points of the rail and wheel in a variety of paths

The thermal load and boundary conditions applied to the wheel are depicted in Fig. 3. The boundary conditions used are that the hub of the wheel is kept at ambient temperature, the edges of the plate are subject to convective film coefficient because air is in contact with the outer surface, and the rim edges that are in contact with the rail generate heat due to friction, which is applied as heat flux load to the wheel. [11-13]

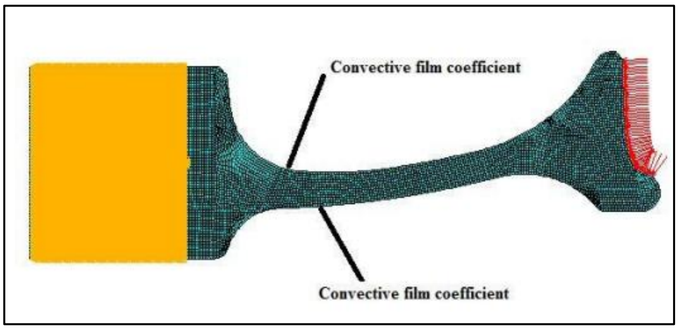

Fig. 3: Thermal load and boundary condition applied on the wheel.

As a result of this complex wheel-rail contact condition, two distinct wear regions appear on the wheel profile: one on the flange and the other on the thread, as illustrated in Fig.

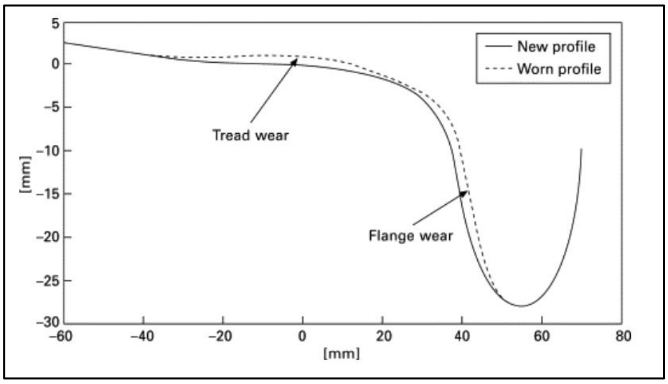

Fig. 3: Wear regions on the wheel profile.

Precise measurements can be made with mechanical or laser devices, as shown in Fig. 5, which has a small roller connected to two arms with encoders from which the precise locus of the roller and thus the wheel or rail geometry can be determined. Figure 6[15] depicts typical measured wheel and rail profiles.

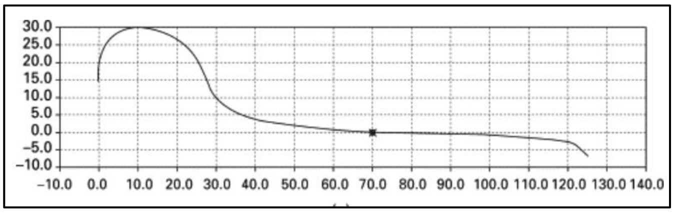

Fig. 5: MiniProf measuring device: (a) rail profile; (b) wheel profile.

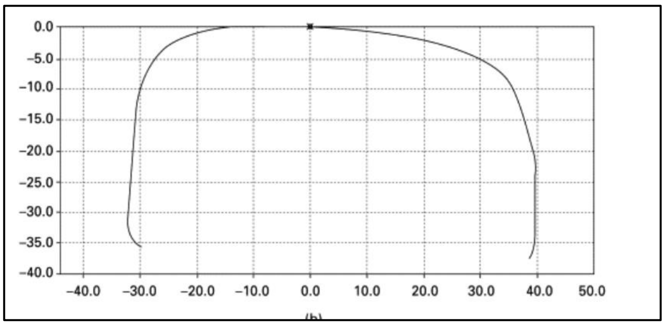

Fig. 6: Measured profiles: (a) wheel; (b) rail.

The equivalent parameter model is set to the yaw damper. The calculated variable is set to the car body and frame's later alacceleration. Co-simulation is used to determine whether the effect of equivalent parameters on the vehicle is consistent with reality. Figure 7 depicts a frequency domain comparison of simulation and test vibration acceleration of the car body and frame. It can be seen that the co-simulation results are roughly consistent with the test results. Because there are fewer interference factors in the simulation, the amplitude of vibration acceleration is slightly lower than in the test.

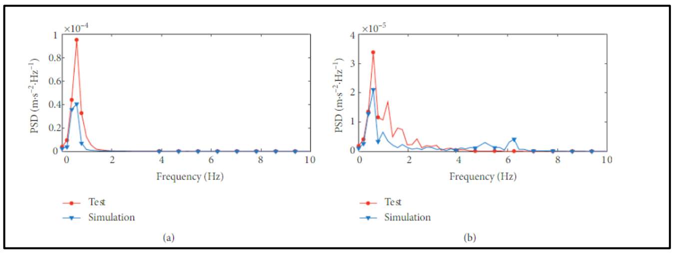

Fig. 7: Comparision of vibrartion acceleration between simulation and test (a)Car body (b) Bogie

CONCLUSION

The analysis outcome depicts the behaviour of the wheel under various loading conditions. Excessive braking of the wheel causes thermal overloading, which causes fatigue, crack propagation leading to fracture, and wear. Measures must be taken to ensure a consistent wheel monitoring process and an examination of residual stresses to prevent fracture. The findings indicate that the thermal effect is important in amplifying the rail/sleeper contact forces (railseat loads). However, for wheel-rail forces, such an effect is insignificant. The ballast pressure remains static and quasi-static due to the loss of dynamic content. The insight implies that sleepers will be subjected to excessive dynamic uplift loads, which can degrade and weaken ballast-sleeper friction and lateral track stiffness. In the near future, more results on the parametric effects of rail squats, as well as the effect of adjacent track movement on track load distribution, will be investigated. This understanding will assist track engineers in managing and operating infrastructure assets more efficiently and effectively in the face of climate change. The knowledge is critical for improving rail infrastructure's climate change adaptation strategy.

REFERENCES

1. *Tanel Telliskivi, "Wheel-Rail Interaction Analysis", PhD dissertation, Dept. of Machine Design, Royal Institute of Technology, 2003. (Thesis)*
2. *K. D. Cole, C. M. Tarawneh, A. A. Fuentes,B. M. Wilson,and L. Navarro, "Thermal models of railroad wheels and bearings", Published in International Journal of Heat and Mass Transfer 53:9-10 (April 2010), pp. 1636 -1645.*
3. *Kaewunruen, S., 'Discussion of "Field Test Performance of Noncontact Ultrasonic Rail Inspection System" by Stefano Mariani, Thompson Nguyen, Xuan Zhu, and Francesco Lanza di Scalea', Journal of Transportation Engineering, Part A: Systems 144 (4), 07018001 (2018). doi: 10.1061/JTEPBS.0000134*
4. *Kaewunruen, S., 'Identification and prioritization of rail squat defects in the field using rail magnetisation technology', Proceedings of SPIE - The International Society for Optical Engineering 9437, 94371H (2015). doi: 10.1117/12.2083851*
5. *Jabbar–Ali Zakeri, Masoud Fathali and Nima Boloukian Roudsari: Effectsof Rail Cant on Wheel–Rail Contact Forces in Slab Tracks, International Journal ofMechanics and Applications, 1(1), 12–21, 2011.*
6. *Zong, N. and Dhanasekar, M.: Analysis of Rail Ends under Wheel ContactLoading, International Journal of Aerospace and Mechanical Engineering, 6, 452–460,2012.*
7. *Zhu, J. J., Ahmed, A. K. W. and Rakheja, S.: An Adaptive Contact Model forsimulation of Wheel–rail Impact Load due to a Wheel Flat, 13th National Conferenceon Mechanisms and Machines, IISc, Bangalore, India, 12–13, 2007*
8. *Monfared, V. and Khalili, M. R.: Investigation of Relations between AtomicNumber and Composition Weight Ratio in PZT and SMA and Prediction of Mechan-ical Beha vior, Acta Phys. Pol. A., 120, 424–428, 2011*
9. *Kerr, M.B., Wilson, A., Marich, S.: The epidemiology of squats and related defects. In: Proceedings of Conference on Railway Engineering, Perth, Australia (2008).*
10. *Burstow, M.C.: A model to predict and understand rolling contact fatigue in wheels and rails. In: Proceedings of the 7th World Congress on Railway Research (WCRR 2006), Montreal, Canada (2006).*
11. *Remennikov A.M. and Kaewunruen S., "A review on loading conditions for railway track structures due to train and track vertical interaction". Structural Control and Health Monitoring, 15(2), 207-234, (2008).*
12. *Soleimani H, Nejad RM, Moavenian M (2016) Common failures in wheel and rail and different methods of measuring their profiles. In: Proceedings of the 1st international conference on mechanical and aerospace engineering, Iran*
13. *Zakeri JA, Ghorbani V (2011) Investigation on dynamic behavior of railway track in transition zone. J Mech Sci Technol 25(2):287–292*
14. *Mohammadzadeh S, Ghahremani S (2012) Estimation of train derailment probability using rail profile alterations. Struct Infrastruct Eng Mainten Manag Life Cycle Des Perform 8(11):1034–1053*
15. *Chevaliera L, Cloupet S, Quillien M (2006) Friction and wear during twin-disc experiments under ambient and cryogenic conditions. Tribol Int 39(11):1376–1387*