

Neutral Point AC Withstand Voltage Test of 500kV Main Transformer at Tingzikou Power Station

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Abstract: The AC withstand voltage test is the most effective and direct method for identifying insulation strength of power transformer and also an important component of preventive test. Because the voltage of AC test is higher than running voltage and power transformer has great safety margin after the test, AC withstand voltage test is vital to ensuring safe operation of power transformer. The paper briefly introduces the method of neutral point AC withstand voltage test of 500kV transformer at Tingzikou hydro-power station.

Key words: power transformer, AC withstand voltage test, insulation strength; Tingzikou hydro-power station

1. Overview

Four sets of 500kV outdoors three-phase double-coil OFWF power transformers, produced by TBEA, are installed at Tingzikou Water Control Hub. Its rated capacity is 310MVA and rated voltage is $525 \pm 2 \times 2.5\%$ kV/15.75kV. The connection method is YNd11. The oil or SF6 bushing is utilized to connect the high voltage side of transformer with GIS. The low voltage side adopts oil or gas bushing to connect IPB.

The running transformer will degrade and form the fault when its insulation are exposed under the electric field, temperature and mechanical vibration for a long time. However, the neutral point AC withstand voltage test can detect whether the transformer neutral point has insulation faults and whether the insulation level conforms to relevant standards and technical requirements.

2. Basis of Neutral Point DC Withstand Voltage Test of 500kV Transformer

GB50150-2006 *Standard for Hand-over Test of Electric Equipment Installation Engineering* stipulates that AC withstand voltage test can adopt the method of applied power frequency voltage or induced voltage; the waveform of test voltage is close to the sine as much as possible; test voltage value is the measured voltage dividing $\sqrt{2}$; when conducting the test, monitor at the high voltage end; frequency of applied AC voltage test voltage is ranging from 45Hz to 65Hz; withstand time under full voltage. The system nominal voltage is 500kV in this project. The neutral point adopts direct grounding mode. Therefore, DC withstand voltage on site is 68.0kV. Main instruments used in the neutral point test are shown in Table 1.

Tab. 1 Main instruments used in the neutral point AC withstand voltage

test

Name	Qty	Parameter
Variable frequency power source	1	Output 30-300Hz Voltage 400V Current 1250A Sine wave 450kW
Step-up transformer	1	Turn ratio: Low voltage 900V High voltage 35V Output power: 450kVA
High voltage reactor	3	Inductance: 100H Rated voltage: 250kV Rated current: 6A
Voltage divider	1	Rated voltage: 1000kV Capacitance: 750pF Precision: 0.1kV

3. Conditions for Neutral Point AC Withstand Voltage Test of 500kV Transformer

3.1 Natural conditions

Temperature: 0°C-40°C; relative humidity: ≤ 80%; wind speed: 0-3m/s

3.2 Project schedule

Transformer has been installed, full of oil and stewing for above 72 hours; complete all routine tests (turn ratio test, DC resistance test, AC leakage, polarity test, insulation resistance and oil insulation test) except neutral point AC withstand voltage test,

induced withstand voltage test of winding and bushing and PD measurement test; winding deformation detection and be qualified.

Do not install or disassemble the connection conductor in the oil or gas bushing of high voltage side of the transformer; fill the gas room with SF6 gas; remove leading wire of low voltage side and neutral point bushing; reliably ground bushing and enclosed busbar of low voltage side; secondary side of ascending flange current transformer is short circuit and grounded; place tap changing switch at I tap position; Well earth GIS and enclosed busbar to prevent the induced electricity from interfering.

4. Voltage Applying Procedure of Neutral Point AC Withstand Voltage Test of 500kV Transformer

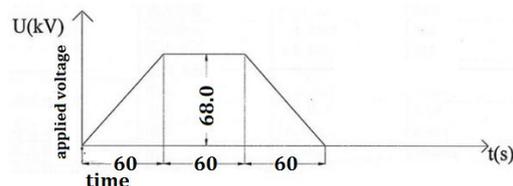


Fig.1 voltage-applying procedure of test

Fig. 1 shows the voltage-applying procedure of neutral point AC voltage test. Based on Fig.1, start to arise the voltage from zero; rise to 68.0kV after 1min and remain the voltage for 1min; then begin to reduce at 2min from withstand test voltage and reach zero at 3 min; finally cut off test source.

5. Calculation for Test Parameters of Neutral Point AC Withstand Voltage Test of 500kV Transformer

The capacitance of neutral point

bushing and high voltage winding to low voltage winding and ground is about 15.43nF; rated voltage of measuring voltage divider is 1000kV and its capacitance is around 750pF; the capacitance of each compensation capacitor is 3.0nF and there are four stages all told; the capacitance of four shunt capacitors is 12.0nF or so; then the total capacitance is 28.18nF.

Select three reactors; rated voltage of each reactor is 250kV; the inductance is 100H; rated current is 6A; connect reactors in series; rated voltage of three reactors is 750kV; total inductance is 300H and rated current is 6A. The resonant frequency is as follows:

$$f = \frac{1}{2\pi\sqrt{LC}} \approx \frac{1}{2\pi\sqrt{300 \times 28.18 \times 10^{-9}}} \approx 54.60 \text{ (Hz)} \quad (1)$$

Under the highest test voltage (68.0kV), the circuit current is:

$$I = U \sqrt{\frac{L}{C}} \approx 68.0 \times \sqrt{\frac{28.18 \times 10^{-9}}{300}} \approx 0.66 \text{ (A)} \quad (2)$$

In the formula: f : resonant frequency (Hz); L : inductance (H); C : capacitance (F); I : circuit current under highest test voltage

Main parameters of test equipment are shown in Table 2.

Tab. 2 Main test parameters of equipment used in the neutral point AC voltage test

Name	Item	Parameter	Rated value
Variable Frequency Power Source	Input voltage	≈400V	400V
	Input current/phase	≈2A	643A
	Output voltage	≈75V	350V
	Output current	≈11.5A	1285A
Middle Transformer	Output power	≈0.82kVA	450kVA
	Input voltage	≈75V	700V
	Input current	≈11.5A	640A
	Output voltage	≈1.23kV	6kV
High voltage reactor	Output current	≈0.66	A24A
	Output power	≈0.82kVA	225kVA
	Voltage	≈22.67kV	250kV
Compensation capacitor	Current	≈0.66A	6.0A
	Voltage	68.0kV	250kV
Voltage divider	Voltage	68.0kV	1000kV

Through the calculation, all parameters of test equipment can meet the requirement of main transformer neutral point AC withstand voltage test.

6. Judgment on Neutral Point AC Withstand Voltage Test of 500kV Transformer

If the test meets the following requirements, then the neutral point AC voltage test is qualified:

- (1) No sudden reduction in test voltage during the whole test;
- (2) No internal penetrable discharge and external insulation flashover.

7. Conclusions

The power frequency AC withstand voltage test plays a decisive role in detecting main dielectric strength of the transformer and partial fault. This type of test can effectively detect the winding main insulation being affected with damp and cracked. Or it can find out that the lead distance is not enough long caused by winding loosening or placement during the transportation, and the winding

insulation is covered with dirt. As for organic solid insulation, AC withstand voltage test belongs to a destructive test and can further develop the original insulation weakness, reducing insulation strength and forming degrading cumulative effect. Hence, you should correctly select test voltage standards and withstand voltage time. The test voltage is very high and effectiveness of insulation fault is high, but it is likely that the breakdown of test object occurs and cumulative effect becomes more serious. Meanwhile, we should conduct the AC withstand voltage test when the result of non-destructive test is qualified. If the insulation has faults in the non-destructive test, you need to eliminate faults first and then conduct the test in order to avoid the damage.

REFERENCES

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