Statistical Analysis of AC and DC Breakdown Voltage of JMEO (Jatropha Methyl Ester Oil), Mineral Oil and Their Mixtures

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Abstract— **This paper reports on a comparative study of statistical Breakdown Voltage (BDV) in a natural ester oil namely jatropha curcas methyl ester oil (JMEO) extracted from the fruit seeds of jatropha curcas plants, mineral oil (MO) and two JMEO/MO oil mixtures (namely (50%JMEO+50%MO) and (80%JMEO+20%MO)) using spherical electrode under DC and AC voltages. It is shown that the average AC breakdown voltage of JMEO is higher than that of mineral oil. Meanwhile it is similar under DC voltage. The statistical analysis shows that all large data groups (n>40) for AC and DC breakdown voltages of JMEO, MO and oil mixtures obey to the normal distribution law. This is proved using Shapiro-Wilk test, skewness and kurtosis values. It also observed that AC mean breakdown voltage of JMEO is higher than that of oils mixture (50%JMEO+50%MO) and MO, but it is similar with oils mixture (80%JMEO+20%MO). AC mean breakdown voltage of MO is the lowest one. DC mean breakdown voltages of JMEO, MO and oil mixtures (50%JMEO+50%MO) are similar. In contrast, DC mean breakdown voltage of oils mixture (80%JMEO+20%MO) is the highest one.**

Keywords— Breakdown voltage; AC; DC; jatropha curcas methyl ester oil (JMEO); mineral oil (MO); JMEO/MO mixtures; breakdown voltage; statistical analysis.

I. INTRODUCTION

Despite some characteristic parameters as their high viscosity that can be improved by the adjunction of specific additives, the use of natural (vegetable) ester oils as substitutes for mineral oil in high-voltage oil-filled equipment (especially high voltage transformers) have become a reality today. Indeed, some vegetable oils such as FR3 and BIOTEMP® fluid are presently applied in distribution transformers and even in some big unities [1-4]. Unfortunately, these vegetable oils are derived from food products (rape-seeds, sunflower, olive ...) what constitutes an ethic problem since in some regions of the world are suffering from malnutrition. Therefore, it is needed to divert our attention to non-food materials so that the searches of new material alternatives do not interfere with foodstuffs.

Recently, we developed a vegetable oil derived from jatropha curcas namely JMEO (Jatropha curcas methyl ester oil) which is a non-food crops and that can constitute a potential substitute for mineral oil [5]. Also, when replacing mineral oil by JMEO in installed transformer, the mixing of JMEO and mineral oil cannot be avoided, because the draining process will still leave remain oil in the spaces between windings and the bottom of tank; the residual mineral oil in the transformer tank is estimated at about 10-20% of the total volume of oil. Therefore, it is necessary to examine the effect of the mixture percentage on breakdown voltage.

This paper is aimed at the comparison of breakdown voltage of JMEO, mineral oil (MO) and two JMEO/MO oil mixtures namely 50%JMEO/50%MO and 80%JMEO/20%MO under DC and AC voltages. Breakdown voltage test results are analyzed using statistical method that is distribution normal law. Statistical analysis is performed by using SPSS 17.0 software.

II. EXPERIMENTAL TECHNIQUE

Breakdown voltage measurements were performed in sphere - sphere electrode system with 12.5 mm of diameter, 2.5±0.05 mm of distance according to main lines of IEC 60156 specifications [6]. The investigated oil samples are: (1) JMEO (jatropha curcas methyl ester oil), a new vegetable oil derived from a non-food crops, produced through trans-esterification process of jatropha curcas oil which comes from the pressing of the jatropha fruits; (2) Mineral oil (MO); and (3) two JMEO/MO oil mixtures namely 50%JMEO/50%MO and 80%JMEO/20%MO.

AC high voltage is supplied by a high voltage test transformer 200 kV-50 Hz - 60 kVA. The experimental results used in the analysis are the maximum AC voltage values. The voltage is continuously applied with a rate of rise 2±0.2 kV/s until breakdown occurs. The rest time between each test was 10 minutes and 5 minutes respectively for JMEO and mineral oil (MO). In order to obtain sufficient measured data for accurate statistical evaluation, the tests were carried out by 40 of series for each oil sample. It is more than eight times the 6 measurements required by the IEC 60156 standard [6].

DC voltage is supplied by a Spellman type DC generator with an AC 220 V input and a 0 - 200 kV / 2 mA DC output. In breakdown tests, the applied voltage is increased step by step until the breakdown occurs. In the range 0 - 40 kV, the applied

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