Application and Research of Composite Insulators on the ACCC Conductor

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Keywords: ACCC, composite insulator, identification test

Abstract. This paper based on the 220kV ACCC wire part of Liao Yuan line composite insulator for insulating properties, mechanical properties and material performance testing, a comprehensive assessment of the effect of high temperature on the properties, define physical stability and reliability, composite insulator in determining long-term operation under high temperature wire provide guidance and recommendations for the application of composite insulator in ACCC on the conductor.

Introduction

At present, transmission lines in China widely used steel core aluminum stranded conductor (the ACSR wire), maximum use temperature of 100C. Composite insulator is insulating element universal application of transmission line, the curing temperature of mandrel is 170 to 180 C, the umbrella cover injection molding temperature 140 to 160 C, heat resistance in the operation stability, composite insulating materials can effectively curb the pollution flashover accident, reduce the insulator cleaning and zero value detection operation and maintenance management, to the decisive effect to enhance the safe operation of power transmission and transformation equipment up[1-3].

Carbon fiber composite core conductor (the ACCC wire) is high quality transmission conductor material model, compared with the conventional ACSR conductors, and has the advantages of light weight, high strength, low thermal expansion, high temperature resistant, low sag and large carrying capacity and many other advantages. Because there is no magnetic loss and thermal effect caused by the wire material, in the same transmission capacity, the operating temperature of ACCC is lower, can reduce transmission line loss of 6% or so, increase the carrying capacity of 29%. At a temperature of 180 C operation conditions, the load flow theory is two times of ACSR wires, the permissible temperature can be even more than 200 C[4,5].

Question analysis

Once the temperature and duration exceeds a certain range, the epoxy resin mandrel within the migration occurs, silicon rubber material will deteriorate, the crimping strength of the mandrel and metal accessories connected region will decline, serious ,can cause the string dropping accident. Therefore, in actual operation, the safety performance of composite insulators under the condition of high temperature long what changes will occur? When the conductor temperature rise to 200 C, how to composite the temperature distribution of insulator ? Up to now, the property changes in the long-term and safe reliability of wire under the condition of high temperature composite insulator is also poorly understood, composite insulator in ACCC wire operation is still in the exploration of. Therefore, the test sample of composite insulators in operation, under various environment temperatures on the electrical properties, mechanical properties and material properties are able to meet the operating temperature of the ACCC wires required in-depth study, a comprehensive assessment of the physical stability of composite insulators in high temperature and long term reliability.

Performance characterization of composite insulator:

1) Choose the subjects of composite insulator

In 2007 May, Fushun power supply company 220kV Liao Yuan line of original LGJ-400 type ACSR wire replacement for ACCC-713 type wire, carrying current from 840A to 1600A. This experiment used sample taken from the composite insulator Liao Yuan line operation, all for the pressing connection structure, running for 4 years, the ACSR wires running for 2 years, ACCC wires running for 2 years. Figure 1 is a sample of composite insulators.

Figure 1 The sampling of composite insulator

2) Visual inspection

Carry out a visual inspection of the sample, in addition to surface fouling, different degrees of contamination phenomenon, no obvious deterioration phenomenon found. Inspection of the main contents is listed in the table 1.

Table 1 sample appearance inspection table

Serial number	Check the contents	Conclusion
1	Whether there is partial discharge traces of insulator surface	no
2	Whether Silicon rubber umbrella cover surface without erosion, tracking, dendritic discharge or arc burn marks, etc.	no
3	Whether there is hardened, brittle, powder, crack	no
4	Whether the umbrella skirt deformation, bonding position of the umbrella skirt is arranged between the degumming phenomenon	no
5	Whether the End fitting connecting parts are obvious slip, there are traces of seal failure	no
6	Steel foot or steel cap whether there is corrosion, steel legs bent, the arc erosion, lack of phenomena such as locking pin	no

3) Hydrophobic test

Using the spray method, for all specimen,taken the upper part (the grounding end), middle part, lower part(high end) surface hydrophobicity test, partial sample hydrophobic test is shown in Figure 2.

Figure 2 The sample hydrophobic test

Sample hydrophobic of HC4 and above, according to the DL/T 864-2004 standard for qualified, can continue to run. The measurement results are shown in table 2.

Table 2 The hydrophobic test results

Sample number	Hydrophobic level			Conclusion
	Upper part	Lower part	middle part	Qualified
1	HC2	HC3	HC3	Qualified
2	HC2	HC3	HC3	Qualified
3	HC3	HC3	HC3	Qualified
4	HC2	HC3	HC3	Qualified
5	HC3	HC4	HC3	Qualified
6	HC2	HC3	HC3	Qualified
7	HC3	HC4	HC3	Qualified
8	HC3	HC3	HC3	Qualified
9	HC3	HC4	HC3	Qualified

4) Electrical test current check

Take 3#, 7#, 1# sample for electrical test. Frequency 1 min wet tolerance test

The sample water for 96h out, in the rain condition, the umbrella skirt surface is hydrophilic, then the pressure test, no obvious discharge phenomenon. With the test data and the results are presented in table 3.

Table 3 frequency 1 min wet tolerance test report

Sample number	The specified value （kV）	A correction value （kV）	The applied voltage （kV）	The tolerance time (min)	Results
3#	395	395	398	1	Tolerance
7#				1	Tolerance
1#				1	Tolerance

The lightning impulse withstand voltage test

The sample water for 96h out, in the rain condition ,the umbrella skirt surface is hydrophilic, lightning impulse withstand voltage test. The test results show that the lightning impulse level still meet the standard requirements. Detailed test data are listed in Table 4

Table 4 the lightning impulse withstand voltage test report

Sample number	Test waveform (μ s)	A correction value (kV)	The applied voltage (kV)	Tolerance times	Results
3#	1.21/50	1006	1010～1022	15	No flashover
7#				15	No flashover
1#				15	No flashover

Steep front impulse voltage test

Put the product into NaCl, which concentration is 0.1% ,in solution boiling after 42 h, sample retains extraction in a container until cooled to 50C , visual inspection samples of intact, steep wave impulse voltage test in the subsequent 48h. The test results show that the steep wave performance testing of products qualified. Steep front wave impulse voltage test results as shown in Table 5.

Table 5 steep impulse voltage test report

Sample number	Wave steepness (kV/ μ s)	The impact number		Results
		Positive	Negative	
3#	1220～1430	25	25	No breakdown
7#		25	25	No breakdown
1#		25	25	No breakdown

5) Seal test

Methods according to the provisions of ISO3452:1984 "nondestructive testing -- penetration test -- General principles", choose 3 supported trial product ,make staining test in metal accessories and insulating sheath interface permeability . The results show that the sample has good sealing.

Detailed test data are listed in Table 6.

Table 6 metal accessories and insulating sheath interface of permeability test results

Sample number	Penetration time (min)	Rated mechanical load tolerance test 70%		Surface inspection	Conclusion
		Mechanical load （kN）	The tolerance time (min)		
2	20	70	1	No cracks	Qualified
6	20	70	1	No cracks	Qualified
10	20	70	1	No cracks	Qualified

Sampling the test Liao Yuan line of 220kV composite insulators appearance and no obvious deterioration, hydrophobic qualified; frequency 1 min wet withstand voltage test and the lightning impulse withstand voltage test, steep wave impulse voltage test meet the standard requirements; when the conductor temperature rise to 210 C, the environment temperature is 45 C, the highest temperature no more than 70C, in high voltage terminal portion of composite insulator. mechanical failure load values were higher than the rated value, the dispersion of small, and still has a large margin; below 70C, short-term mechanical performance of composite insulators are less affected, about 5% ~ 8% at ambient temperature.

Conclusion

The results showed that, ACCC composite insulators put into operation dielectric strength and mechanical strength still meet the safety requirements, can continue to run. But considering the random test sample is less, the running time of only 2 years, and has not been fully tested high current operation conditions, partial sample hydrophobic has been reduced to HC4 level, in the next operation, also need to continue to track and detect the hydrophobic performance, to grasp the long-term variation of composite insulators and insulating properties and mechanical properties on the ACCC conductors running, accumulation of operating experience under high temperature conditions.

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