Research on the Prediction and Evaluation Method of Rolling Noise

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Railway noise is generated from various components that form the track and rolling stock. In the case of railways in Japan, rolling noise is a significant sound source. Rolling noise is generated by the vibration of wheels and rails due to the forces of wheel/rail interaction, caused by micron-order roughness existing on the surface of wheels and rails (Fig. 1). In order to understand how rolling noise is generated, RTRI has conducted research on the roughness distribution on the surface of wheels and rails and on the vibration and acoustic characteristics of wheels and track by carrying out field tests and numerical simulation. Further, RTRI has developed vibration and acoustic models related to the generation of rolling noise. These models are based on the concept of TWINS (Track-Wheel Interaction Noise Software), which is widely used in Europe.

Validation of the vibration/acoustic models was carried out on four sections of railway lines. It was found that the predicted results show good agreement with the measured results. The difference in noise level was about 1 dB on average and standard deviation was about 3 dB (Fig. 2). In determining the contribution of each sound source to the total rolling noise generated on meter-gauge lines, it was evident that rails are the main sound source in the frequency range of 500 to 1,600 Hz, and that wheels are the dominant sound source above 2,500 Hz (Fig. 3).

RTRI next quantified the effects of various wheel/track parameters on the generation of rolling noise by using the models, and then proceeded to develop measures to reduce noise (Fig. 4). Controlling the roughness of wheels and rails has a great effect on rolling noise. In particular, it was found that rail grinding reduces rolling noise by up to about 7 dB on sections where rail roughness has not been controlled. Rolling noise also depends on rail pad stiffness. Soft rail pads, have been applied as one way of reducing noise on bridges. However, soft rail pads increase rolling noise, especially noise generated by the rails. This is due to the fact that: (1) rail vibration is increased at lower frequencies; (2) rail vibration propagates for a long distance along the rail. Increasing the loss factor of the rails by installing rail dampers has the effect of reducing rolling noise by about 1 dB. This is because the damper increases the track decay rate, and then reduces the effective noise radiation length. Installing damping devices on wheels such as damping rings has a small effect on the total rolling noise. This is because: (1) damping devices such as damping rings are effective for only a few wheel vibration modes; (2) the damping generated on wheels when running on rails is greater than that attained by the damping rings. These results have been partly verified by the measured results. By using the models, it has become possible to investigate the mechanism of noise reduction for measures taken to reduce rolling noise which has not been clarified until now. It has also been possible to quantitatively evaluate the effect of noise reduction measures depending on the proportion of the total rolling noise contributed by each sound source. From now on, RTRI is going to work on improving the accuracy of the models, and to carry out research and development related to the impact noise generated by wheel flats and rail joints.

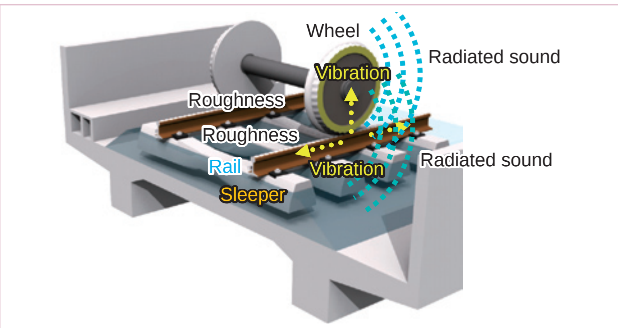

Fig. 1 Generation mechanism for rolling noise

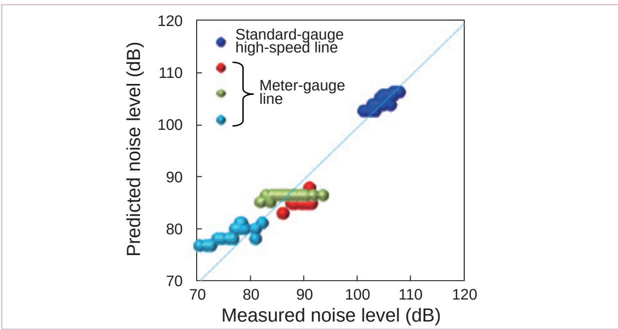

Fig. 2 Validation of the vibration/acoustic models

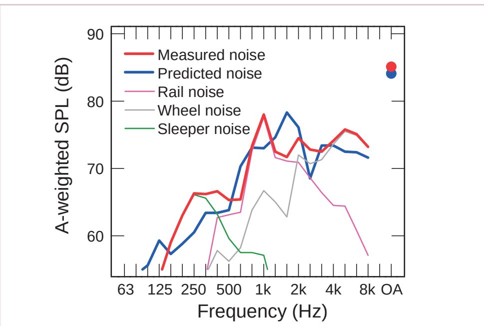

Fig. 3 Contribution of each sound source to rolling noise (meter-gauge line, 80 km/h, ballasted track)

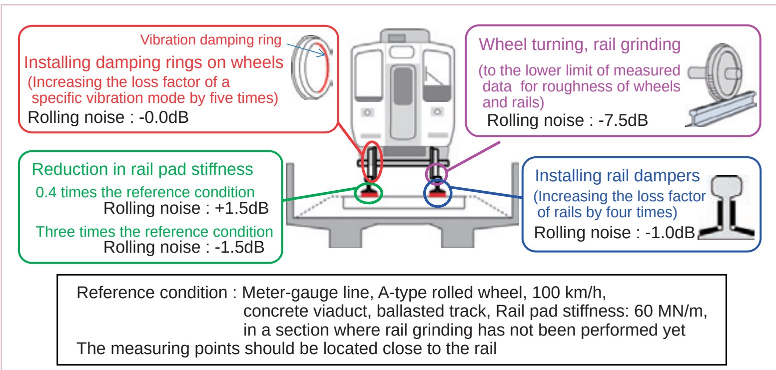

Fig. 4 Noise reduction effects using the models