Measurement of Wheel Flange/Rail Gauge Corner Contact Conditions

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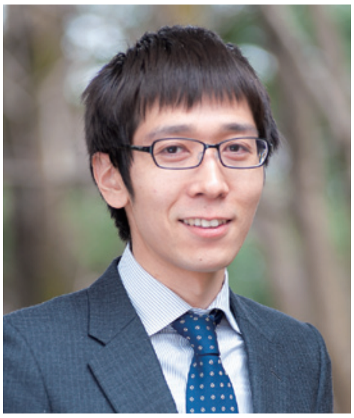
The wheels and rails used in railways, while playing a fundamental role in supporting rolling stock, transmit driving (traction) forces, guide trains in the running direction. They are also important to operation of the signal system and feeding circuits (track circuits). Knowledge of the phenomena taking place at the contact point between wheel and rail enables railway operators to establish measures against various problems such as vibration, noise, wheel skids and slips, and derailment. To investigate certain phenomena such as flange climb derailment, wear and noise, etc., occurring at the wheel/rail gauge corner contact point when trains pass sharp curves or turnouts, we are now developing a technique to measure the contact area and the distribution of contact pressure at the contact point. This technique is currently being used in laboratory studies by applying an ultrasonic measuring method.

Figure 1 shows the principle of ultrasonic measurement and the measuring system used in this study. The sound wave radiated from an ultrasonic probe transmits to the contact area, reflects at the non-contact area and returns to the probe. The intensity of the reflected wave (known as the "echo height") decreases as the contact pressure increases, and thus we are able to estimate the contact conditions between two surfaces. Two-dimensional scanning in parallel to the contact surface with a probe gives the contact area configuration and the distribution of contact pressure.

In this study, we used a wheel/rail contact unit testing machine. Figure 2 illustrates the testing machine and installation of measuring instruments. The testing machine uses an actual wheel and a short length of rail placed upside down on its top. To achieve a wheel/rail loading condition, the rail is hydraulically loaded in the axial load direction to generate an axial (vertical) load up to a maximum of 50 kN. A maximum force of 40 kN can be applied in the lateral direction. We radiated an ultrasonic wave from a notch machined on the flange back surface. The position of rail was adjusted to contact the wheel flange on the straight portion.



Regarding the area where the wheel flange and the rail gauge corner are statically in contact, Fig. 3 compares the experimental result obtained with the ultrasonic method with that obtained from pressure sensitive paper and that calculated by applying Kalker's exact theory. The contact area measured with pressure sensitive paper is larger than that obtained by the ultrasonic method, presumably because the former presents a configuration that is affected by the thickness of the pressure sensitive paper. On the other hand, a comparison of the results of calculation and ultrasonic measurement indicate that the two are comparatively in good agreement, though the former is a little smaller.

We also measured the distribution of contact pressure between flange and rail in the cases (i) where cutting traces (turning marks) remain on the wheel surface and (ii) cutting traces are worn due to the contact between wheel and rail (see the top of Fig. 4). The measurement results using the ultrasonic method are shown at the bottom of Fig. 4. A comparison between the two cases shows that the pressure distribution is comparatively smooth in (i), while it presents a saw-toothed configuration in (ii). It is thought in qualitative terms that the pressure contribution changes to a great extent within the contact area that is affected by the rolling of the cut (turned) wheel.

We will improve the measuring technique further and study the wheel flange/rail gauge corner contact phenomenon in the case where the wheel is rotating and generates a tangential force.

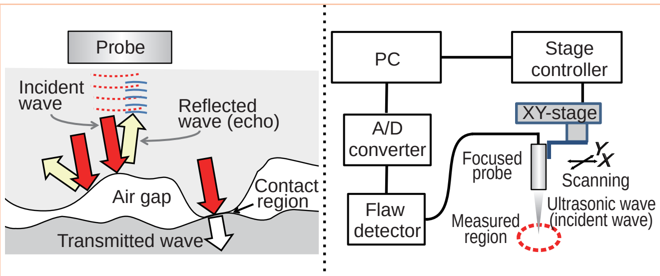


Fig. 1 Principle of ultrasonic measurement and a measuring system

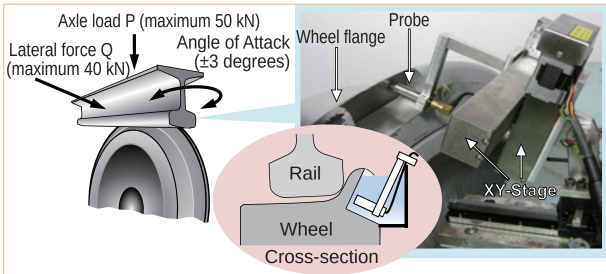


Fig. 2 Testing machine and installation of measuring instruments

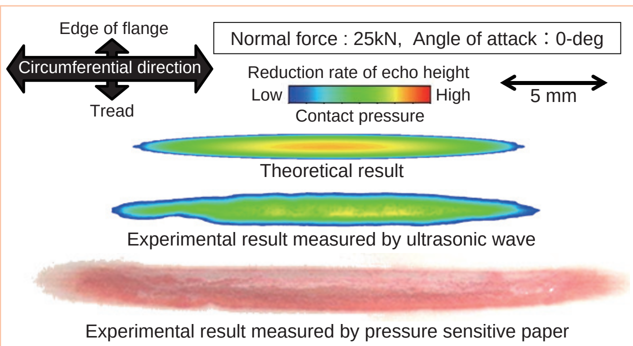


Fig. 3 Results obtained through calculation, measurement with pressure sensitive paper and application of the ultrasonic measuring method

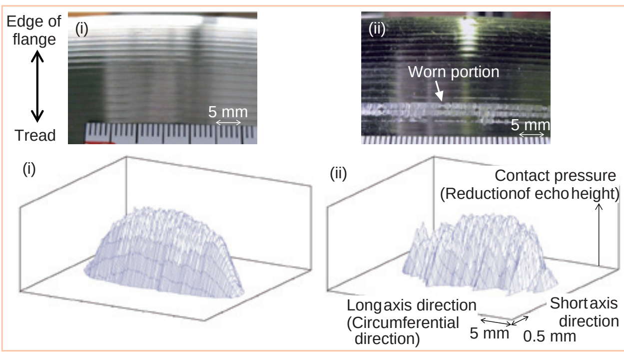


Fig. 4 Pressure distributions at the flange/rail contact point in the case (i) where cutting traces remain on the wheel surface and (ii) where cutting traces are worn due to the contact between wheel and rail