ELECTROMECHANICAL WEAR PROPERTIES OF METAL/CARBON COMPOSITE SLIDERS

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INTRODUCTION

Reduction of maintenance is demanded in electric railways. Wear reduction of contact wire is demanded strongly in contact wire / pantograph system. It is known that use of carbon materials as contact strip is effective to reduce wear of contact wire. However the conventional carbon materials cannot endure the high speed and the heavy current load of recent rolling stocks any more. Then it is necessary to raise mechanical strength and to lower electrical resistivity. The authors have developed a composite material that possesses the required properties by efficiently impregnating metal into carbon. In this paper, wear properties of the composite material have been studied with the laboratory wear test and the field test.

EXPERIMENTAL

Wear rates of the contact strips are simulated with a revolving copper disc (5.0 mm thick and has a diameter of 1000 mm) representing the contact wire, and one or two shaped contact strips 25.0 mm wide in the direction of sliding. The strip is pressed against the periphery of the disc and is held stationary. The disc surface was made rough by abrasion with a contact strip made of sintered copper alloy to imitate the effect of actual contact wire. The roughness was not measured.

The developed metal/carbon composite is impregnated with copper and tin alloy. Its base carbon material also has been examined. Their physical properties are shown in Table 1. The microscopic structure of the composite is shown in Figure 1.

The wear performance at speed 100km/h under the static contact force (49N) is examined with and without current collection. The dependence of the wear rate on the current density (0-320 A/cm^2 DC 100V) and the percentage contact loss has been determined. The time of sliding is 30 minutes. The results of the lab-test quoted here are in terms of the specific wear rate.

RESULTS AND DISCUSSION

Wear rates of the composite material and its base material are shown in Figure 2. The wear of both materials depends on the current density. As for metal impregnation material, it is less worn than its base material.

Figure 3 represents wear rate of the composite as area of circle. Ordinate represents the percentage contact loss and abscissa does the current density. Without arcing (percentage contact loss = 0), the current hardly affects the wear. When arcing occurs (percentage contact loss $\neq$ 0), the effect of current on wear is remarkable, in particular, when percentage contact loss is high. We have observed in the structure near the surface of test piece that arcing was heavy, and that the quantity of impregnation metal had been reduced in neighborhood of sliding surface (Figure 4). Impregnation metal is supposed to have been evaporated by heat of arcing and in consequence the quantity of metal dropped. As shown in Figure 2, wear performance is improved by metal impregnation. We can suppose that wear resistance drops by the reduction of quantity of metal, thereby promoting the wear.

We have installed the developed material to pantographs of various DC electrified vehicles and have measured the wear rates. Figure 5 shows the results of the field tests, representing the wear rate as area of circle. Ordinate represents the maximum travelling speed of the vehicles and abscissa does the collecting current density. Wear is found to depend on the speed and current density. It is known that the percentage contact loss increases according to the travelling speed. On the analogy of the percentage contact loss to the maximum travelling speed, it can be said that the wear of the actual vehicles also depends on contact loss and current density.

CONCLUSIONS

The developed metal/carbon composite material for the pantograph slider has been examined. Results of the laboratory wear tests show that wear resistance has been improved with metal impregnation, and that the wear depends on the density of collecting current and the percentage contact loss. It seems that impregnation metal evaporates with arcing that occurs and in consequence the wear resistance of the strip drops, thereby promoting the wear. For pantographs installed in actual vehicles, travelling speed and collecting current density are the factors causing the wear of the strips.

Table 1: Physical properties of the examined materials

Material	Bulk Density (g/cm³)	Electric Resistivity (μΩm)	Hardness (HS)	Flexural Strength (MPa)
Composite	3.0	2.7	85	120
Base Carbon	1.5	55	87	50

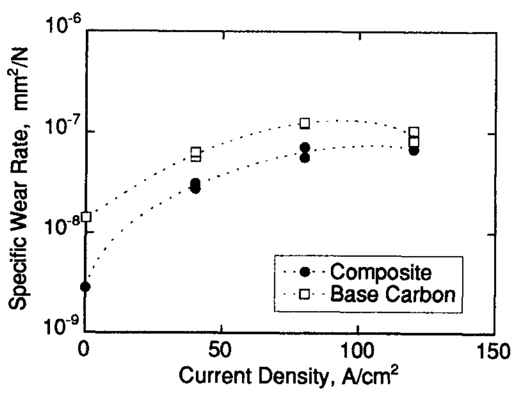

Figure 2 : Comparison of wear rates (the composite vs. its base carbon)

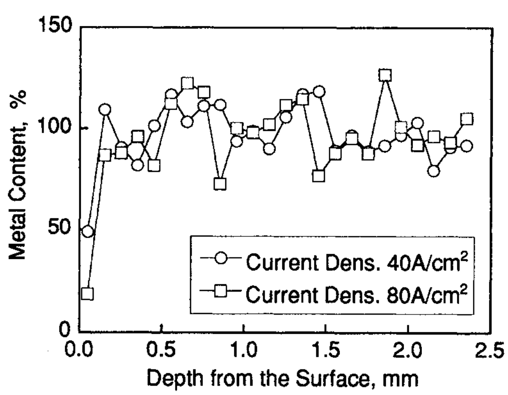

Figure 4 : Metal Content near the Contact Surface

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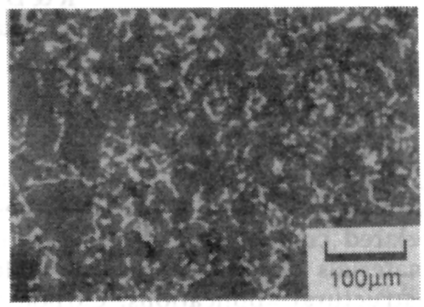

Figure 1 : Microscopic structure of the composite

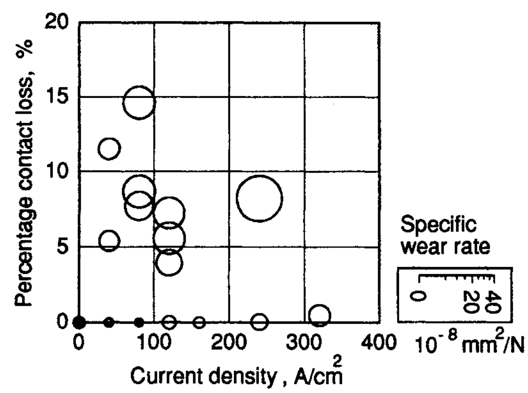

Figure 3 : Wear vs. current density, percentage contact loss

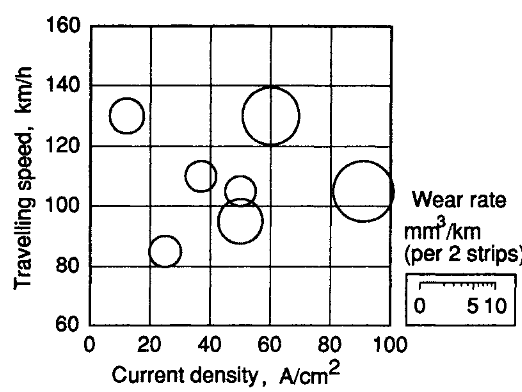

Figure 5 : Wear vs. current density, maximum travelling speed