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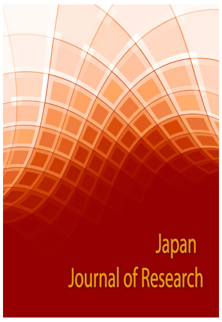

Dynamic Characteristics of Iced Pantograph-Catenary System

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Abstract

Ice coating on overhead contact system (OCS) will affect the sliding of pantograph and arc discharge phenomena will occur between pantograph and catenary, which will threaten the normal operation of train. At present, there are three different methods to equivalent the ice coating on OCS. The increased density method, uniform load method and combinatorial material method of icing are used to analyze the icing problem of pantograph-catenary (PAC) system. The dynamic response of the PAC system with icing is compared and analyzed by different methods. The results show that with the increase of icing thickness, the current collection quality of PAC system becomes worse..

Keywords

overhead contact system (OCS); pantograph-catenary (PAC); current collection quality, ice coating

Introduction

The problem of catenary icing is becoming more and more serious [1-2]. Catenary icing will bring a series of hazards, such as aggravating the generation of arc, causing low-frequency and large-scale vibration of catenary, reducing the current collection quality of PAC, etc [3-4]. Jamaleddine [5] considered the overhead transmission line as a load uniformly distributed on the cable, and simulates the process of cable icing and deicing by adding load and undoing the load. Duan [6] equivalent the ice quality to the catenary system, that is, by increasing the line density of the contact wire and the messenger wire to simulate the icing of the catenary system, and studied the influence of icing thickness on the current collection performance of the pantograph-catenary system. Yao [7] used the composite material method to study the icing problem of catenary system, and compared the differences of different methods to study the icing problem of OCS. This paper compares and analyzes the influence of icing on current collection quality of PAC when the train passes through the iced OCS by different methods.

Three Different Ice-coating Models

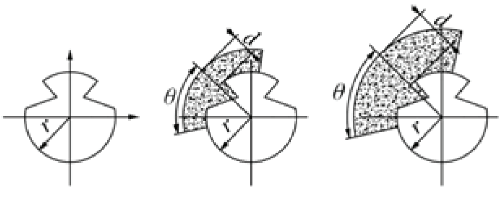
It is assumed that the ice-covering shape of the cable is fan-shaped. The ice-covering section is shown in Figure 1. λ is defined as the ratio of ice thickness *d* to cable radius *r*.

$$\lambda = \frac{d}{r} \quad \text{.....................................} \tag{1}$$

The first method is the increase density method, which regards icing as an increase in the density of the cable. The change in the shape of the cable after icing was not considered, and the inertial effect caused by icing was considered. The density of the iced cable can be written as

$$\rho' = \frac{\theta}{2\pi}\left(\lambda^2 + 2\lambda\right)\rho_{ice} + \rho_{wire} \quad \text{.....................} \tag{2}$$

Where, ρ_{ice} is the density of ice and ρ_{wire} is the density of cable .



(a) d=0 (No Ice) (b) d=r/2 (c) d=r

Figure 1. *Cross section diagram of cables with different icing thickness*

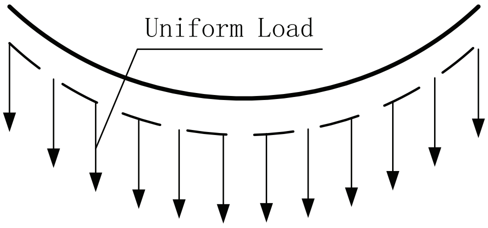


Figure 2. *Uniform load on cable*

The second method is the uniform load method, which applies ice as a load on the catenary system (as shown in Figure. 2), regardless of the shape and inertia of the ice. Here, the tension of catenary does not change with the application of uniform load.

The third method is combinatorial material method, which takes into account the change of cable shape and inertia characteristics after icing. The ice and the cable are regarded as a coupled whole. The material properties of the ice-wire coupling system are determined by the properties of the cable and the ice, and are affected by the respective proportions of the

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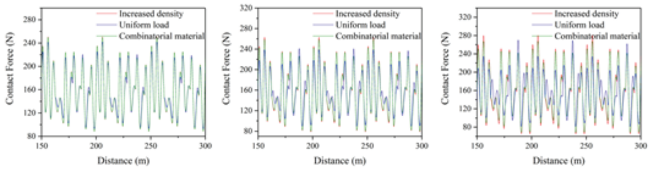
two materials. The performance of ice-wire coupling system can be calculated by equation (3).

$$\begin{cases} EI = E_{wire}I_{wire} + E_{ice}I_{ice} \\ EA = E_{wire}A_{wire} + E_{ice}A_{ice} \\ GA = G_{wire}A_{wire} + G_{ice}A_{ice} \end{cases} \quad \text{.....................}(3)$$

Where E, A, I, G are the elastic modulus, cross-sectional area, the moment of inertia and modulus of rigidity of the cable with no ice; $E_{wire}, A_{wire}, I_{wire}, G_{wire}$ are the elastic modulus, cross-sectional area, the moment of inertia and modulus of rigidity of the cable after icing; $E_{ice}, A_{ice}, I_{ice}, G_{ice}$ are the elastic modulus, cross-sectional area, the moment of inertia and modulus of rigidity of ice.

Case

Taking a train passing through the iced OCS at the speed of 300km/h as an example. When the ratio of icing thickness to cable radius is 1, 2 and 3 respectively, the time history of contact force is shown in Figure.3. It can be seen from the figure that the amplitude of contact force increases with the increase of icing thickness. Moreover, with the increase of icing thickness, the difference of contact force calculated by the three methods becomes obvious.



(a) λ=1 (b) λ=2 (c) λ=3

Figure 3. *The contact force with different icing thickness calculated by different methods.*

Conclusion

In this paper, three different methods are used to calculate the variation of the current collection quality of the iced PAC system with the icing thickness. With the increase of icing thickness, the fluctuation range of contact force increases, which indicates that the current collection quality of PAC becomes worse. In addition, the difference of the results of the three methods increases with the increase of icing thickness.

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