Experimental Investigation on evolution of partial discharge in polypropylene films impregnated with jarylec

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Abstract: **In this paper we present an experimental study on the interest of the evolution of different characteristics of partial discharges under the influence of low temperature (0 °, -10 °, -20 °). These partial discharges were measured on a capacitor model, made of impregnated polypropylene films with jarylec, supplied from high voltage. We present results for the probability distribution of charge of partial discharges and the average charge depending on the application of voltage for different temperature values. We also noted the average charge, the amount of energy dissipation by partial discharges and the change in their frequencies as a function of temperature.**

Index Terms--**partial discharges, insulation, capacitor, ageing, polypropylene, jarylec**

1. Introduction

The study of partial discharges in mixed dielectric structure are still the subject of intense research, in fact one of the important phenomena of loss of dielectric properties of insulating materials is the development of partial discharges. The electrical discharge is a phenomenon that occurs when the electric field exceeds the dielectric strength of the material and may lead to partial or complete deterioration of insulation ability of material.

The mechanism of breakdown concerning gas, solid or mixed dielectric structure have been largely studied and the evaluation of characteristics of partial discharges is relatively well known [1]-[2]-[3]-[4].

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In this paper we are interested in the effects of temperature on the evolution of partial discharges in particular at low temperatures.

Several works have studied the evolution of discharges in various surrounding temperatures [5]-[6], the results have clearly shown an increases in temperature in the dielectric volume, even a reduction in the threshold electric field required for initiation of partial discharges. According to work done on the development of discharges at low temperatures [7], we note that the results have focused on the emergence of two regimes of discharges with a random evolution. It appears that the frequency of discharges increases when the temperature decreases.

In our works, we use capacitor aluminium separated by polypropylene films impregnated with dielectric (jarylec) and inserted between two flat and parallel electrodes.

2. Expriment

The detection and measurement of partial discharge was carried out with a device manufactured at laboratory of electrostatic and dielectric materials (LEMD) Grenoble [3], Fig1.

The device shown in Figure 1 consists of a Faraday cage with two separate compartments.

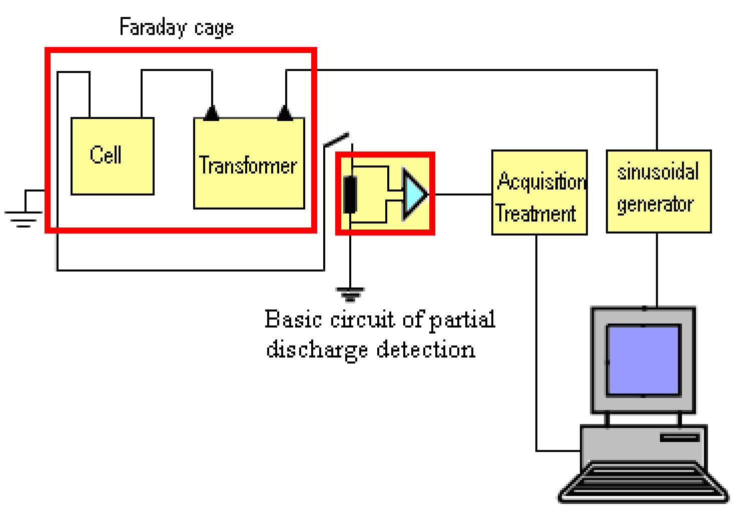


Fig. 1: Experimental setup

The transformer is placed in one compartment while the test cell is placed inside the other compartment. A digital waveform generator frequency and amplitude variables is controlled by a microcomputer to feed the primary of a step-up transformer.
This device uses the electrical and optical expressions of partial discharges. The study cell is a capacitors model for any film impregnated. It consists of a plastic material (Teflon) in which two aluminium ribbons are disposed at 90 degrees and separated by polypropylene films of 13.6 µm thickness
The study cell is filled with a dielectric liquid: the jarylec C100, used in power capacitors.
The Jarylec is a mixture of monobenzyltoluene and dibenzyltoluene, also with traces of tribenzyltoluene. The impregnation's role is to fill any air pockets in the dielectric to avoid the initiation of partial discharges at relatively low voltage.
When a partial discharge appears in the study cell, an apparent current flows through the external circuit (Basic circuit). It allows making measures of discharges in the order 0.05 pC and the minimum duration between two successive discharges is 330 ns. When a discharge is detected, its amplitude, its polarity as well as the instant of its appearance are measured. The phase of the discharge appearance is deduced from this instant. The device includes a thermostatic drying-room that reaches temperatures until - 40 °C.

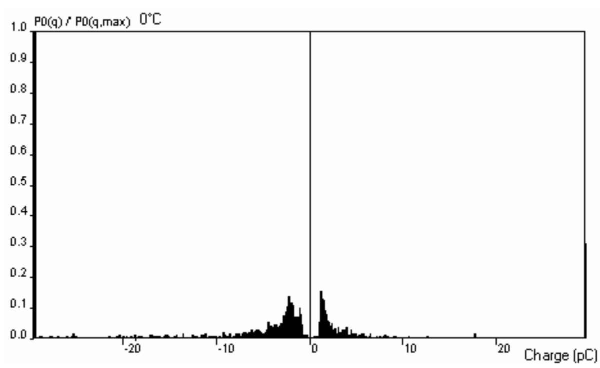
3. Results and discussions

Figure 2 shows the distribution of the probability of obtaining a discharge value q for values of temperatures of 0°C, -10°C and -20°C. This distribution allows determining the most likely discharge value. The results obtained show the appearance not too different from one temperature to another. We note first a charge distribution of values not too high. The value of the discharge the most probable for different temperatures is shown in Table 1.

	The charge of the second most likely regime	
T°C	q – (pC)	q + (pC)
0°C	-2. 9	2.4
- 10°C	- 4	3
- 20°C	-3.5	2

Table 1: The charge of the most likely discharge

According to the work of Hammel and at ambients temperatures [7], we noted the most likely value equal to 20 pc for the positive discharges and -12 pc for the release of negative, our results for low temperatures are much low.



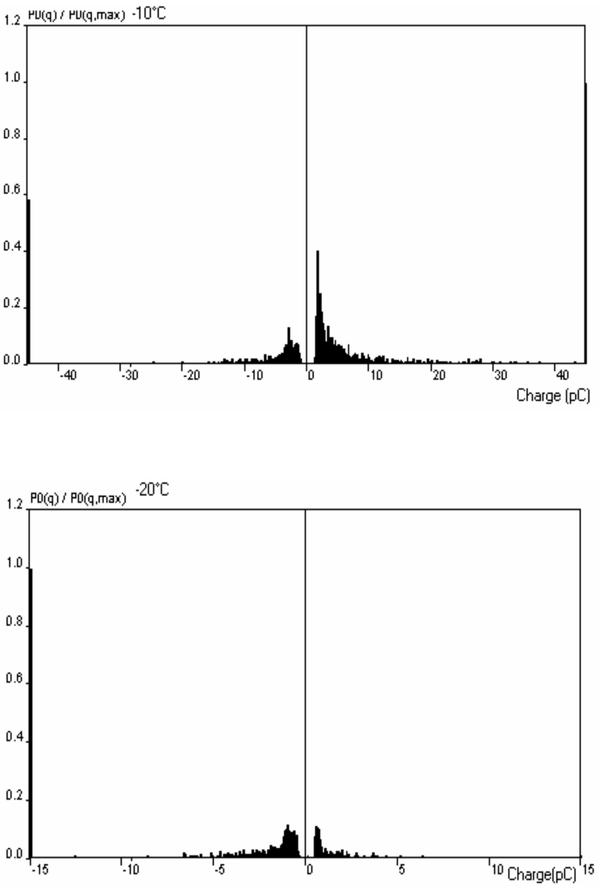


Fig. 2: The probability distribution of a low Discharge temperature

Fig. 3 shows the change in the average charge developed by partial discharges as a function of the applied voltage for different values of temperature. The result of the comparison between these characteristics shows clearly the two regimes of evolution of partial discharges according to the level of the applied voltage. The average charge remains at a low level for low temperatures relatively to that found for a temperature of 28°C Fig. 3. Similar results were recorded by Hammel [7].

We record the average charge about 65.04 pC to a voltage of 7800 V at a temperature of 28°C and a charge about 10 pC for the same voltage to -10°C. Therefore, the results are completely in accordance with the conductivity-temperature relationship. Indeed, according Dervos [5], conductivity in liquids and solids decreases when temperature decreases. Figures 4, 5 and 6 shows the variation of the average charge, frequency and energy of partial discharges as a function of temperature when the voltage is kept constant.

The average charge and energy indicate a significant decrease at temperatures below 0°C and a slight gradual increase at temperatures above 0°C. Moreover, the variation of these two values depends on the applied voltage.

We note that the variation of these values is almost proportional to the applied voltage. These results are in good agreement with those obtained previously [8]-[9]. However, the measure of the frequency versus temperature for two different and constant voltages allows us to observe at first that the frequency of the partial discharges increases considerably when the temperature decreases and decreases with increasing temperature, it varies 38,68 s-1 at the temperature -20°C to 3,75s-1 at the temperature 28°C. In a similar way, there is some proportionality between frequency and voltage depending on temperature.

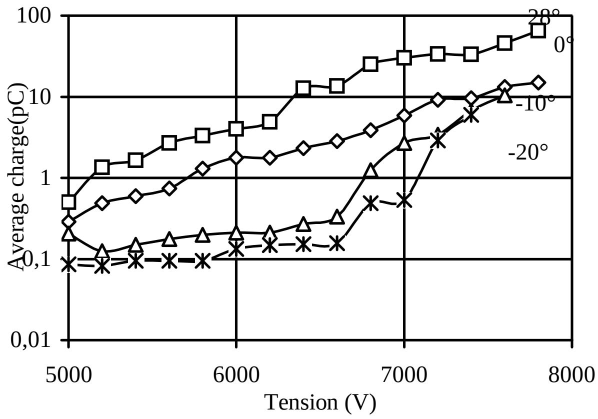


Fig. 3: Variation of the average charge in terms of voltage

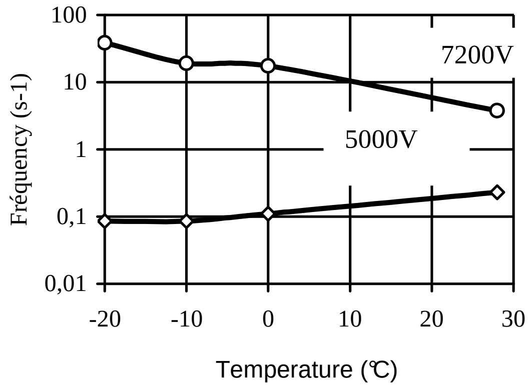


Fig 4: Variation of the frequency in terms of temperature

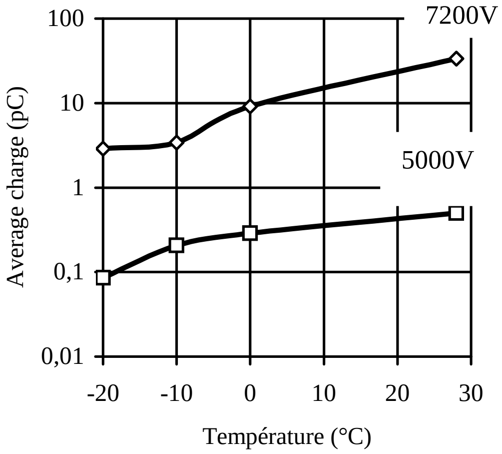


Fig. 5: variation of the average charge depending on the temperature

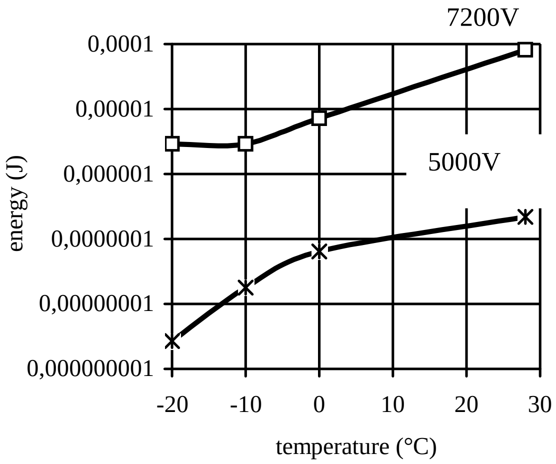


Fig. 6: variation of the energy depending on the temperature

4. Conclusion

It follows from this work, that the evolution of partial discharges is dependent on low temperatures. These discharges appear in bubbles of gas in the impregnate liquid. Correlations between temperature and the different characteristics of partial discharges studied are highlighted, such as frequency, the average charge and energy.

It was found experimentally that the frequency of partial discharge increases with the voltage applied at low temperature.

The average charge and the energy of partial discharges are lower for low temperatures. This change in evolution observed is translated by the increase of frequency of partial discharges, because the increase of the lifetime of a bubble has for consequence the increase of the probability of discharges in this bubble. Moreover, the experimental results confirm the existence of two regimes of partial discharges and show that the low temperature assist breakdown of capacitors at lower voltage levels

Acknowledgment

The work reported in this paper is part of a programme under N°: CMEP01MDU523 supported by a cooperation service French-Algeria, which is gratefully acknowledged.

References

1. H. Suzuki, K. Aihara, T. Okamoto « *Complex behaviour of a simple partial discharge model* » A Letters Journal Exploring the frontiers of Physics, 66, Issue1, pp. 28 34, 2004.

2. A. Cavallini, G.C. Montanari and F. Ciani «*Analysis of partial discharge phenomena in paper oil insulation systems as a basis for risk assessment evaluation* » IEEE Int.Cof. On. Die. Liq (ICDL), pp. 241-245, Portugal 2005.

3. M. Nemancha, J.P Gosse, B. Gosse and C. Marteau « *Monotoring of PD in capacitors models* » Proc. of 4 th Int. Conf. On. Cond. and Break. Insul. Diel (ICDL), pp.171-174, Italy, 1992.

4. C. Hantouche « *Partial discharge have had diagnostic tool for power capacitor* » EDA, DER, DEP CIMA 1995.

5.C. Dervos, P.D Bourkas, E.A. Kayafas and I. A Stathopulos « *Enhanced PD due to temperature increase in the combined system of a solid- liquid dielectric* » IEEE. Trans .On .Elect . Insul . Vol .25, N° 3, 1990.

6. H.R. Zeller «*Breakdown and prebreakdown phenomena in solid dielectrics* » IEEE Trans .elect .Insul. Vol . 22, pp. 115-122, 1987.

7. R. Hammal, P. Rain, J.P. Gosse and C. Hantouche «*Characterisation of partial discharge in impregnated capacitor* » Proc.XII, the ICDL, pp. 171-174, Rome 1996.

8. M. Nemamcha, J. P. Gosse and B. Gosse, "*Effect of Partial Discharges on Impregnated Polypropylene Films*", IEEE. Trans. on Dielec. and Elec. Insul. Vol. 1, No 4, pp. 578–584, 1994.

9. M. Nemamcha, L. Herous, M. Remadnia, M. Kachi, P. Rain and J.P. Gosse, " *Partial Discharges in capacitor model at low temperature*", J. Of. Eng. Sci. And. Techn.. Rev. 2 (1), pp. 137–140, 2009.