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Partial Discharges Phase Resolved Analysis of the B and F Temperature Classes Insulation Systems

***Streszczenie**: (**Analiza fazowo-rozdzielcza wyładowań niezupełnych w układach izolacyjnych klasy temperaturowej B i F**) Analiza fazowo-rozdzielcza wyładowań niezupełnych może być użyta do określenia stanu izolacji generatorów. Występują istotne różnice kształtu rozkładów fazowych w zależności od rodzaju izolacji. W artykule przestawiono je dla układów izolacyjnych wykonanych z materiałów klasy temperaturowej B i F. Sformułowano wnioski w celu wykorzystania tego efektu.*

***Abstract.** The phase resolved analysis of partial discharges contributes to the real condition stage of the generator insulation description. There are specific differences on phase distribution formation depending on insulation class. The paper describes those differences for generator insulation systems based on B and F insulation temperature classes materials. The results on utilization of this phenomena are concluded.*

Słowa kluczowe: wyładowania niezupełne, analiza fazowo-rozdzielcza, klasy temperaturowe B i F, generatory, uzwojenia
Keywords: partial discharges, phase resolved analysis, temperature classes B and F, power generator, windings

Introduction

The life of power generators refers to the life of the windings before they require rewinding. The temperature rise of the windings and the insulation materials an power generator is critical to the life expectancy of the generator. The insulation materials age overtime and this aging process is directly related to temperature. Eventually the materials lose their insulating properties and break down may cause a short circuit.

There are two main insulation systems classes used in design of the power generators of the Slovak power plants, temperature class B and F insulation systems.

The measurement of the partial discharges is wide-used diagnostic methods for the power devices insulation monitoring. Commonly used absolute magnitude value of the apparent charge seems to be not efficient hence phase resolved analysis helps to improve in insulation system life trend predication. Partial discharge phase resolved analysis refers to different results for temperature class B and F insulation materials used in insulation systems of power devices with similar construction design and output power.

The insulation materials used commonly in the insulation of the stator windings are based on split mica or mica paper, which consists of mica wafers impregnated on skeleton foil. The resulting parameters of insulation material are done by the impregnant properties. There are two main categories of the mica-based insulation systems: thermoplastic, temperature class B – with natural resins (shellac, asphalt, bitumen) and thermosetic, temperature class F – with synthetic ones (polyesther, epoxy resin, silcones). The maximum temperature at hottest spot is 130°C for class B and 155°C for temperature class F insulation.

The thermal deterioration takes effects on chemical and physical non-revesible events. The long-term temperature exposition and oxigen reaction causing start of the cavity gap and insluation cracks formation process. The material becomes flagile. The inverse phenomena is possible too. The eventuality is the chemical decomposition caused by high temperature exposition. The insulation grow softer by the disappearance of the fugitive substances. The physical changes of the insulation system due to temperature action depend on insulation framework design and structure.

The thermosetic insulation deterioration starts with the epoxy resin chemical decomposition. It becomes tender and the mechanical consistence is disrupted. In the case of the thermoplastic insulation the moving of the material take place due to various thermal expansion parameters of the cooper, iron and insulation. After temperature exposition insulation cool down but do not drop back to the preceding origin position. The insulation moving is the strongest in the case of insulation tape technology with asphalt filling agent. The adhesive power of the asphalt falls down with temperature increasement. The thermo-oxidative destruction of the insulation material leads to internal gas filled voids and gaps creation in the material volume.

Another process, which cannot be out of mind, is front winding expansion near the place where winding bar leaves the stator sparing.

The experiment

The experiment was comprised of partial discharge measuring procedure and evaluation for two power generators of the same rated power (14.5 MVA) and the same voltage level (10.5 kV). The windings both of the generators were several years in operation after their repairing. The winding insulation material of the first of the generators was temperature class B. The second generator had winding insulation based on temperature class F material. The value of the service hours the both of devices were approximately equal.

The measurement of partial discharges with digital recording were done according the standard IEC 60270 procedure. After data collection the statistical phase resolved partial discharges analysis was computed and fingerprints were composed. Figure 1 shows the measuring circuit connection.

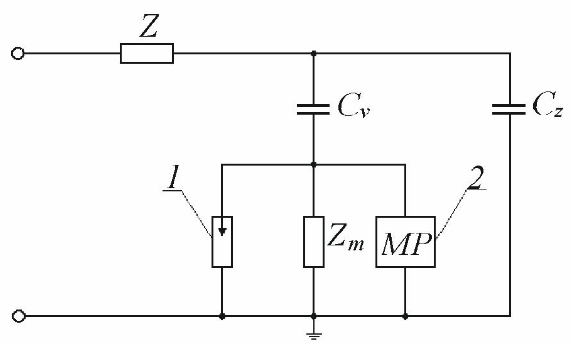

Fig. 1. Partial discharge measuring circuit.

The Figure 1 symbols: *1* – overvoltage protection, *2* – measuring device, *Z* – input filter impedance, C_v – coupling capacitor, C_z – measured object capacity, Z_m – measuring impedance.

Each of the three phases was separately measured. Unmeasured branches and stator construction were grounded and connected mutually, see Figure 2.

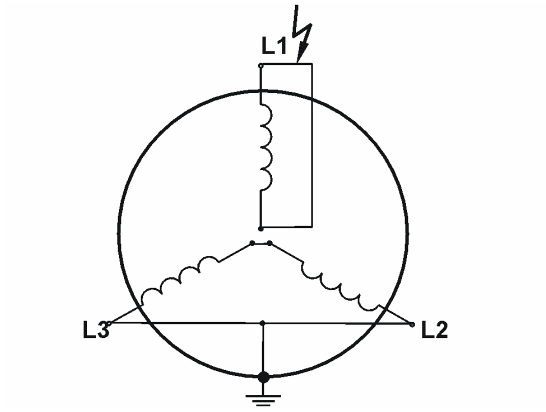

Fig. 2. The device windings connection

Measurements of partial discharges

At the beginning of the experimental works the measurement of partial discharges on generator with thermoplastic insulation at nominal voltage level was done. Partial discharges were measured separately for each of the phases. Results from phase resolved analysis of partial discharges from the thermoplastic insulation measurements are shown on the Figure 3.

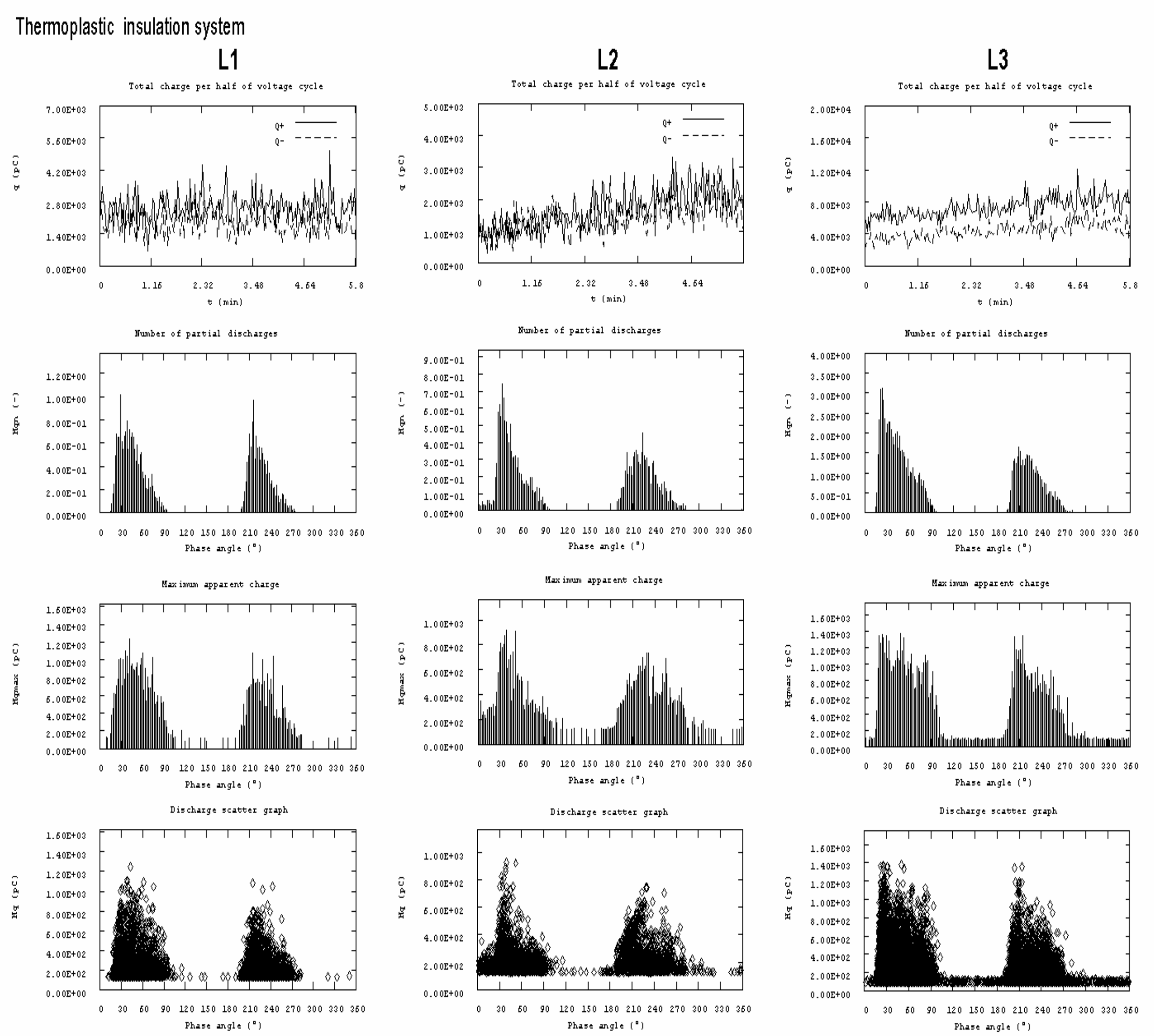

Fig. 3 Phase resolved analysis, thermplastic insulation

The maximal magnitudes of apparent charge were 1200 pC for phase L1, 900 for phase L2 and 1400 pC for phase L3. In the case of thermosetic insulation maximal magnitudes of apparent charge were: 3000 pC for phase L1, 10000 pC for phase L2 and 1500pC for phase L3, see Figure 4. The result of simple comparison says that there are parial discharges have higher magnitudes of the apparent charge in the case of thermosetic insulation. On Figure 3, phase L2 there can be seen partial discharges in voids of insulation. Partial discharges in the stator slots are become evident from phase L2, Figure 4. Hold generally that internal partial discharges in gas filled voids are more dangerous such as discharges in stator slot. It is considered the same also when magnitudes of stator slot partial discharges become higher compared to internal discharges.

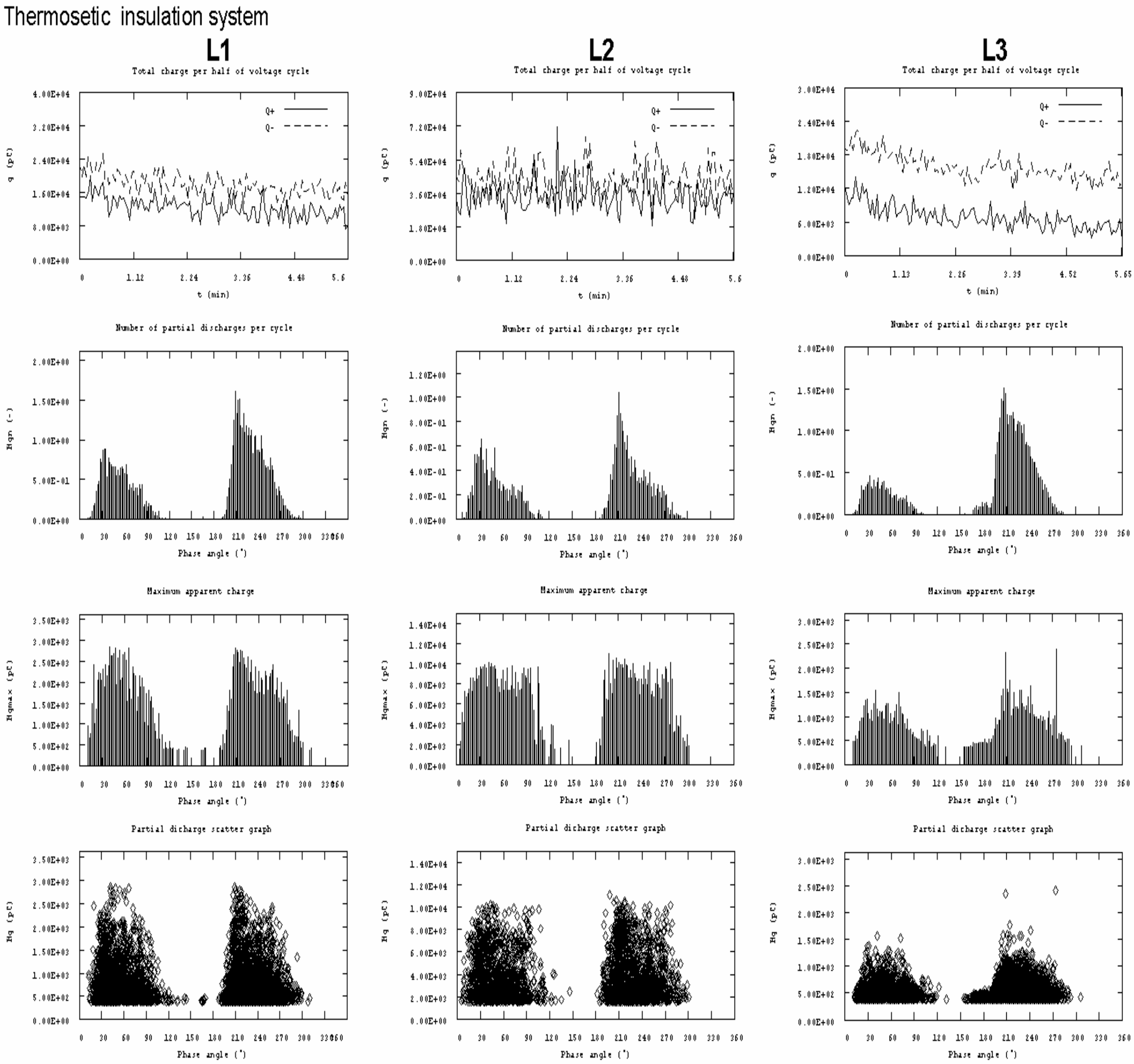

Fig. 4 Phase resolved analysis, thermosetic insulation

Conclusion

The temperature influence on air-cooled hydro-generators and turbogenerators deterioration become dominant for those with thermoplastic insulation material. The twenty years – it is the recommended lifetime of the insulation system of such devices, but there are known cases of winding exchange over twelve years. The recommended lifetime of the thermoplastic insulation systems is forty years. The deterioration process can slow down by exploiting of the hydrogen cooling system of the windings. The influence of temperature is the minimal when winding are cooled by water.

The proper diagnostic results need regular diagnostic measurements. Also comparison of diagnostic results of identical machines leads to better answers. Not only power and voltage level but also temperature class of the insulation material would be taken into account. Thermal deterioration and partial discharge development have unequal trends for thermosetic and themoplastic insulations.

REFERENCES

[1] Zališ K., Evaluation of Partial Discharge Measurement, In: *Proceedings of the VII Sympozjum EUI 99*, Zakopane (1999), 496-503

[2] Kolcunová I., Kršňák I., Kurimský J., Modeling and phase analysis of internal partial discharges, In: *Proceedings of the VIII Sympozjum EUI 01*, AGH Krakow (2001), 299-304

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