شبكة المعلومات الجامعية

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شبكة المعلومات الجامعية

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التوثيق الالكتروني والميكروفيلم

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قسم

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بالرسالة صفحات لم ترد بالأصل

Dielectric Properties of Insulating Liquids Under High Electrical Stress and Nonuniform Fields

Ph. D. Thesis

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ABSTRACT

This thesis presents the results of an experimental investigation into the effect of enforced co-field motion and cross-field motion on the conduction current in transformer oil under highly non-uniform field , using direct voltage and a point-to-plane electrode geometry. The plane electrode was either solid or fitted with a 0.16 mm mesh screen.

Before each conduction current test, a complete set of breakdown voltage tests were carried out, to determine the voltages at which the conduction current would be measured.

The present work is characterized by eliminating any human interference in conduction current measurements, recording and plotting by using a highly sensitive electronic electrometer (with built in memory for measuring the conduction current) directly connected to the test cell & interfaced with a computer. Conduction current values were recorded at preset intervals that varied from 360 ms. to 10 s. and transferred to computer for plotting.

Tests on oil were carried out for negative and positive point polarities under the following conditions:-

1- Degassed oil .

2- Oil saturated with oxygen .

3- Oil saturated with sulfurhexafluoride (SF_6) .

4- Oil containing 1-methylnaphthalene .

5- Oil containing N-dimethylaniline .

The gas additives were bubbled through degassed oil up to saturation. The liquid additives were dissolved in the degassed oil at predetermined concentrations. The velocity of both co-field motion and cross-field motion varied between 0 (stationary oil) and 52 cm/sec.. The gap length between the electrodes varied from 200 μ m to 900 μ m .

A good correlation was found to exist between the effect of oil flow on conduction current and on the breakdown voltage for both co-field and cross-field motions .

For degassed oil and all oil with additives, both the co-field motion and cross-field motion produced a significant reduction in conduction current .The faster the oil flow the larger the reduction in current. This phenomenon was common for the whole range of gaps examined and for both point polarities. However, for oxygen-saturated oil , SF_6 saturated oil and oil with 1-methylnaphthalene, the effect of the oil flow on conduction current was markedly dependent on the polarity of the point electrode in case of a co-field motion. With point negative , there was a marked decrease in the conduction current with increasing oil velocity . With point positive, there was a decrease in conduction current at the low rate of flow (up to 22.7 cm/sec.) , with no further significant decrease at higher velocities.

With oxygen or SF_6 in solution , current fluctuations were much larger than for the other oil conditions. This distinct difference was observed for both needle polarities , for solid and mesh plane electrodes, and for co-field and cross-field motions .

For gas saturated oil (oxygen and SF_6) , an increase in pressure which is required to produce the oil flow, produced an increase in the conduction current only for solid plane electrode in case of co-field motion .

In general oil flow whether co-field or cross-field motion, resulted in an improvement in breakdown voltage of the oil compared with stationary oil . For all oil conditions , the increase in breakdown voltage in case of cross-field motion was higher than that in case of co-field motion for positive needle. For negative needle, however, the percentage increase in breakdown voltage was almost the same for both types of liquid motion.

CHAPTER 1

INTRODUCTION

Motion of liquid insulant is of two types; self or electrohydrodynamic (**EHD**) motion which is induced by the applied field, and enforced motion which is produced by external mechanical means. Enforced motion can be either parallel to the direction of the field **(co-field)** or perpendicular to it **(cross-field)** .

EHD has received considerable attention since first reported by Ostroumov in 1965. The effect of enforced motion on conduction current and breakdown in insulating liquids is of practical importance in all applications in which fluids are used as insulants and coolants. Work in this area has been rather limited specially for co-field flow and was confined to breakdown voltage measurements [70] 1985, [84] 1990.

The electrical breakdown mechanism of dielectric liquids has been studied in this laboratory for a number of years by many workers. In the present work we studied the effect of enforced co-field and cross-field liquid flow on the pre-breakdown conduction current and breakdown voltage in transformer oil, under highly non-uniform field, using needle-solid plane and needle-mesh plane electrode geometry. Experiments were carried out on transformer oil sample under the following conditions:-

1- Degassed oil.

2- Oil saturated with oxygen.

3- Oil saturated with SF_6 .

4- Oil with 0.1 molar concentration of 1-methylnaphthalene.

5- Oil with 1 molar concentration of N-dimethylaniline.

The molar concentration of 1-methylnaphthalene and N-dimethylaniline were chosen as being the optimum concentrations reported earlier [65 & 84] to give the highest breakdown voltage measurements.

Both gaseous and liquid additives used in the present study were selected to explain its following inherent characteristics:-

1- High ionization potential and electron trapping (oxygen & SF_6)

2-Low ionization potential and electron trapping (1-methylnaphthalene)

3-Low ionization potential and no electron trapping (N-dimethylaniline)

Gap lengths used ranged from 200 to 900 microns were used. All tests were carried out using positive and negative polarities of the needle electrode.

The present work is characterized by eliminating any human interference in conduction current measurements, recording and plotting . A highly sensitive electronic electrometer (down to 10^{-15} amp.) with built in memory for measuring the conduction current. The electrometer is directly connected to the test cell & interfaced with a computer. Conduction current values were recorded at a preset interval that varied from 360 ms. to 10 s. and transferred to computer for plotting and analysis .

In chapter 2 , a general review of previous work is presented.

In chapter 3 , a detailed description of the experimental apparatus is given. The chapter comprises the test procedure and method of measurement.

In chapter 4 , the test results are presented.

In chapter 5 , the results are analyzed and discussed.