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Replacing GB/T 20835-2007

Guides for Magnetization Test of Generator Stator Core 发电机定子铁心磁化试验导则

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Foreword

This Standard was drafted in accordance with the rules given in GB/T 1.1-2009.

This Standard replaces GB/T 20835-2007, *Guides for Magnetization Test of Generator Stator Core*. Compared with GB/T 20835-2007, the major changes of this Standard are as follows:

- it adds normative references, i.e. GB/T 2521, *Cold-rolled Grain-oriented and Non-oriented Electrical Steel Strip (Sheet)*, and GB/T 20160, *Recommended Practice for Testing Insulation Resistance of Rotating Machinery (Article 2)*;
- it deletes normative references GB/T 7064, *Specific Requirements for Cylindrical Rotor Synchronous Machines*, and GB/T 8564, *Specification for Installation of Hydraulic Turbine Generator Unit* (see Article 2 of edition 2007);
- it modifies the values of stator core stacking factor (see 4.1; 4.1 of edition 2007);
- it adds the calculation formula of actual magnetic induction intensity B [see Formula (7) of 6.4.1];
- it adds the minimum limit of field density during core magnetization test (see 6.4.1);
- it adds the test and its quality evaluation criteria of generator of rated frequency 60 Hz (see 6.4.2 and Article 7);
- it modifies the conversion of stator core specific loss of cylindrical rotor synchronous generator [see Formula (A.1) of Annex A and Formula (A.1) of Annex A of edition 2007];
- it adds Annex B (see Annex B);
- it adds Annex C (see Annex C).

This Standard was proposed by China Electrical Equipment Industry Association.

This Standard shall be under the jurisdiction of China National Standardization Technical Committee on Large Generators (SAC/TC 511).

The drafting organizations of this Standard: Harbin Institute of Large Electrical Machinery, Dongfang Electric Corporation Dongfang Electric Machinery Co., Ltd., Shanghai Electric Power Station Equipment Co., Ltd., Shandong Qilu Electrical Machinery Manufacture Co., Ltd., HydroChina Huadong Engineering Corporation, China Three Gorges Corporation, State Grid Liaoning Province Electric Power Co., Ltd. Electric Power Research Institute, Huadian Electric Power Research Institute Co., Ltd., Toshiba Hydro Power (Hangzhou) Co., Ltd., Zhejiang Fuchunjiang Hydropower Equipment Co, Ltd., Fujian Nandian Co., Ltd., Xiangtan Electric Manufacturing Group Co., Ltd..

Guides for Magnetization

Test of Generator Stator Core

1 Application Scope

This Standard specifies the test preparation, test requirements, test method and core quality evaluation criteria for magnetization test of generator stator core.

This Standard applies to magnetization test of cylindrical rotor synchronous generator and water-turbine generator of voltage class 6.3 kV and above; it is used for the inspection of assembly quality of generator stator core.

2 Normative References

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

GB/T 2521-2008, *Cold-rolled Grain-oriented And Non-oriented Electrical Steel Strip (Sheet)*

GB/T 20160, *Recommended Practice for Testing Insulation Resistance of Rotating Machinery*

3 Symbols

For the purposes of this document, the following symbols apply.

b_v — stator vent width, in m;

B — stator core yoke field density during test, in T;

D_1 — outer diameter of stator core, in m;

D_{fl} — inner diameter of stator core, in m;

f — test power supply frequency, in Hz;

f_0 — reference frequency, 50 Hz (for generator of 50 Hz) or 60 Hz (for generator of 60 Hz), in Hz;

f_1 — measured power supply frequency during test, in Hz;

H — stator yoke magnetic field intensity, in A/m;

h_{ys} — stator core yoke height, in m;

h_s — stator slot depth, in m;

I — excitation coil current, in A;

k_{Fe} — stator core stacking factor;

K_S — power supply capacity factor;

l_u — stator core net length, in m;

l — stator core length, in m;

m — stator core yoke mass, in kg;

n_v — number of stator vents;

P — measured power, in W;

P_1 — stator core specific loss calculated from test, in W/kg;

$P_S(1.0)$ — standard specific loss of stator core silicon steel sheet material under 1.0 T, 50 Hz or 60 Hz, in W/kg;

$P_S(1.5)$ — standard specific loss of stator core silicon steel sheet material under 1.5 T, 50 Hz or 60 Hz, in W/kg;

Q — stator core yoke sectional area, in m²;

ρ — silicon steel sheet density, in kg/m³;

S — test power supply capacity, in kVA;

t — test duration, in min;

t_0 — environmental temperature, in °C;

t_i — temperature of the i -th temperature measuring point during test, in °C;

U_1 — excitation coil voltage, in V;

U_2 — measuring coil voltage, in V;

W_1 — number of turns of excitation coil;

W_2 — number of turns of measuring coil;

$\Delta t_{\max}$ — maximum core temperature rise from the start to the end of test, in K;

$\Delta t_{\min}$ — minimum core temperature rise from the start to the end of test, in K;

wind stator core only.

4.5 Measuring coil voltage

Measuring coil voltage is estimated in accordance with Formula (6); the measuring range of voltmeter is selected based on the estimation.

$$U_2 = U_1 \frac{W_2}{W_1} \dots\dots\dots (6)$$

where,

W_2 — number of measuring coil turns, generally 1 or 2.

4.6 Core temperature measurement

Measurement of core temperature with infrared thermography shall be given precedence. If thermometric elements are embedded, thermocouples or thermometers are arranged uniformly at the upper, middle and lower positions of outer and inner circumferences of core; thermometers shall be placed in core yoke vent as far as possible.

5 Test Requirements

5.1 Test power supply

Test power supply shall be an adequate alternating current power supply; its capacity shall meet the power supply capacity value calculated in accordance with Formula (5).

5.2 Measuring apparatus

5.2.1 Electrical measuring apparatus

The accuracy of electrical measuring apparatus shall not be lower than grade 0.5; power meter shall be lower power factor wattmeter. The measuring range of apparatus shall be chosen as required by actual readings.

5.2.2 Instrument transformer

The accuracy of instrument transformer shall not be lower than grade 0.2.

5.2.3 Temperature measurement requirements

Temperature measurement can be carried out with infrared thermography, alcohol thermometer or thermocouple thermometer or other instruments; it is not permissible to use mercurial thermometer. The accuracy of temperature measurement of infrared thermography shall not be greater than $\pm 2^\circ\text{C}$ or measured value multiplied by $\pm 2\%$

6.5 Test records

Measure and record frequency, excitation coil terminal voltage, measuring coil terminal voltage, excitation coil current and power, core temperature and environmental temperature at least every 15 min. If possible, measure the temperature of core embedded thermometer.

Calculate actual field intensity, power loss, unit iron loss, maximum core temperature rise and maximum core temperature difference, based on the results of all measurements.

6.6 Test precautions

Closely monitor stator core temperature rise, vibration and noise during test. In case of smoking, local radiation and severe abnormal sound, cut off power supply and stop test.

7 Core Quality Evaluation Criteria

7.1 Core maximum temperature rise limit

The maximum temperature rise limit of 50 Hz/60 Hz generator core is less than or equal to 25 K under specified field intensity, after specified time in test.

7.2 Limit of temperature difference of the same position of core (stator tooth or slot)

The limit of temperature difference of the same position of 50 Hz/60 Hz generator (stator tooth or slot) is less than or equal to 15 K under specified field intensity, after specified time in test.

Annex C

(Informative)

Electromagnetic Core Imperfection Detector (ELCID)

(Electromagnetic Core Imperfection Detector-ELCID)

In case of a certain local failure of stator core, ELCID can be used for test.

In ELCID test, an annular coil is used to excite stator core in order to produce a magnetic field and confirm the short-circuit position of stator core. Only 4% of normal excitation quantity needs to be applied in for this method; one inductive probe passing the surface of stator core detects the magnetic field produced by stator core short-circuit, other than detects the thermal effect produced by stator core short circuit. This method requires low electric power capacity, so the power supply capacity of most working locations can be satisfactory, e.g. for generator of hundreds of thousands of kilowatts' capacity, only a power supply of capacity 2 kVA ~ 3 kVA is needed.

Because of the existence of excitation and stator core short-circuit eddy current, stator core produces a loop magnetic field. The magnetic field will produce magnetic potential gradients on the surface of stator core; one purpose-made coil, Chattock potentiometer, is used to measure magnetic potential difference. Chattock is placed on the outer edge of two adjacent slots, and provides longitudinal scan for the surface of core along core tooth slot. Chattock detects each slot and its adjacent two teeth each time and finally detects all core tooth slots. The detection of magnetic potential difference includes two parts: one is the constant magnetic field on the surface of core provided by excitation; the other is the magnetic potential difference formed on the surface of stator core by any short-circuit point current in stator core. Both signals are detected by Chattock. The output signal value of Chattock potentiometer has an equal proportion to its magnetic potential difference on both ends.

Electromagnetic core imperfection detector receives Chattock signals and analyze them together with the reference signals taken from self-excitation current. The common part of detection signals and reference signals mainly comes from the magnetic field produced by self-excitation, and this part of signals are relatively strong. However, there is a phase difference of 90° between eddy current caused by core short circuit and excitation current, so it is QUADRATURE current, i.e. quadrature-axis current. Signal processing host analyzes QUADRATURE elements in Chattock signals through reference signals taken from self-excitation current and synchronous detector; both kinds of signals can be displayed and recorded. Signal processing host has been corrected, which is capable of displaying QUADRATURE current value directly. Signal processing host will record the signals of each two adjacent core teeth detected by Chattock, in order to give QUADRATURE curve of each slot. These curves will display core short-circuit point locations and QUADRATURE current amplitudes; then a small

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