Symposium of Advances in Contact Mechanics: a tribute to Prof. J.J. Kalker
22- 24 October 2008, Delft, The Netherlands

Some Practical Issues based on Wheel/Rail Rolling Contact

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Keywords: Corrugation, Lubrication, Flange climb derailment, Coefficient of Friction, Adhesion

1 INTRODUCTION

Rolling contact fatigue and wear are typical practical issues related to wheel/rail rolling contact. Also, rail corrugation and adhesion of wheel/rail interface under wet conditions are important issues associated with vehicle/track and/or wheel/rail dynamic behavior. This paper describes rail corrugations generated on low rails at sharp curves and the effect of lubrication on preventing rail corrugations, and the effect of water temperature on adhesion of wheel/rail interface based on elasto-hydrodynamic lubrication (EHL) theory.

2 RAIL CORRUGATION

The four types of rail corrugations have been recognized in Japan. One is very short pitch corrugations whose wavelengths are 30 to 80mm on tangent tracks or on very gentle curves. The other is relatively long pitch corrugations whose wavelengths are 400 to 600mm on high rails at sharp curves in narrow gauge, middle speed, tracks with a radius of curvature more than 600 m or tangent tracks and around 1.2m in Shinkansen, high speed, tracks. The other is relatively short pitch corrugations whose wavelengths are 80 to 150mm on low rails at sharp curves with a radius of curvature less than 600m, mostly 400m. Rail corrugations have been studied so far and a lot of sophisticated findings have been obtained. Grassie and Kalousek reported an extensive research review of rail corrugations **[1]**. The report covers many railway systems in the world and provides helpful suggestions. Many curves in the Japanese metro systems have radii of curvature less than 200 m. Almost all sharp curves suffer from short pitch corrugations on low rails. Matsumoto, et. al., systematically studied these short pitch corrugations **[2]**. In this paper, the effect of lateral force caused by vehicles negotiating sharp curves on the generation of low rail corrugations is investigated based on track site measurements and vehicle dynamics simulation. Also, the possibility of lubrication on preventing low rail corrugations in sharp curves is described .

3 LUBRICATION

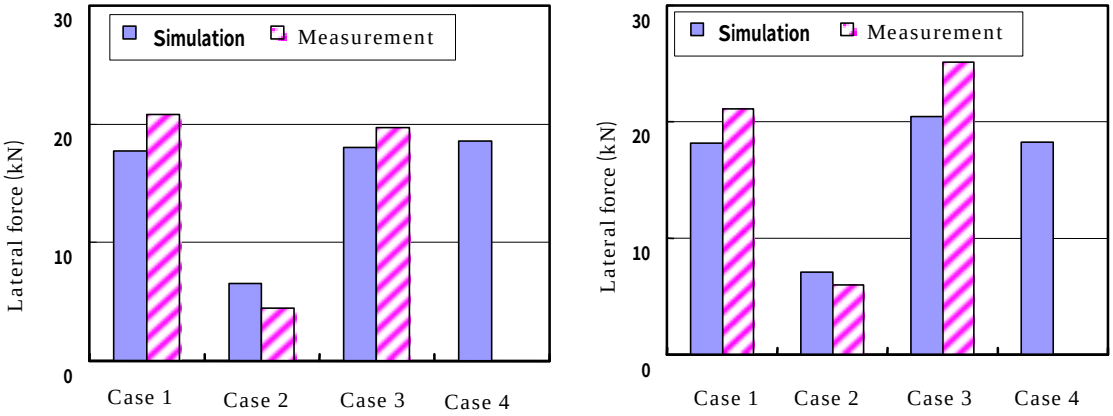
Railway vehicles negotiate sharp curves with large lateral force interacting between wheel/rail interface and the angle of attack of a leading axle in a bogie which depends on its steering performance. Such a large lateral force is one of main facilitators causing wheel flange climb derailment from the aspect of running stability and/or safety, also low rail corrugations, thin flange wear of wheel and gauge face wear of rail from the aspect of material integrity, particularly squealing noise from the aspect of environmental issues in urban railways. Currently lubrication of interface between wheel tread and the top of rail has been focused on to decrease large lateral forces and to reduce the wear of wheel/rail interface, low rail corrugation and squealing noise as a result. However, the lubrication between wheel tread and the top of rail interface has some risk of wheel sliding due to low traction coefficient, which requires that the friction of such an interface must be appropriately controlled. Friction modifier is considered as one of promising solutions **[3]**. In this paper, the influence of wheel/rail lubrication as one of main methods of moderating friction on vehicle/track dynamic behaviour has been evaluated by vehicle running experiments in a test track. And the experimental re-

sults were discussed from the aspect of interacting forces between wheel and rail with a vehicle dynamic simulator (VDS) developed by Railway Technical Research Institute. Table 1 gives the technical details of track and lubrication arrangements. Fig. 1 shows lateral forces measured at track site and those obtained by VDS under non lubrication and lubrication. At first, good agreement with track site measurements and analytical results is obtained. Next, the effect of lubrication on reducing lateral forces is clearly identified.

Table 1 Technical details of track and lubrication arrangements

Curve radius	Rail	Cant	Lubrication arrangements	
160 m	JIS50N	90mm	Case 1	No lubrication
			Case 2	Grease lubrication on the top of a low rail
			Case 3	Grease lubrication at the gauge face of a high rail
			Case 4*	Lubrication on both the gauge face and top of a high rail

[Case 4*: lubrication arrangement not for vehicle running tests but only for vehicle dynamic simulation which is discussed later on.]



(a) Low rail side (b) High rail side

Fig. 1 Effect of lubrication on lateral forces

4 ADHESION

In high-speed railways, adhesion between wheel and rail is a very important function particularly under wet condition to keep running safety and stable operation from the aspects of braking and driving performance. This paper describes an experimental investigation and analytical study based on EHL theory with the focus placed on the effects of surface roughness and water temperature on the adhesion between wheel and rail under wet condition. Fig. 2 shows the effect of water temperature on the maximum traction coefficient which is commonly called adhesion coefficient in railway industry. Not so small variation can be identified , but the effect of water viscosity based on temperature on adhesion of wheel/rail interface is roughly identified. This means cold district may have some risk of low adhesion.

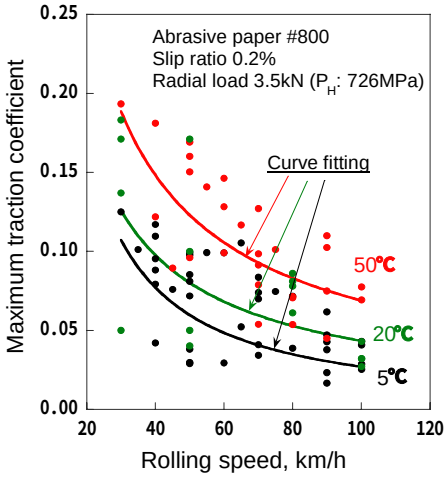


Fig. 2 Effect of water temperature on adhesion

Reference

[1] Grassie, S.L. and Kalousek, J., Proc. of IMechE Part F, 207, 1993, pp. 57-68
[2] Matsumoto, A., et. al., Wear, 253, 2002, pp. 178-184
[3] Eadie, D.T., et. al., Wear, 253, 2002, pp.185-192.