INFLUENCE OF ELECTRODE SETTING TO MAIN INSULATION tgδ MEASUREMENT OF TURBOGENERATOR BARS

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ABSTRACT

This paper describes power loss factor measuring of turbogenerator bars. Then it focuses in influence of measuring electrode setting to power loss factor magnitude. It was tested 16 measuring electrode settings. Measurements showed weaknesses in certain methodologies and therefore were proposed changes in methodology.

KEYWORDS

Turbogenerator, insulation, power loss factor, electrode setting.

1. INTRODUCTION

The present system of quality management in manufacturing includes a wide range of in-process controls of individual parts of the final product. In the realm of turbogenerator stator winding is one of them power loss factor measuring of main insulation on the bars. During individual test it is necessary ensure various aspects, which may have influence on measurement result and consequently unsatisfactory products count. It is concerned firstly about suitable selection of measuring method, equipment, qualified attendance etc. With experimental measuring was ascertained, that the significant influence on power loss factor measuring of insulation has electrode setting, especially measuring electrode.

2. POWER LOSS FACTOR tgδ AND ITS MEASURING

Power loss factor tgδ expresses heat losses in dielectrics under the action of an external alternating electric field. These heat losses may be caused by several phenomena. In real dielectric are mainly conductance losses caused by the leakage current through insulation and on its surface. Their proportional share considerably affects the conductivity of the material. Next are the polarization losses. Partial suppression of chaotic thermal elements motion causes these owing to external electric field. Part of the energy gained at the expense of an external field is transformed to heat. The quantum of this energy is adequate to the temperature of insulation and frequency of applied electric field. Partial discharges are last but not least reason of losses. Those occur, if the applied voltage exceeds the value of so-called ignition voltage of partial discharges. Originate in the gas-filled voids in the solid dielectric and during the discharging produce among others thermal energy.

At formulation of dielectric losses consider alternating harmonic electric field. A current flow in the dielectric is then also a harmonic and can be resolved into several components in accordance with the phasor diagram in *Figure 1*. With current I_{c0} is charged capacity C_0 of the sample. Current I_{bzp} conform to fast lossless polarization. Absorption current I_a conform to losing slow polarization. It can be resolved into lossless component I_{aj}, which conform to the capacity C_p and which increased the capacity C_0 due to absorption phenomena and loss component I_{aw} conform to energy losses in dielectrics due to flow of current I_a. Conduction current I_v caused by the non-zero conductivity of real dielectric has zero phase shift against applied voltage. Phase diagram shows that in ideal lossless dielectric is phase shift 90° between current and voltage phasor. However, in real dielectrics is the loss angle *δ* lesser.

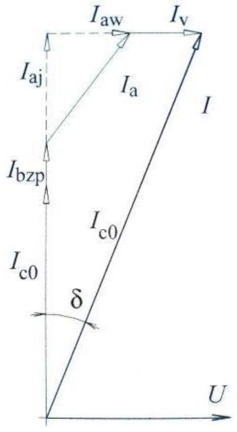

Figure 1 – Phasor diagram of real dielectric

For process measurements tgδ at 50 Hz frequency are used bridge methods, in our case the Schering’s bridge method, see *Figure 2*. The principle of this method is to determine the elements *C* and *R* of dielectric equivalent circuit. In the diagram is on the high-voltage side capacitance normal C_N = 103.8 pF and C_X is the capacity of the measured bar. On the side of low voltage using a resistor decade R_3 and capacitor decade C_4 is bridge balanced, and thus are defined values of the dielectric equivalent circuit. For the loss factor will apply

$$tg\delta = \omega \cdot R_4 \cdot C_4 , \tag{1}$$

and providing $R_4 = 1000/\pi$ and C_4 in pF is

$$tg\delta = 0{,}1 \cdot C_4 . \tag{2}$$

Bridge balancing and tgδ calculation proceed automatically using an electronic low-voltage part of the bridge Tettex Instruments 2816.

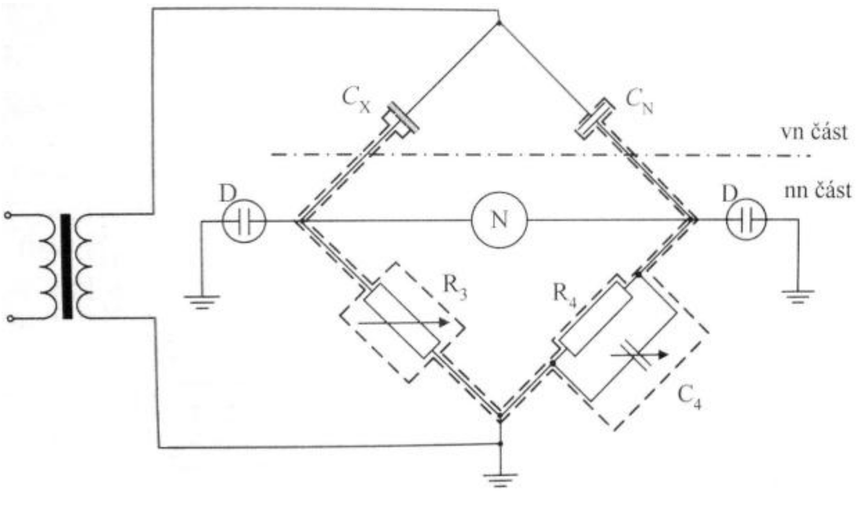

Figure 2 – Measuring of power loss factor using Schering’s bridge

3. INFLUENCE OF MEASURING ELECTRODE ON THE POWER LOSS FACTOR LEVEL

Power loss factor was measured on the bar with a continuous main insulation for rated voltage 15 kV. It was measured voltage dependence at six levels 3, 6, 9, 12, 15 and 18 kV so that not occur discharge activity, which distorted the measurement. Test voltage was connected to all the copper wires of bar and as measuring electrode was used external semiconductive corona protection. Tested were 16 variants of measuring electrodes:

1. single-electrode measurement, measuring electrode poorly looped with stranded copper, clamp connected outside the stranded copper,
2. single-electrode measurement, measuring electrode poorly looped with stranded copper, clamp connected on the stranded copper,
3. single-electrode measurement, measuring electrode equally looped with stranded copper, clamp connected outside the stranded copper,
4. single-electrode measurement, measuring electrode equally looped with stranded copper, clamp connected on the stranded copper,
5. three-electrode measurement, measuring electrode equally looped with stranded copper, clamp connected on the stranded copper, guard electrode clamps connected directly on bar,
6. three-electrode measurement, measuring electrode equally looped with stranded copper, clamp connected on the stranded copper, guard electrode clamps connected on conductive tape,
7. three-electrode measurement, measuring electrode prolonged over stress grading tapes and equally looped with stranded copper, clamp connected on the stranded copper, guard electrode clamps connected directly on bar,
8. three-electrode measurement, measuring electrode prolonged over stress grading tapes and equally looped with stranded copper, clamp connected on the stranded copper, guard electrode clamps connected on conductive tape,
9. single-electrode measurement, measuring electrode inserted into the aluminium "L" profiles, clamp connected to the profile,
10. three-electrode measurement, measuring electrode inserted into the aluminium "L" profiles, clamp connected to the profile, guard electrode clamps connected directly on bar,
11. three-electrode measurement, measuring electrode inserted into the aluminium "L" profiles, clamp connected to the profile, guard electrode clamps connected on conductive tape,
12. three-electrode measurement, measuring electrode inserted into the aluminium "L" profiles and prolonged over stress grading tapes, clamp connected to the profile, guard electrode clamps connected directly on bar,
13. three-electrode measurement, measuring electrode inserted into the aluminium "L" profiles and prolonged over stress grading tapes, clamp connected to the profile, guard electrode clamps connected on conductive tape,
14. three-electrode measurement, measuring electrode equally looped with stranded copper, clamp connected on the stranded copper, guard electrodes created through the use of external corona protection erasing on slot part ends of bar, guard electrode clamps connected directly on bar,
15. three-electrode measurement, measuring electrode equally looped with stranded copper, clamp connected on the stranded copper, erasing locations repaired through the use of conductive varnish, guard electrode clamps connected directly on bar,
16. three-electrode measurement, measuring electrode equally looped with stranded copper, clamp connected on the stranded copper, erasing locations repaired through the use of conductive varnish, guard electrode clamps connected on conductive tapes.

Graph on *Figure 3* shows measured voltage dependences of power loss factor for various electrodes setting.

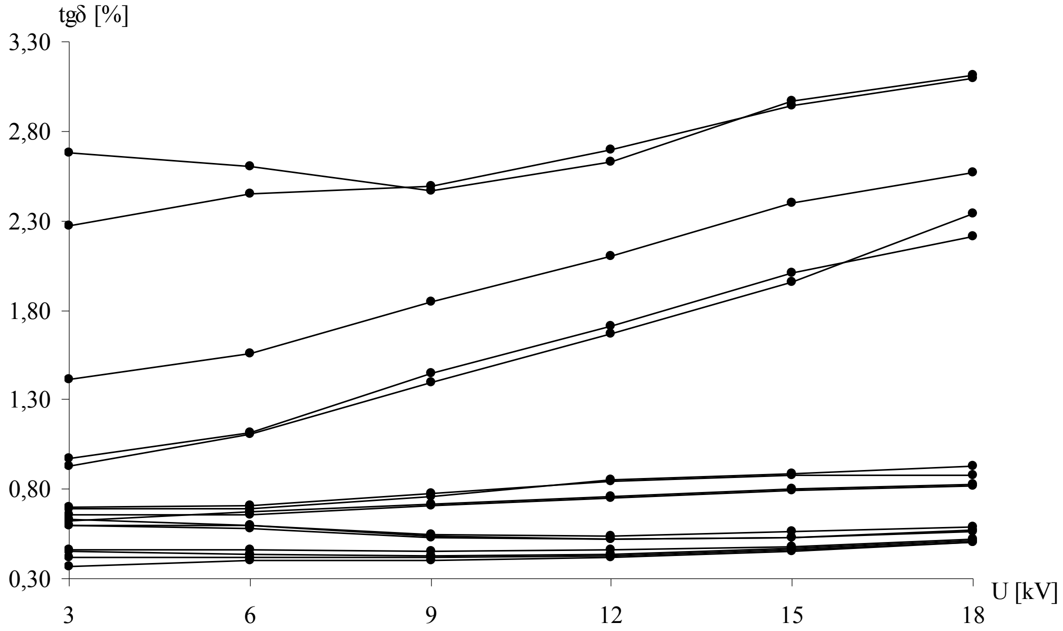

Figure 3 – Power loss factor measured dependences of turbogenerator bar main insulation

4. CONCLUSIONS

Significant impact on the tgδ value has the measuring electrode preparation and connection to the bridge. Measuring electrode is in principle semiconductive tape, which functions as external corona protection. Her semiconducting character may result additional losses owing to surface currents. Measured results correspond to this, when largest losses were measured with the electrode formed poorly looped with stranded copper. Lesser losses reached with equally loped and minimum losses when inserting bar into the aluminium "L" profiles, while there is a conductive connection on whole surface of the bar. Furthermore, observed difference between single and three-electrode measurement. Single-electrode measuring leads to edge effect additional losses. At the slot exit have bars stress grading system to suppress discharge activity. Through this protection flow currents, which increase losses especially with growing voltage, behaviour 1 – 4, 9. Creating guard electrodes in accordance with [1] leads to reduction of edge effects. Measurement enables changes in methodologies so that comply with strict standards of quality management, time and economic modesty of sample preparation.

REFERENCES

[1] *Mentlík, Václav*: Dielektrické prvky a systémy. Prague, BEN, 2006.

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