Preventing Excessive Temperatures of the Overhead Contact Wire When Rapidly Recharging Battery-Powered Trains

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1. Introduction

A battery-powered electric train is recharged while it is in electrified sections, and then runs in non-electrified sections by consuming the power stored in the batteries. Recharging is carried out while the train is stopped at a station or other facility by use of the contact wire and pantograph. However, the re-charging process creates heat and when the contact wire temperature reaches 90 °C, it begins to soften. Since the catenary wire is under tension, wire breakage can occur in the worst case. The thickness of the film on the contact wire at the contact point between it and the pantograph has a significant influence on the temperature rise of the contact wire. However, the relationships between the film growth rate, the film thickness and the contact resistance have not been quantified sufficiently.

Hence, we have worked to determine the relationships between the condition of the contact point and temperature rise by conducting simulations to examine the temperature rise under a variety of conditions. The research has resulted in the formulation of a proposal for maintenance work to alleviate the potential problem of excessive contact wire temperatures.

2. Test results and simulation schemes

Figure 1 shows the relationships between contact wire film thickness and number of exposure days. The data were obtained from a contact wire exposure test. The film is found to grow thicker with the number of exposure days. It was noted that the film thickness reached 4 μm in about one year and the contact resistance increased to 2.23 mΩ. Figure 2 shows a simulation result about the relationships between collection current and contact wire temperature rise in the catenary wire. The recharging current for the present battery-powered train in the catenary wire section is 250 A. If it is recharged with this current value, the temperature of the contact wire exceeds 90 °C when the contact resistance is 2.23 mΩ. As discussed before, the elapsed time to reach the resistance of 2.23 mΩ was about one year, and thus, grinding the surface of contact wire is required every six months including a certain allowance for the maintenance servicing.

For the simulation, we apply an electric field and thermal conductivity analysis through a finite element method. With this approach, the study of temperature rise in various pantograph shapes and contact point conditions has been made feasible.

3. Conclusion

There is a concern that the rapid recharging of battery-powered trains by using the catenary wire and pantographs can potentially cause a sharp temperature rise of the contact wire, with consequent wire breakage depending on conditions. Notably, the adverse effect of the film on the wire as a cause of temperature rise had not been clarified sufficiently. Through this research, we are recommending that grinding the contact wire once every six months is an appropriate standard for maintenance planning.

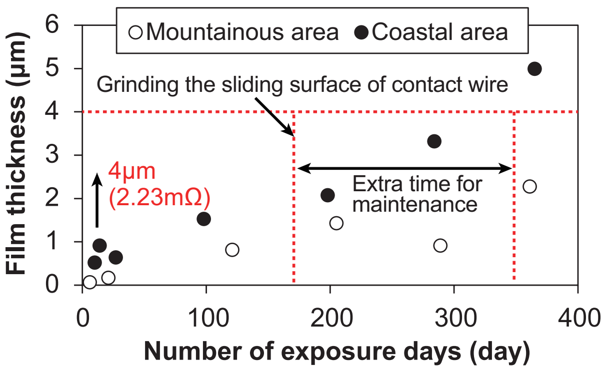

Fig. 1 Relationships between the number of exposure days and film thickness

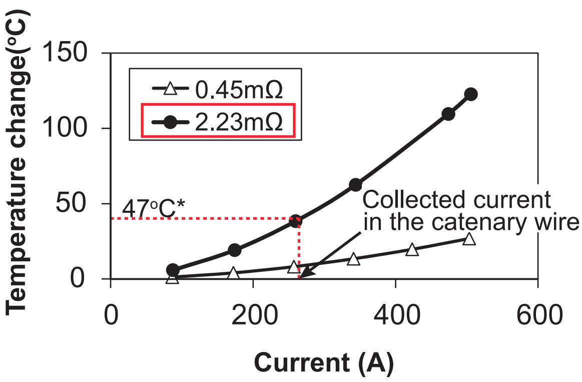

Fig. 2 Relationships between current and temperature rise
* Allowable temperature rise assuming the outdoor temperature to be 43 °C