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Investigations on Partial Discharge Characteristics of Vegetable Oil and Mineral Oil

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***Abstract*— Partial discharge (PD) detection plays an important role in the life assessment of liquid insulation in transformers. This paper investigates on the PD activity and characteristics in mineral oil and vegetable oil (named as IO-18 & IO-19). To simulate corona discharges, point plane electrode configuration was used. The phase resolved PD patterns of vegetable oil and mineral oil with pressboard were recorded and analyzed. From the results it is observed that the inception voltage of vegetable oils is higher than mineral oil. Also vegetable oil shows better PD characteristics hence they can be used for high voltage insulation applications.**

Keywords—Partial discharge, discharge power, events/sec

I. INTRODUCTION

Reliability of electric power systems mainly depends on the high voltage transformers. With increase in demand of electrical power, it is crucial that electricity supplies should be protected and always available. Any breakdown of transformer results in heavy repair expenses. A large amount of distribution transformer failure is due to long term thermal aging and degradation of insulation system [1]. Partial Discharges (PD) are one of the major reasons for degradation of high voltage insulation systems. PD measurement is used as diagnostic tool for monitoring the condition of insulation system [2-4]. PD inception voltage, charge magnitude, number of discharge pulses and its distribution are the important parameters to be analyzed.

Mineral oil are the commonly used insulating fluid in power apparatus. Mineral oil are poorly biodegradable and cause serious contamination of soil and water ways if spill occurs. Since petroleum products are eventually going to run out leading to shortage. Hence it is necessary to carry out in the development of new biodegradable insulating fluids. Vegetable seed oils are biodegradable, non-toxic and most environmental friendly [5-11]. Hence extensive studies were carried out to find suitable insulating oil for electrical applications.

Partial discharge (PD) due to electric field enhancement in a localized area of insulation accelerates the degradation and thermal aging of insulating oil. Hence PD plays a major role in determining the insulation strength and life time of oil [12]. Therefore it is very important to understand the PD characteristics of vegetable oil. Considering these facts the major aim of present work is to obtain the typical PD patterns of two vegetable seed oil to find its suitability for power apparatus applications. In this paper Phase Resolved PD characteristics of two fresh vegetable oils named as IO-18 and IO-19 are investigated. For the comparison the PD characteristics of mineral oil are also discussed.

II. .

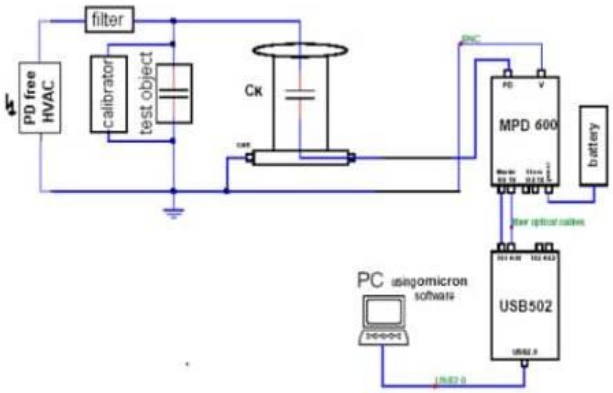

Fig 1: *Circuit arrangement for PD measurement*

The PD measurements are conducted using Omicron make MPD 600 digital PD detector. The test source used is a 100KV PD free transformer. PD free 1000pF capacitor is used as coupling device. The whole test setup is enclosed inside the Faraday's cage. To conduct PD measurement on oil/pressboard a point-plane electrode arrangement is used. PD measurement is carried out according to the IEC 60270 test procedures. The circuit arrangement is as shown in figure 1.

III. EXPERIMENTAL RESULTS

PRPD pattern

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Partial Discharge pattern identification and analysis have been proven tool for the diagnostics of the insulation condition of the high voltage apparatus. PD takes place when the local electric field exceeds the threshold value and produces a partial breakdown of the surrounding insulating material. The electric field necessary to produce a partial discharge is obtained by utilizing a point- plane electrode configuration. Since the electric field under point-plane configuration is non-uniform, it produces maximum electric field [13]. To find the suitability of vegetable oils as insulating media in high voltage apparatus, PD characteristics of vegetable oil & mineral oil using a point plane configuration has to be obtained and analyzed.

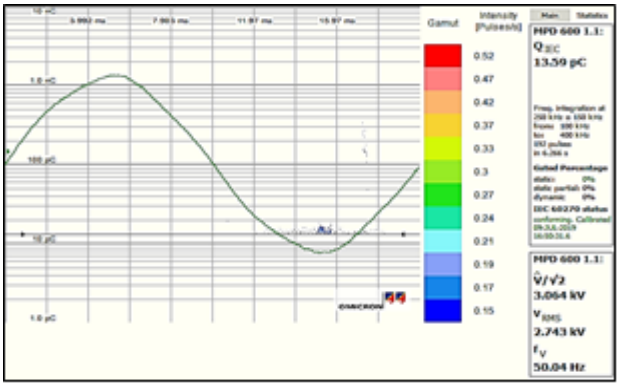

Fig 2a: *PRPD Pattern of IO-18*

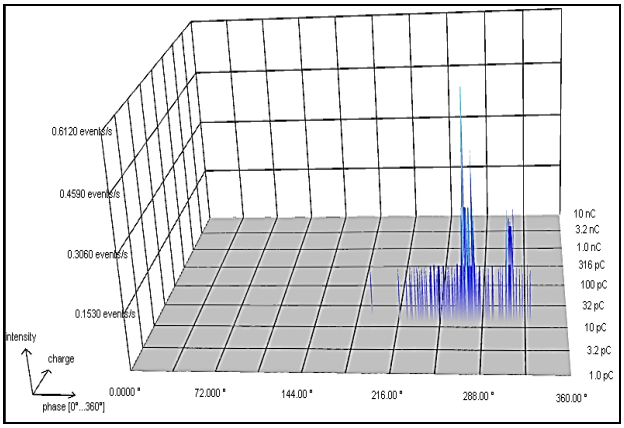

Fig 2b: *Histogram of IO-18*

In the point-plane electrode configuration, initially the partial discharge inception voltage (PDIV) was evaluated. PDIV is the lowest voltage at which observable PD pulses appear on the PD detector. Pompili et al have reported that determination of PDIV in the case of liquid dielectric is difficult because PD pulses appear in pulse bursts and their occurrence rate is more erratic. Voltage is applied to the test object and PD signals were captured and recorded. Figure 2a, 2b, 3a, 3b & 4a, 4b shows the PRPD pattern & histogram during PD inception of IO-18, IO-19 and Mineral oil respectively.

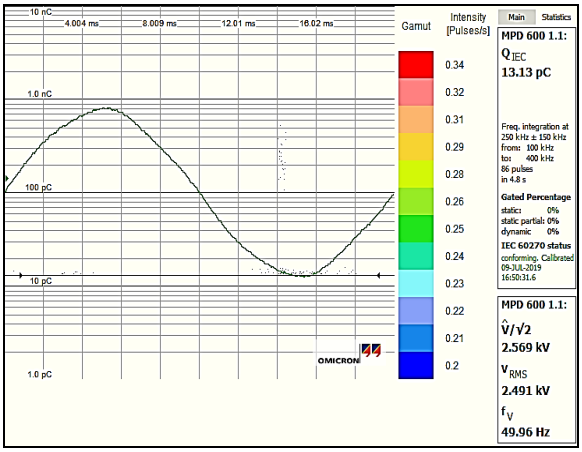

Fig 3a: *PRPD Pattern of IO-19*

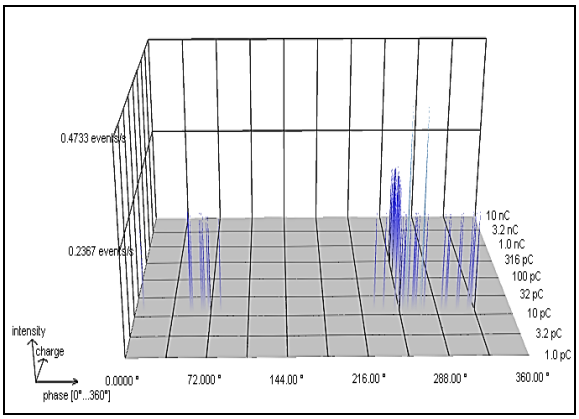

Fig 3b: *Histogram of IO-19*

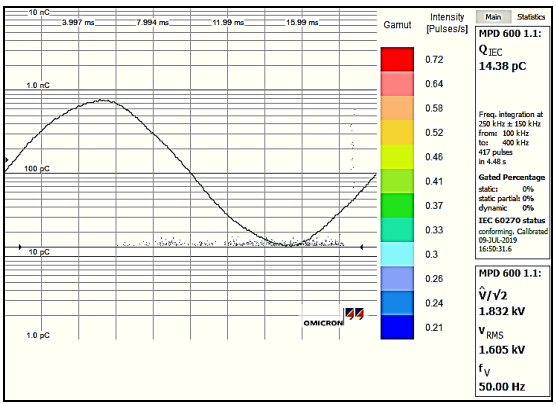

Fig 4a: *PRPD Pattern of Mineral oil*

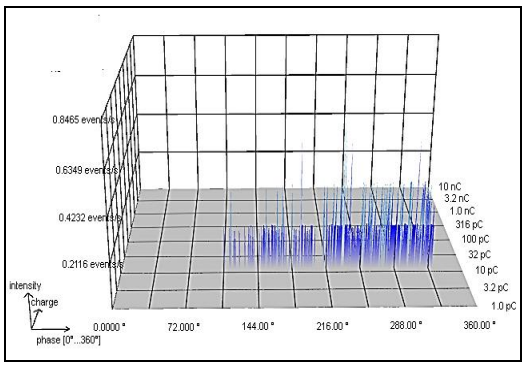

Fig 4b: *Histogram of Mineral oil*

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The inception voltage of IO-18, IO-19 and mineral oil are 3kV, 2.6kV and 1.8kV respectively. The magnitude of peak discharge (Q) and number of PD events/sec (n) are almost same for IO-18 & IO-19 whereas mineral oil shows higher values of Q & n than the vegetable oils. During the PD activity, the discharge powers (Pdis) in IO-18 & IO-19 are very less compared to mineral oil. The PD activities were observed in negative half cycle of applied voltage for IO-18 and IO-19 whereas in mineral oil it is scattered on both half cycles. The detailed results are tabulated in the table 1

TABLE 1: RESULTS OF PD FOR THREE OILS

PD Parameter	IO-18	IO-19	Mineral oil
Inception Voltage (Vi)	3kV	2.6kV	1.8kV
Average charge (Q_{avg})	12pC	11pC	13.8pC
Peak charge (Q_P)	479pC	500pC	575pC
Number of PD events/sec	26.5	19.5	76
Discharge current (I_{dis})	814pC/sec	1nC/sec	1.75nC/sec
Discharge Power (P_{dis})	2µW	1.9µW	3µW

IV CONCLUSION

Due to environmental concerns, biodegradable oil is increasing being used as replacement for mineral oil in transformers. Therefore it is necessary to compare their PD activity. The PD inception voltage of IO-18 and IO-19 are higher than of mineral oil. For the point plane testing, peak PD magnitude, number of PD events/sec, discharge power of IO-18 and IO-19 are lesser than of mineral oil. The experimental results shows that IO-18 & IO-19 has the required potential to be used as liquid insulation in transformers and also obtained results motivates the researchers to carry out further research on these vegetable oils.

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