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CORONA DISCHARGE IN DIFFERENT INSULATING FLUIDS

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***Abstract:** Presented experiment consists of laboratory testing of partial discharges activity in liquid insulating fluids. Corona discharges within different insulation fluids were measured accordingly. The trends of partial discharge main parameters are studied and described in dependence on liquid type and aging time. The studied oils were thermally aged at 90°C for 3000 hours in air atmosphere within special climatic oven. Measuring of virgin state features took place after aging.*
Corona discharges measurement was realized using a point/plane electrode configuration where the whole test set-up was completely immersed in tested oil to suppress ambient conditions.
***Key words:** partial discharge, corona, insulating oil*

1. INTRODUCTION

The working life of electrical machines is primarilly 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. Multiple factor aging can be applied too. During the multiple factor aging all factors take effect together in the same time. Degradation of an insulation system is studied 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 non-destructive test method allows determining the degradation ratio or homogeneity of insulation of large number of apparatus, e.g. cables, rotating machines and transformers. Main parameters of partial discharges such as ignition voltage (*Ui*), extinguish voltage (*Ue*), pulse count (*N*), average discharge current (*NQS*) and apparent charge (*Qiec*) are commonly measured and phase resolved characteristics are analyzed. This analysis is usually made for evaluation of insulation condition.

Corona and other partial discharge types are rapidly studied for long time from 60's of last century. There are well known partial discharge patterns of different setups. In concrete devices used in electrical engineering. Wide interest of scientist is focused on partial discharge behaviour in air or in vacuum surroundings (Kucerovsky, 1996). The mechanism of discharge is described and tyical partial discharge models exist in various modification. Only several papers investigates partial discharge in oil (Sundara, 2009), (Chen, 2009) and studies of partial discharges in strongly divergent field in insulating oil (Cavallini, 2005).

All studies are prepared because of understanding of the discharge and insulation condition evaluation. The interpretation of the discharges and their correlation with the physical processes behind them are very important. Discrimination of the discharge sources within electrical devices is an important step in order to properly considering the necessary action to keep apparatuses to be in normal condition.

Tab. 1.

Recognizing the partial discharge patterns and their pulse sequences is very useful in the high voltage diagnostics (Bozzo 1998).

2. EXPERIMENT AND RESULTS

The study presented in this paper focuses on corona discharge in different insulating oils. The oils in the study are separated into two groups. First group consists of petroleum based oil used in power transformers; the second group consists of vegetable oil investigated for the possible of use in power and distribution transformers, for more details see (Mentlik, 2008). The petroleum based oils are common used DIALA and Y3000 and the vegetable oils used in this study are rapeseed and sunflower oils.

Corona discharges measurement was realized using a point/plane electrode configuration. The tip electrode was connected to the high voltage source and placed 10 mm from the low voltage plane electrode.

The test set-up assembly used for partial discharge testing was completely immersed in insulating oils during corona mesurement. Testing of partial discharge was performed by measuring the inception voltage, partial discharge apparent charge Q_{iec} and phase resolved partial discharge characteristics at inception voltage (PDIV) level.

The studied oils were thermally aged at 90°C for 3000 hours in air atmosphere within special climatic oven. Measuring of virgin state features took place after aging. Subsequently the oils were slowly cooled to ambient temperature before corona and other electrical measurement testing.

In table 1 there are shown typical electrical parameters of insulating oils of tested specimens. There are shown the difference in their insulating parameters and differences during aging

Oil	Breakdown voltage [kV/2,5mm]	Dissipation factor tg δ at 90 °C (-)		Inception Voltage Ui (kV)		Apparent charge Qiec (pC)	
	VS	VS	3000h	VS	3000h	VS	3000h
DIALA	48,8	0,056	0,168	12,2	12,2	8,9	3,4
Y3000	59,9	0,122	0,182	12,1	12,1	7,4	5,8
Rape seed	60,7	1,566	8,241	12,2	10,16	8,6	6,7
Sunflower	54,9	4,627	NM	12,3	NM	8,9	NM

Tab. 1. Electrical properties of tested oils (NM- non-measurable, VS – virgin state)

The test results of partial discharges in phase resolved characteristics are presented in following figures. Figures 1 and 2 presents petroleum based oils and figures 3 and 4 presents vegetable oils.

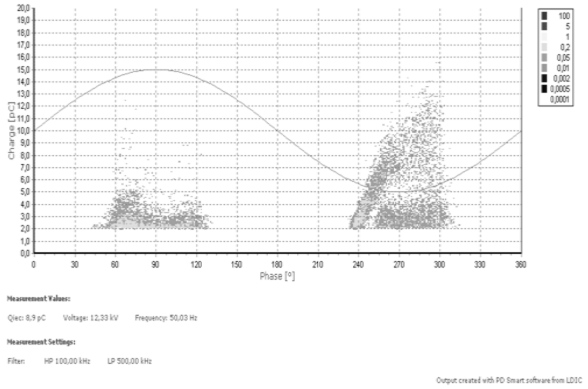

Fig. 1. Diala - 0 hours of ageing

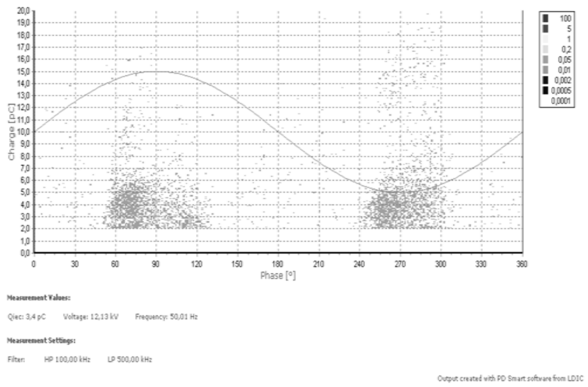

Fig. 2. Diala - 3000 hours of ageing

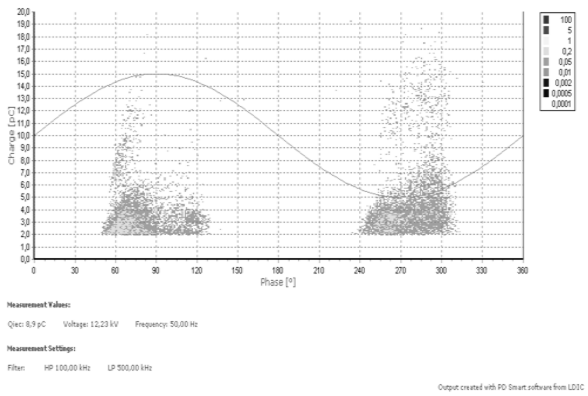

Fig. 3. Rapeseed - 0 hours of ageing

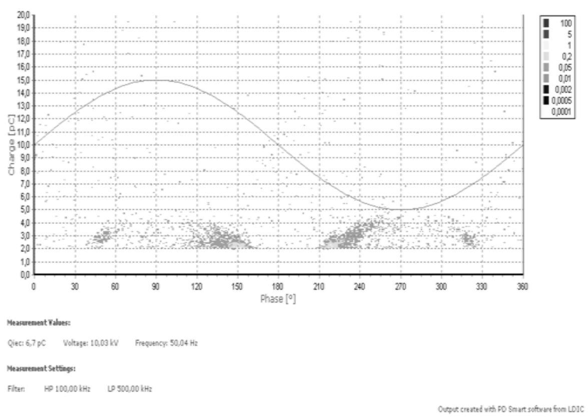

Fig. 4. Rapeseed - 3000 hours of ageing

3. CONCLUSION

Corona discharges in oil were investigated under sinusoidal test voltage using needle/plane electrode system immersed in oil. There are strong differencies of corona discharge compared to the corona measured in air at the same set-up as well known. Corona discharges in oil appear byn both voltage amplitudes, negative and positive. This is different to the corona discharge in air.

When compared the corona behavior in different oil of different aged condition there are slightly differencies among used fluids.

Petroleum based oil don't change the inception voltage during aging and its value is comparable to the inception voltage of vegetable oils. In the contrary the vegetable oils have lower partial discharge inception voltage after thermal aging.

The level of apparent charge for oils in virgin state is comparable for all types of the oils. The best value has mineral oil Y300. The apparent charge of corona discharge decreases during aging. The biggest decrease had DIALA oil approximately 62%. The Y 3000 and Rapeseed oil discharge value decreases appx. of 22%.

The sunflower oil change its viscosity during aging and the corona discharge or other electrical parameters weren't possible to measure.

When compare the partial discharge phase resolved characteristics there are differencies in behavior of new and aged oils, as presented in figures 1,2 a figures 3,4.

The study results are compared with other studies cited in this article. The results help to understand the partial discharge behavior in the oil and bring wide diagnostics knowledge to the high voltage applications.

4. ACKNOWLEDGEMENTS

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