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Anti-vibration Measures of Ultrahigh Strength Steel Cored Aluminum Strand for Long-Span Overhead Line

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Abstract: *It is the key issue for long-span overhead line to take anti-vibration measures for the ultrahigh strength steel cored aluminum strand. Taking the ultrahigh strength steel cored aluminum strand JLHA1/G6A-500/230 as the example, the aeolian vibration control measure for ultrahigh strength steel cored aluminum strand is tested based on the balance principle of conductor aeolian vibration. The result shows that the dynamic bending strain of the conductors exceeds$120\times l0^{-6}$ when the test frequencies are in the range of 14Hz~70 Hz. In order to reduce the dynamic bending strain of the conductors, the anti-vibration measure of the β damping wires combined with vibration dampers is used. The β damping wires have very good energy dissipation capacity within wide frequencies. The layout of the damping wires is designed as combinations of 3.8 m , 3.2 m, 2.7 m...0.9msingle lace damping lines respectively, two vibration dampers are arranged in the mid span of the first and second damping wires. After taking the anti-vibration measure, the maximum dynamic bending strains of the conductors is controlled below $120\times l0^{-6}$, which meet the standard requirements. This study provides useful reference for long-span overhead line.*

Keywords: *aeolian vibration, anti-vibration measure, β damping wire, vibration damper*

1. Introduction

Long-span overhead transmission lines have the characteristics of large span, high suspension point and complex terrain, which are prone to aeolian vibration [1,2]. At present, scholars at home and abroad have carried out extensive research on Aeolian Vibration of transmission lines and achieved a lot of results. Reference [3] studies the self damping characteristics of transmission lines and the vibration damping performance of vibration dampers. It is found that the vibration response of conductors is closely related to factors such as operating tension and installation mode of vibration dampers. Reference [4] studies the energy dissipation characteristics of a new vibration damping device for the transmission line, and finds that the vibration damping effect can meet the engineering requirements. In reference [5], the influence of conductor stiffness on Aeolian Vibration of conductor is studied by finite element method. It is found that ignoring bending stiffness will underestimate the aeolian vibration amplitude of high-frequency vibration. In this paper, the anti-vibration measure of the *β* damping wires combined with vibration dampers for the JLHA1/G6A-500/230 conductor is analysed based on the improved energy balance method. It can effectively reduce the aeolian vibration of the conductor and provide strong support for the safe operation of long-span overhead transmission line.

2. Experimental Design

2.1 Test equipment and materials

According to the test requirements of IEEE [6], the anti vibration test scheme for the JLHA1/G6A-500/230 conductor is given. The properties of the conductors are presented in Table 1，and the general layout of the test is shown in Fig. 1. As shown in Fig. 1, the whole set of test device is mainly composed of tensioning system, suspension and fixing system, excitation system and signal acquisition system. The electromagnetic vibration system is selected as the excitation system, which can provide sinusoidal sweep excitation signal [7]. The acquisition system adopts DHDAS data collector to collect displacement, acceleration and excitation signals in real time[8]. The contact eddy current sensor is

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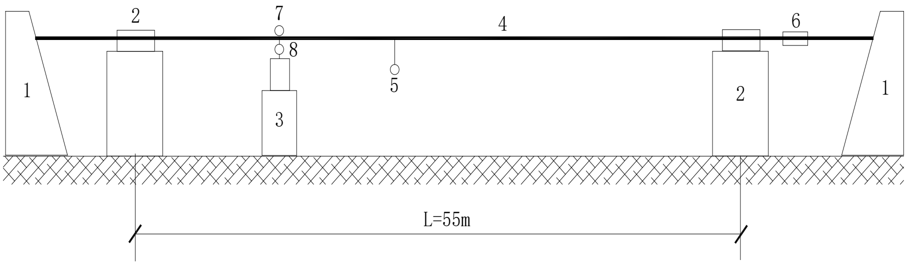
used to measure the amplitude A_0 at the antinode of the conductor. The wire tension, vibration excitation force and acceleration are measured by cable force sensor, force sensor and acceleration sensor respectively. The sensor shall be debugged before the test, and the test can be started after the conductor vibration is stable. Tension has a great influence on the frequency, amplitude and dynamic bending strain of aeolian vibration of long-span transmission lines. It is necessary to accurately control the tension in the test. Therefore, in this test, the cable force dynamic apparatus, which has the characteristics of fast detection speed, high precision, small volume and light weight, is selected to measure the conductor tension.

Table 1: The properties of the conductors (Type: JLHA1/G6A-500/230)

Items			Unit	
Construction	Aluminum wires	Outer Number/diameter	Number/mm	42/3.9
	Galvanized steel wires	Number/diameter	Number/mm	37/2.8
Calculation section		Summation	mm^2	731.7
		Aluminum	mm^2	503.9
		Steel	mm^2	227.8
External diameter			mm	35.1
Unit length quality			kg/km	3173.5
Rated tensile Strength(RTS)			kN	509.0
Elastic Modulus			GPa	97.0



1)fixture 2)vibration device 4)conductor 5)displacement sensor 6)load sensor 7)acceleration sensor 8)force sensor

Figure 1: The test installment for the conductors (Type:JLHA1/G6A-500/230)

2.2 Self damping power test

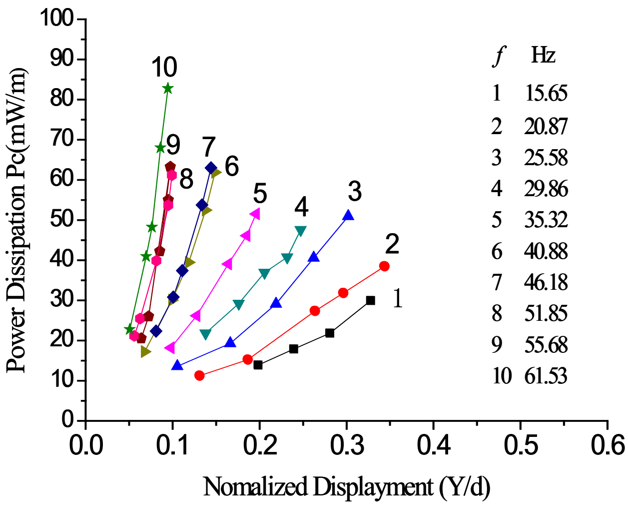


Figure 2: Self-damping characteristic curve with 20% RTS (Type: JLHA1/G6A-500/230)

The indoor simulation test of long-span transmission line is to apply the alternating force of excitation simulation on the JLHA1/G6A-500/230 conductors, measure the acceleration, displacement at the wave fronts and excitation force of the conductors under various working conditions by changing the operating tension and excitation frequency, then obtain the self damping power of the conductors

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according to the power method and energy balance principle, draw the self damping energy dissipation characteristic curve, and finally obtain the analytical formula of the self damping power of the test conductors. The test excitation frequency is 15Hz~65Hz, one working condition is every 5Hz, and multiple amplitudes are selected at each frequency for test. The tension system is used to apply 20% RTS tension to the conductors. As shown in Figure 2， the collected data are filtered, integrated and processed based on the wind input power $P_w=F_yV_y\cos\Phi$ (Φ is the phase difference between F_y and V_y) to obtain the self-damping characteristic curve of the conductors

It can be seen from Figure 2 that when the relative amplitude *Y/D* is constant and the frequency is larger, the power consumed by the wire self damping is more; In double logarithmic coordinates, the self damping power is linearly related to the relative amplitude, and the slope at each frequency is the same. According to the method introduced in literature [8], when the tension is 20% RTS, the analytical formula of the self damping of the JLHA1/G6A-500/230 conductors is:

$$P_c = 10^{1.565+0.048f}(Y/D)^{1.188+0.011f} \tag{1}$$

2.3 Vibration reduction scheme

For the JLHA1/G6A-500/230 conductors with span of 1790m, the anti-vibration scheme layout for JLHA1/G6A-500/230 conductors is shown figure 3. The type of β damping wires used in the vibration reduction scheme is JL/G1A-630/45, the distance between the suspension point of the β damping wires and suspension clamps is 1.0m, and the suspension point is just at the antinode point, so the vibration reduction effect is the best. The layout of the damping wires is designed as combinations of 3.8 m , 3.2 m, 2.7 m...0.9m single lace damping lines respectively. The layout scheme of the β damping wires decreases from the suspension point to the outer chord length. In addition, in order to further reduce the dynamic bending strain of the conductor near the suspension clamps, two Stockbridge vibration dampers (Type: FR-14NL/51,FR-8NL/51) are arranged in the mid span of the first and second damping wires.

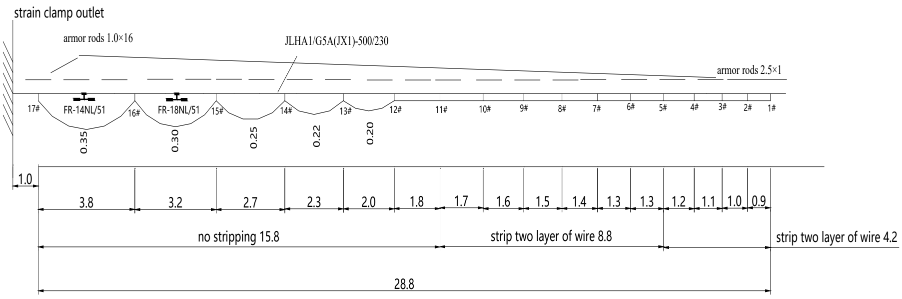

Figure 3 : Anti-vibration scheme layout for the conductor (Type:JLHA1/G6A-500/230)

2.4 Test Result

The aeolian vibration response of the JLHA1/G6A-500/230 conductor with and without anti-vibration dampers were tested based on the test installment. The vibration response measurements were done for the conductors under 20%RTS tension(95.00kN). The figure.4 depicted the vibration response of the JLHA1/G6A-500/230 conductor. It can be seen from the graph that the dynamic bending strain of the conductor exceeds 120×10^{-6} when the test frequencies are in the range of 14Hz ~70Hz. Considering the deficiency of energy consumption in this frequency range of the conductor, the anti vibration scheme of them β damping wires combined with FR dampers was used. The anti vibration scheme can respond to most of the frequencies experienced over the range of wind speeds causing vibration because the long festoon damping wires have very good energy dissipation capacity at low frequencies and the short festoon damping wires have very good energy dissipation capacity at high frequencies. As shown in Fig.3, the maximum dynamic bending strains of the JLHA1/G6A-500/230 conductor is greatly reduced after installation of damping devices, which are the β damping wires combined with FR dampers and the strain of the conductor with this measure can be controlled below 120×10^{-6} so as to meet the standard requirements.

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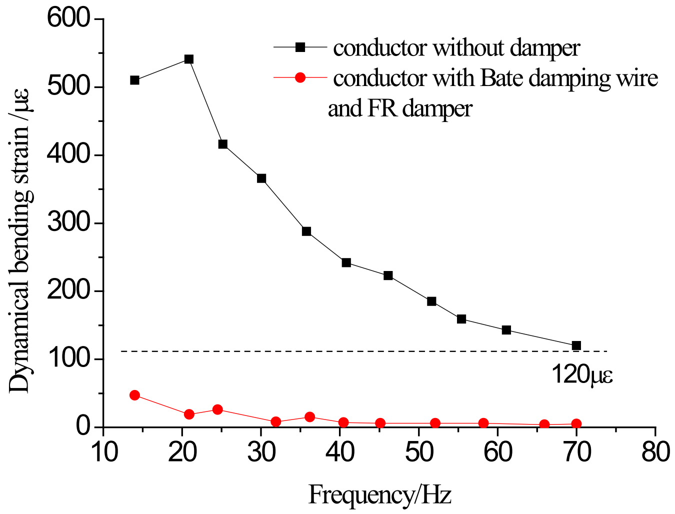

Figure 4: Maximum dynamic bending strain of the conductor (Type: JLHA1/G6A-500/230)

3. Conclusions

1) The maximum dynamic bending strain of the JLHA1/G6A-500/230 conductor exceeds 120×10^{-6} under the conduction of 20%RTS tension.

2) The anti-vibration measure, which is the β damping wires combined with vibration dampers , can greatly reduce the maximum dynamic bending strains of the JLHA1/G6A-500/230 conductor and the maximum dynamic bending strain of the conductor with the measure can be controlled below 120×10^{-6} .

Acknowledgments

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