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PARTIAL DISCHARGES OF THERMALLY AGED INSULATION

CZĘŚCIOWE UWALNIANIE CIEPŁA W ZUŻYTEJ IZOLACJI

Abstract: The working life of electrical machines is primary affected by the insulation system quality. Diagnostics methods help to understand the momentary state of insulation and to avoid the possible damage or breakdown of machines. Partial discharge testing belongs to one of the high applicable test method of insulating materials within electrical machines. The described experiment consists of laboratory thermal aging of insulation and consequently testing of partial discharges. The flat specimens of insulation were used for the partial discharge behavior recognition. The conductive rubber electrodes were used to avoid the gliding discharges on the surface of specimen. The trends of partial discharge main parameters are studied and described.

1. Introduction

The working life of electrical machines is primary affected by the insulation system quality. The working life of electrical insulating system is commonly determined, estimated and predicted in terms of accelerated laboratory aging of studied insulating materials. Accelerated aging could be applied as single factor aging like thermal or electrical aging or multiple factor aging exists. During the multiple factor aging all factors take effect together in the same time. Degradation of an insulation system occurs during the accelerated aging. The degradation is related to the physical and chemical changes within material structure. These changes are consequently detectable with physical or chemical test methods.

Partial discharge testing belongs to one of the high applicable test method of insulating materials within electrical machines. This noninvasive or nondestructive test method allows determining the degradation ratio or homogeneity of insulation.

2. Aging and specimen testing

Investigated mica resin rich composite based on glass fabric and epoxy resin was thermally aged. The changes of its physical- and chemical properties were measured during accelerated aging. Partial discharges were measured as well. The characteristic values of partial discharges like ignition voltage (Ui), extinguish voltage (Ue), pulse count (N), average discharge current (NQS) and peak charge level (Q) were measured and analyzed.

The preliminary and orientation lifetime curves of tested materials were performed first. This step was necessary to determine the aging temperatures and aging times for each temperature [1]. Two points build up the preliminary lifetime curve. First point is the maximal temperature second point is the minimal endurance temperature. Maximal endurance temperature is given by eight hours endurance test. Minimal endurance temperature is given by temperature class and by material producer who declared lifetime of material for 30 years at this temperature. The eight hours maximal temperature was first determined according to the loss factor rapidly increased values comparing to the virgin state or according to the visual changes of specimen (deformations, delaminating, bending, deflection etc).Four aging temperatures were chosen for material accelerated aging (Table 1). The aging times were determined for each temperature. The aging times were determined in agreement with the preliminary lifetime curves [1]. The aging temperatures are chosen according to the experiment total duration as well.

Table 1. Aging temperatures and aging times

Aging temperature (°C)	**Aging times at given temperature (hours)**				
170	192	288	384	480	600
175	48	96	144		
180	8	16	24	32	48
186	2	4	6	8	10

3. Partial discharges of flat specimens

The broadband partial discharge test system Power Diagnostix was used for PRDP (phase resolved partial discharge characteristics) and other partial discharges magnitudes measuring. The test setup is given in figure 1.

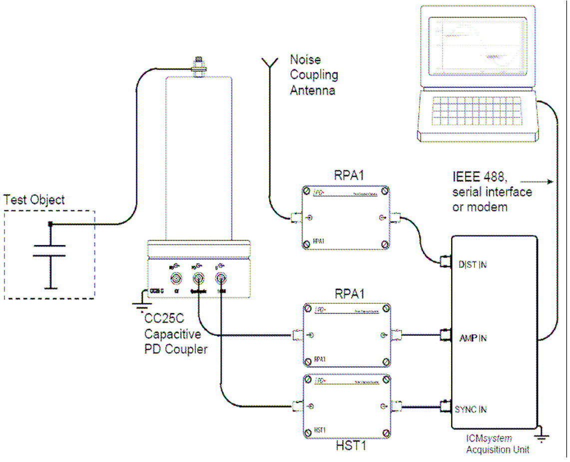

Fig. 1. Measuring setup

Specimens of tested material were performed and cured as flat plate 100×100 mm. The measuring of these specimens was carrying out by test voltage at the electrode test setup (figure 2). The conductive rubber electrodes were used to suppress and to avoid the gliding discharges at the surface of the specimen. The force impact the upper electrode is given thanks to the spring and the force is constant for each test.

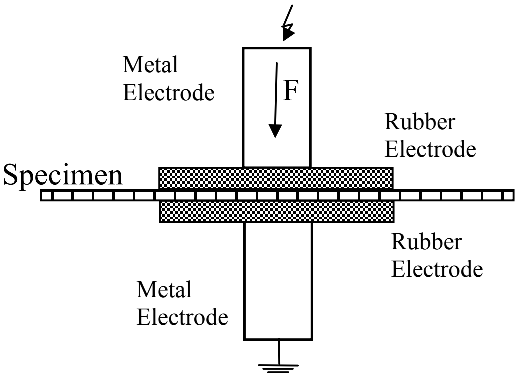

Fig. 2. Electrodes setup for flat specimen testing

Measuring of partial discharges was performed at ten specimens aged at one temperature. The measuring voltage applied on upper electrode (figure 2) was 1,5 kV. This means that the gradient over average specimen thickness 0,45 mm was 3,3 kV/mm.

4. Results and Discussions

Measured data at ten different specimens aged at one temperature shows relatively wide variance and variance coefficient as well. This is given by material character and by the stochastic principle of measured partial discharges firstly. Fig. 3 and Fig. 4 shows recorded phase resolved partial discharges characteristics for specimens aged at two extreme temperatures and times (170°C for 192 hours (Fig.3) and 186°C for 8 hours (Fig.4)).
The lower or less intensive partial discharges activity given by measured apparent charge values and "narrow" partial discharges phase resolved characteristics area is evident in figure 4. The parameters NQS, Ui, Ue and pulse count N measured during accelerated temperature aging are presented in figures 5-12.These parameters were measured as well for the better analysis and understanding of partial discharge behavior during temperature aging. The phase resolved characteristics at figures 3 and 4 are obtained for one minute record of partial discharges.

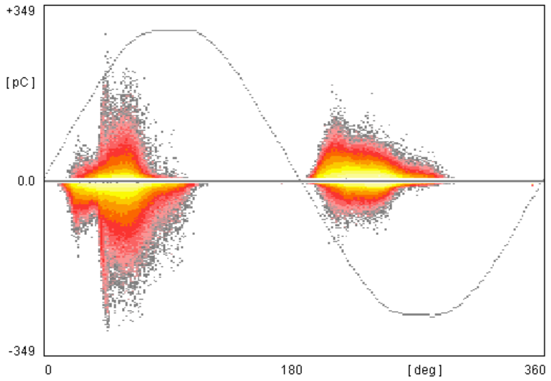

Fig. 3. Phase resolved characteristics at 170°C and 192 hours

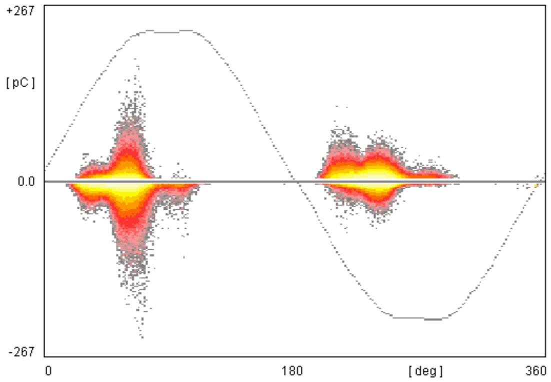

Fig. 4. Phase resolved characteristics at 186°C and 8 hours

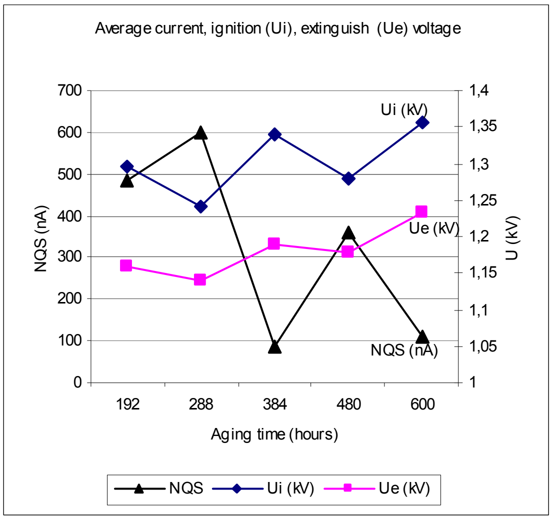

Fig. 5. Dependence of measured values on aging time at 170°C

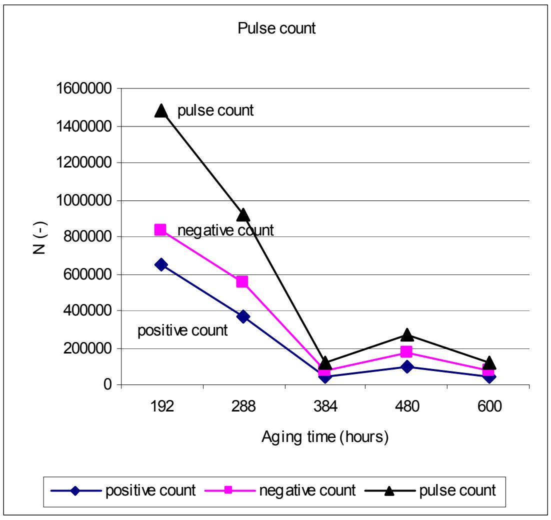

Fig. 6. Dependence of pulse count on aging time at 170°C

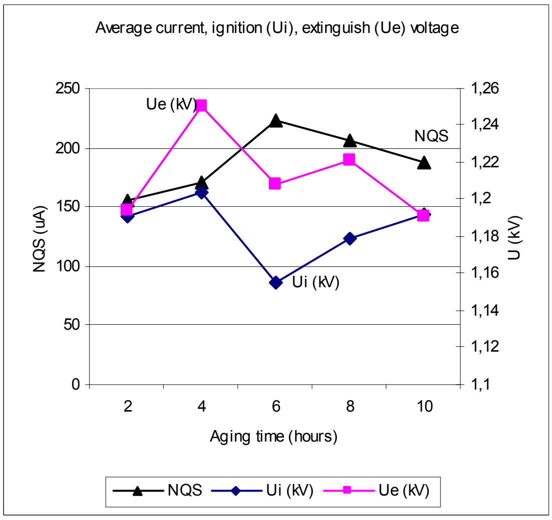

Fig. 7. Dependence of measured values on aging time at 186°C

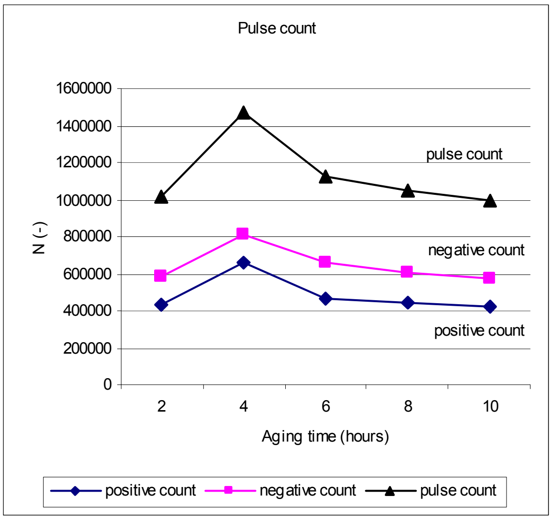

Fig. 8. Dependence of pulse count on aging time at 186°C

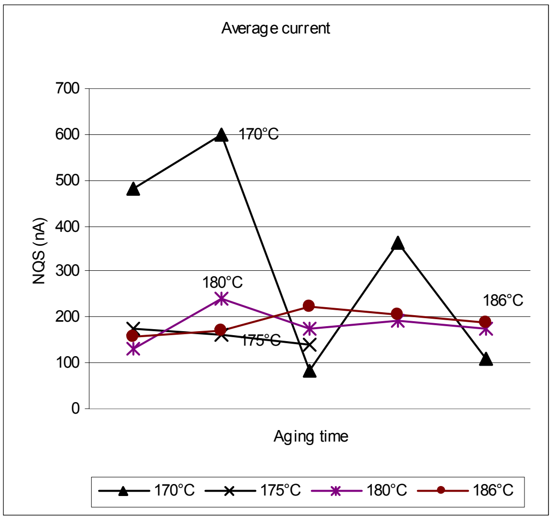

Fig. 9. Average current time chart for different aging temperatures

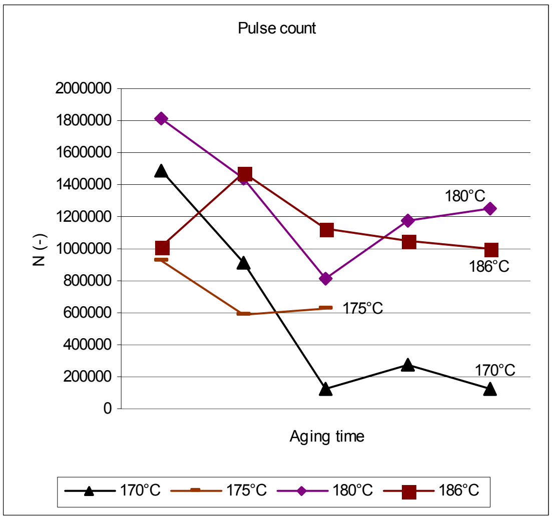

Fig. 10. Pulse count time chart for different aging temperatures

Decrease of pulse count of partial discharges of material aged at one aging temperature over the time is recognizable in figure 10. Second, the significant increase of partial discharge pulse count occurs when the particular aging temperature is rising (see Fig. 10).

Inception voltage doesn't show any evident increasing or decreasing trend during aging at any temperature (see Fig. 11). The differences of this magnitude are obvious for particular aging temperatures (170°C – 186°C). Inception voltage value is the lowest for aging temperature 186°C (see Fig. 11). It means the lowest voltage is necessary to start the partial discharges of specimen aged at 186°C for that reason that the material is the most aged of all aging temperatures.

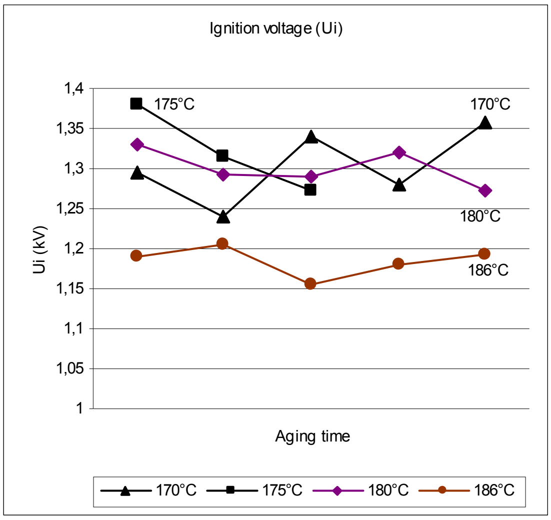

Fig. 11. Ignition voltage time chart for different aging temperatures

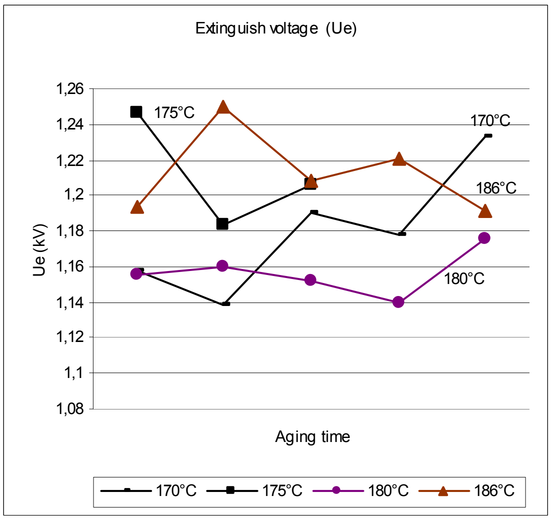

Fig. 12. Extinguish voltage time chart for different aging temperatures

Extinguish voltage of measured partial discharges (see Fig. 12) doesn't show any significant or universal trend depended on applied aging temperature. Otherwise, the extinguish voltage values have slowly increasing trend of magnitudes for each aging temperature over the aging time (Fig. 12).

5. Conclusions

Main parameters of partial discharges such as ignition voltage (Ui), extinguish voltage (Ue), pulse count (N), average discharge current (NQS) were measured and analyzed. This analysis was made for evaluation of insulation based on mica, glass fiber and epoxy resin degradation. Measured material was aged according to [1]. The flat specimens of material were prepared.

Increasing of inception and extinguish voltage and decrease of pulse count is obvious from the data measured over the time at one aging temperature.

Average discharge current doesn't have any significant trend of increasing or decreasing of magnitudes over aging time. Measured data of this parameter have furthermore significant variance of values. This fact is given thanks to stochastic fundament of internal and gliding partial discharges.

The partial discharges of whole setup are measured in the case of flat specimens during experiment. The internal and surface gliding discharges are detected and analyzed.

The real insulated bar specimens which are wrapped with a tape would have any phase resolved characteristics. The bar is here fully wedged and all corona protections paintings and protections are present. The slot discharges, end bar gliding discharges and internal discharges in the insulation cavities occurs at this real setup.

Recording the changes of partial discharges concerning the changes within material according to the aging temperature and aging time is applicable at described flat specimens testing as well.

6. Acknowledgment

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