Development of "Micro-ribbed Wheel Tread Profile" to Reduce the Lateral Force in Curves

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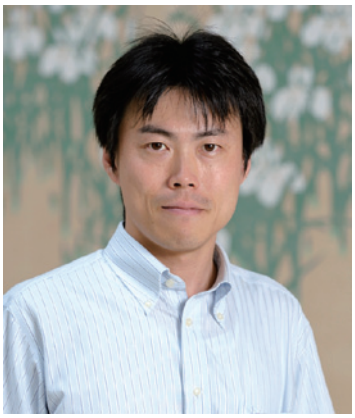

Decreasing the lateral wheel/rail force (tangential force) in curves will increase the margin against derailment and help reduce the maintenance cost of railway vehicles. With this in mind, the Railway Technical Research Institute (RTRI) is now developing a wheel having an appropriately profiled, microscopic rib (micro-rib) on the tread. Research suggests that this will reduce the lateral force during curve negotiation.

1. Tangential fore characteristics with/without microscopic ribs

As a first step, we simulated a combination of rail and wheel in contact by using a simulated rail roller and (1) a wheel roller having a smooth surface, and (2) another two wheel rollers, each having very small ribs machined on the contact surface as shown in Fig 1. With these rollers (hereinafter referred to as specimens), we repeated tests to examine the effect of humidity conditions on the characteristics of the tangential force at the contact surface. We found that the wheel specimens with the smooth surface and the surface with ribs of 1 mm pitch demonstrated similar values of tangential force, even when the humidity is low. A condition that the humidity is lower normally implies that the lubricating effect on the contact surface is smaller, affected by the smaller volume of atmospheric moisture. This means that the coefficient of friction in this state can be regarded as larger than when humidity is higher. The tests of the wheel roller with the larger (3mm) pitch of the peaks of the ribs resulted in smaller derailment coefficients (tangential force divided by wheel load) as shown in Fig. 1.

2. A proposal of "Micro-ribbed wheel tread"

To reduce the lateral force on the wheels of railway vehicles during curve negotiation based on this knowledge, we have proposed a wheel having an microscopic rib, triangular in cross-section, height 150μm and width 12mm, on a circumferential line located away from the flange on the tread, i.e., towards the outside of the tread. Hereinafter this is referred to simply as a "Micro-Ribbed Wheel Tread" and is shown in Fig 2. Figure 2 shows the calculated contact patch profiles between the inside rail and the wheels with conventional profiles and with the micro-ribbed tread. If the wheelset has displaced 5mm or more toward the outside rail, the micro-ribbed wheel tread contacts the rail in the micro-rib area to make the profile of contact patch long and narrow in the longitudinal direction. As a result, the tangential force between rail and wheel on the inside rail becomes smaller according to the characteristics of the tangential force marked Δ in Fig. 1 and the tangential force between rail and wheel on the outside rail becomes smaller correspondingly.

3. The verification of reduction effect of lateral force

To verify the practical validity of the micro-ribbed wheel tread, we implemented a running test with actual vehicles on a dry day (humidity approximately 30%) to measure the lateral force (Y) and the wheel load (Q) and calculated the ratio Y/Q (derailment coefficient). The results are shown in Fig 3. At the initial stage of running, the coefficient of friction between rail and wheel is smaller affected by rust and dirt to make the ratio Y/Q smaller. Rust and dirt are removed, however, after running a certain distance, to make the coefficient of friction and subsequently the ratio Y/Q larger. A comparison between the maximum values of tangential force that works on conventional and micro-ribbed wheels indicates that the ratio Y/Q is smaller with the micro-ribbed wheel tread and larger with the conventional wheel. Furthermore, the difference between the maximum and minimum values of the ratio Y/Q is smaller with the micro-ribbed wheel tread. These phenomena are due to (1) the effect of the tangential force on the inside rail being decreased by the micro-rib on the wheel tread and (2) the characteristics of tangential force being unaffected by the coefficient of friction.

Based on the above, we conclude that an appropriately profiled micro-rib located towards the outside of the tread effectively decreases the lateral force and makes it insusceptible to the coefficient of friction even with actual vehicles.

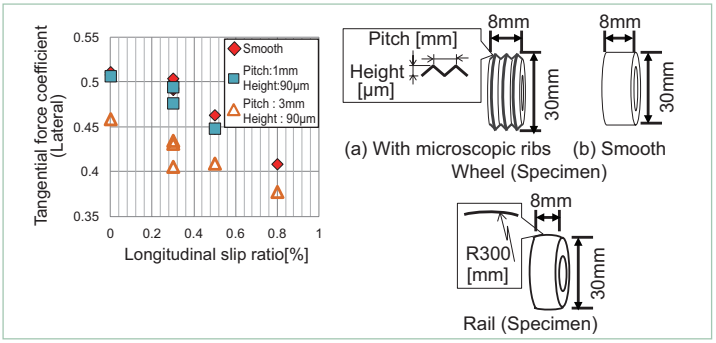

Fig. 1 Relations between contact surface and tangential force coefficient

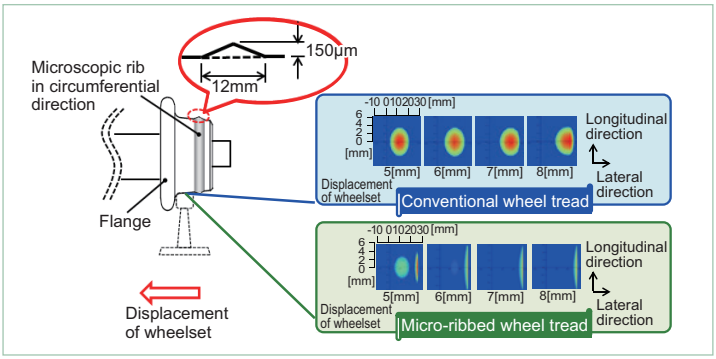

Fig. 2 Numerical analysis results of contact patch between wheel and rail

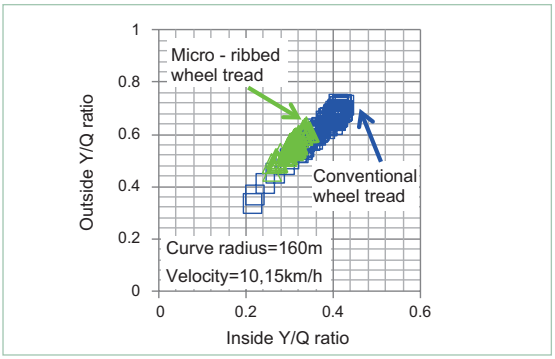

Fig. 3 Reduction effect of lateral force on the wheel tread