Wheel-rail friction measurement in the V-Track

Yang, Zhen ; Li, Zili; Moraal, Jan

Publication date
2024

Document Version
Final published version

Published in
In2Track3

Citation (APA)
Yang, Z., Li, Z., & Moraal, J. (2024). Wheel-rail friction measurement in the V-Track. In P. Edlund, & A. Ekberg (Eds.), *In2Track3: Concluding Technical Report* (pp. 70-71). In2Track3.

29 Wheel-rail friction measurement in the V-Track

Zhen Yang, Jan Moraal,, Zili Li, *Delft University of Technology / ProRail*

Background

Friction/adhesion management in railway networks is a challenge for infrastructure managers and railway operators. Friction/adhesion at the wheel–rail interface influences the braking and traction performance of railway vehicles and the formation of wheel and rail defects. A minimum level of friction/adhesion must be guaranteed to ensure appropriate braking and traction of vehicles, whereas high friction/adhesion increases wear and rolling contact fatigue (RCF) of wheels and rails, noise emissions and carbon footprint (transportation energy consumption). A crucial part of friction/adhesion management is to reliably measure the wheel–rail friction levels and creepage. A train-borne tribometer is desired because the wheel-rail friction level depends on, among others, the normal contact load and speed. A light vehicle will thus experience adhesion different from a heavy train, and the accuracy of hand-pushed tribometers is adversely affected by scaling and low speed.

Aiming to contribute to the development of a train-borne tribometer for friction/adhesion management, this study conducted a comprehensive lab test in the V-Track in the Railway lab of TU Delft. The V-Track is a downscaled wheel-rail contact test rig consisting of a 4-meter-diameter ring track and 1~4 wheel assemblies running over it with well-controlled and measurable normal load and friction forces. The coefficient of friction (COF) was measured with two schemes: 1. Increase the angle of attack (AoA) to get friction saturation in the lateral direction and 2. Increase the traction/braking torque of the wheel to get friction saturation in the longitudinal direction. The wheel-rail contact forces in the three directions, AoA, wheel rolling speed and rotational/circumferential speed, and traction/braking torques were measured and analysed to obtain the COF of the V-Track.

Increased knowledge and implementable results

Figure 29-1 shows the adhesion levels, in terms of adhesion coefficients (ACs), measured along one V-Track circle in the dry clean condition using scheme 1. The AC is the ratio of the wheel-rail friction force to the normal load, and is thus bounded by the COF. It shows that the AC increases with AoA, and when the AoA is sufficiently large, a trivial increase of AC, if any, is observed with the further increase of AoA . The friction saturation is then considered to be reached and the AC equals COF, which is about 0.45. The measured ACs oscillate due to the presence of wheel/rail surface irregularities. The adhesion levels measured in the same dry clean condition using scheme 2 were analysed as well and compared to the results obtained using scheme 1. Likewise, a trivial increase of the AC was observed with the further increase of wheel torque when the friction saturation was achieved. The corresponding AC, i.e. the COF, is also 0.45, in line with the results measured with scheme 1. The COFs measured by the two approaches can thus be cross-validated.

An interesting finding was also provided. The measurement conducted in a different, also dry clean, track condition showed significant stick–slip contact behaviour when using scheme 1. That track has a lower level of surface roughness/irregularity, indicated by a lower COF=0.35 and less oscillation of ACs for the testing cases without friction saturation. The comparison between the two measurements suggests that the surface roughness/irregularity may act as turbulence and prevent the occurrence of stick-slip.

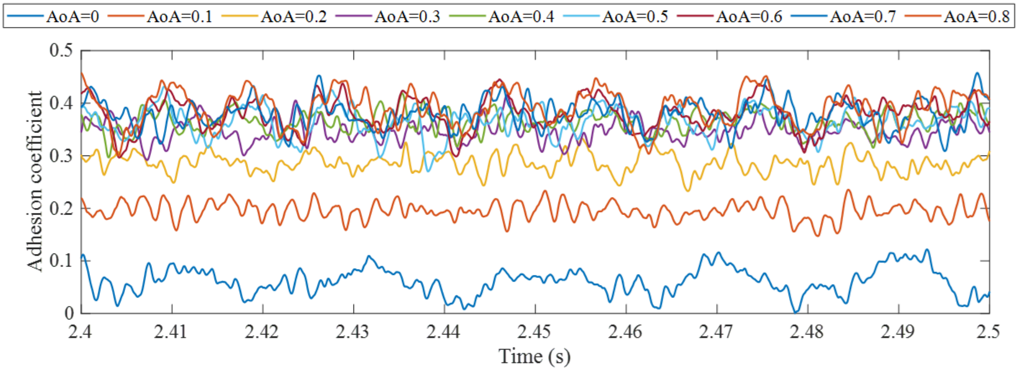

Figure 29-1 Increase of AC with AoA and friction saturation

This study proves the reliability of the wheel-rail friction/adhesion measurement on V-Track by cross-validation of the results obtained with two the measurement schemes, enhances the understanding of the friction saturation process with increasing torque and AoAs, and discovers that under dry contact conditions, the occurrence of stick–slip is determined or affected by wheel–rail surface roughness/irregularity. These may contribute to the development of a train-borne tribometer as well as the mitigation of wheel–rail sliding and squeal by e.g. optimising train acceleration, braking and curving behaviour.

Implementation and open questions

A torque modulation concept will be employed for the development of a no-sliding train-borne tribometer, considering that reliable measurement of wheel - rail creepage is challenging, especially in field conditions. The concept is based on the fact that acting as variable damping, wheel–rail friction causes a phase difference between the wheel torque and angular velocity. This phase difference will be measured in the modulated condition and used to derive the friction behaviour, e.g. in terms of the slope of the creep curve.

The concept has been verified via numerical simulations and will be experimentally validated in the lab. After that, a prototype of the train-borne tribometer, which can reliably measure wheel-rail contact force, wheel torque and angular velocity, is expected to be developed. Note that although the dependence of the friction level on contact stress and rolling speed are considered in the lab test, the V-Track test rig may not fully reproduce real-life wheel - rail contact in the field with greater variations in, e.g. the loading amplitude, contact geometry and environment. The difference in contact behaviour between the downscaled V-Track test rig and full-scale wheel - rail contact will be further investigated.

Deliverable(s): D3.4