A Measure to Reduce Contact Wire Wear in Shinkansen Overlap Sections

Masatoshi SHIMIZU
Senior Researcher, Contact Line Structures, Power Supply Technology Division

The Shinkansen overlap section consists of four spans, in which the height of two contact wires are changed, up for one and down for the other, at their central supporting point. Compared with the contact wire in the ordinary section, the one in the overlap section tends to wear easily. This is a weak point in the overlap equipment (e.g., the contact wire needs to be replaced relatively frequently). It is possible to reduce the wear of the contact wire in an overlap section by setting the contact wire height and deviation properly.

Fig. 1 shows an example of measured wear, height and deviation of contact wires in an overlap section. In the figure, wire A is the contact wire with which the pantograph makes contact before it passes through the overlap, and wire B is the contact wire with which the pantograph makes contact after it passes through the overlap.

In the overlap, the wear of wire B is conspicuous. The wear of the wire portion enclosed with circle 1 has occurred within a relatively narrow range. It is due to an improper height of the wire (wire B is 20 mm down at the intersecting point). On the other hand, the wire portion enclosed with flattened circle 2 has worn uniformly in a wide range. This range coincides with the one in which the wire deviation is 150 mm or more. Thus, the wear is due to a large deviation of the wire. The deviation of 150 mm is the standard deviation set for the contact wire in the ordinary section.

When the contact wire height in the overlap section is set improperly, the contact wire is subject to impact and vibration, which cause the contact force with the pantograph to increase. This in turn causes the wear of the contact wire to increase. Fig. 2 shows the contact force characteristic obtained by a dynamic simulation of a catenary/pantograph system. It can be seen from the figure that the overlap configuration that permits the pantograph to move smoothly without being subject to impact is one in which wire B is set about 20 mm higher than wire A.

In the overlap section, the standard space between the right and left contact wires is 300 mm. Because of this, the contact wire deviation in the overlap section tends to become larger than that in the ordinary section (standard deviation: 150 mm).

The contact wire used for the Shinkansen is made of copper alloy, and the slider is made of iron-based sintered metal which has lubricating ability. As the slider slides along the contact wire, the metal having lubricating ability and a low melting point melts and deposits on the sliding surface, thereby preventing the wear due to friction between the contact wire and the slider (Fig. 3).

Fig. 4 shows the relationship between the rate of contact wire wear relative to deviation and the rate of deposition of the metal having lubricating ability on the sliding surface. As the deviation exceeds 150 mm, the rate of metal deposition decreases and the rate of contact wire wear increases. Fig. 5 shows a thermograph of a pantograph in operation. It can be seen that the slider portion corresponding to the deviation of 150 mm or less has turned white, indicating that its temperature has risen. On the other hand, the temperature of the slider portion corresponding to deviations greater than 150 mm has remained the same. This accounts for the low rate of deposition of the metal having lubricating effect and the high rate of contact wire wear where the contact wire deviation is large.

From the facts mentioned above, in order to reduce the wear of contact wire in the Shinkansen overlap section, it is effective to set wire B about 20 mm higher than wire A and keep the contact wire deviation within about 150 mm.

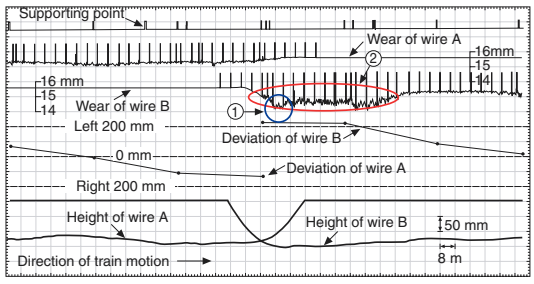

Figure 1. Example of measured contact wire wear in overlap section.

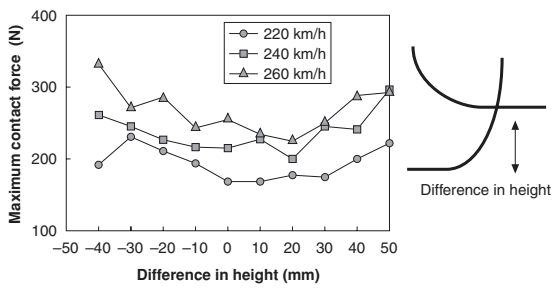

Figure 2. Results of dynamic simulation of contact force.

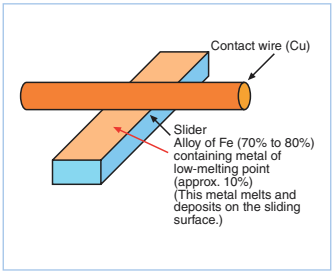

Figure 3. Mechanism that reduces frictional wear of Shinkansen contact wire.

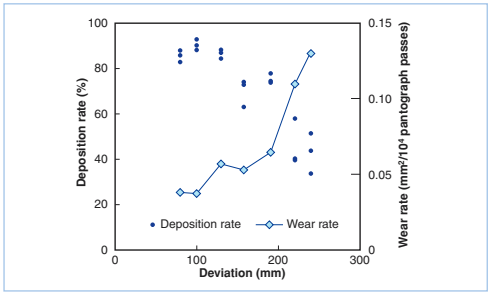

Figure 4. Correlation of contact wire deviation and wear rate and metal deposition rate.

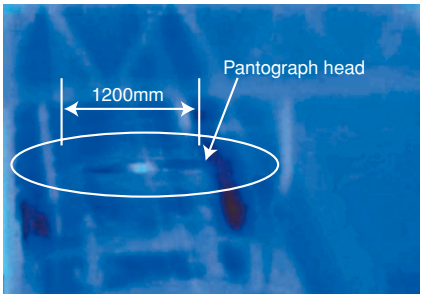

Figure 5. Thermograph of pantograph in operation.