

Studies on Breakdown Voltages of Liquid Dielectrics

S Vasudevamurthy¹, Girisha², Shubham Shah³, Varun kumar B L⁴, Uday N⁵

Associated Professor, Electrical and Electronics Engineering, Dr.AIT, Bengaluru, India¹

B.E in Electrical and Electronics Engineering, Dr AIT, Bengaluru, India^{2,3,4,5}

Abstract: The objective of proposed work is to study the dielectric behavior of the natural ester based oil and it is compared with the transformer oil to find their suitability for use as liquid dielectric. Mineral oil contains a lot of toxic inhibitors to improve their properties. Due to this it is necessary to find a new source and that will be substitute for the mineral oil. For use as insulating liquids in power transformers, Natural ester based oils are gaining worldwide attention as biodegradable alternatives and competitors to the mineral based oils.

Keywords: Liquid insulation, breakdown voltage, moisture content.

INTRODUCTION

Transformer plays a vital role in the field of transmission and distribution of electrical power. It is used to transform electrical energy from one circuit to another circuit without change in frequency. Power transformers are used in transmission network of higher voltages for step-up and step-down. PT generally rated above 200MVA. A distribution transformer provides the final voltages transformation in the electrical power distribution system. It is used to stepping down the voltages as per the power requirement level of the customer. Transformer encounters lightning and other switching surges, hence it requires proper insulation. Heat is generated during operation of transformer, therefore a coolant is necessary to dissipate this heat. To overcome this problem liquid dielectric used as both insulating medium and coolant. It transfers the heat effectively in transformer, power cables, circuit breakers, bushing and switches. Mineral oil used in transformer called transformer mineral oil. It is obtained from fractional distillation of crude petroleum. Mineral oil serves as insulations and coolant in transformer. But in spite of many advantages, the poor biodegradability of mineral oil results in contamination of soil and water in the event of accidental spill. Due to this disadvantage of mineral oil, in 90's the United States find a suitable substitute for the mineral oil based transformer oil. Last couple of decades has seen in the development of natural ester based oil for use in transformer.

METHODOLOGY

Random selection of commercially available oil in market-rice bran oil

The parameter under studied are:

- Break down voltage
- Moisture level
- Tan delta (Dissipation factor)

Are compared with the mineral oils.

Breakdown voltage:

Breakdown voltage of transformer oil is the voltage at which breakdown occurs between the two electrodes when oil is subjected to an electrical field under prescribed condition. In the present project the breakdown test of insulating oils is done as per Indian Standard (IS 6792/1972). As per the IS 335 BDV of unfiltered mineral oil is 30kV (rms) and for filtered mineral oil is 60kV (rms). Break down test is very important test for insulation oil in transformer. This testing method entails that a steady incremental voltage of 2 kV/s be applied to the test cell containing the oil sample until breakdown occurs. According to the standard, the test procedure is repeated five times and the mean breakdown voltage is recorded as the Breakdown Voltage (BDV) of the sample.

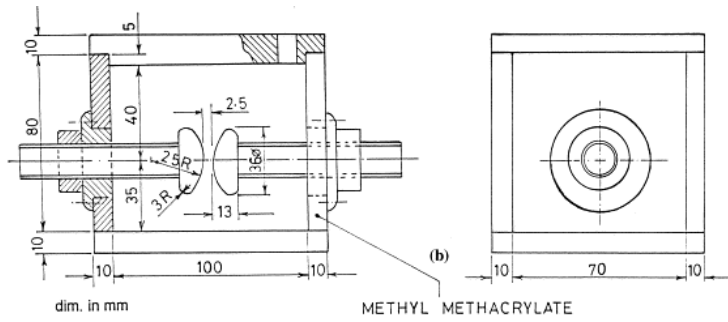


Fig: Schematic diagram of Breakdown Voltage test cell

Moisture test:

The amount of free and bound water present in the oil is its moisture content. Water content in oil allowed up to 50ppm as recommended by IS 335. Water content in oil is highly undesirable and hence rate of degradation of oil increases with increase in moisture.

The measure of water content in an insulating oil we use **Karl fisher titration** as basic technique. In this titration, water (H₂O) is oxidized with iodine (I₂), sulfur dioxide (SO₂), organic base (C₅H₅C) and alcohol (CH₃OH) in an organic solvent.

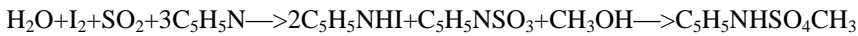
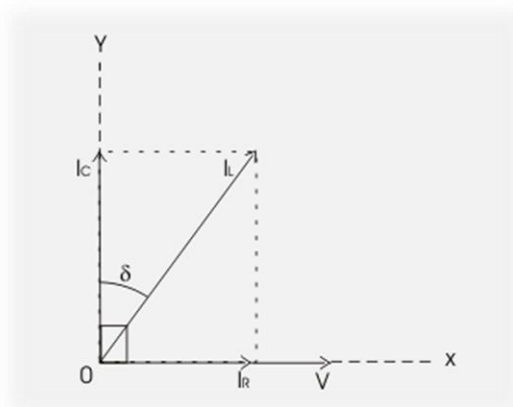


Fig: Moisture test kit

Dissipation factor:



In the vector diagram above, the system voltage is represented along x-axis. The capacitive component of leakage electric current I_c represented along y-axis and it leads the system voltage by 90°. Conductive electric current i.e. resistive component of leakage current, I_R will also be along x-axis. Now, total leakage electric current makes an angle δ (say) with y-axis. Now, from the diagram above, it is cleared, the ratio, I_R to I_C is nothing but $\tan \delta$ or $\tan \delta$.

$$\text{Thus, } \tan \delta = \frac{I_R}{I_C}$$

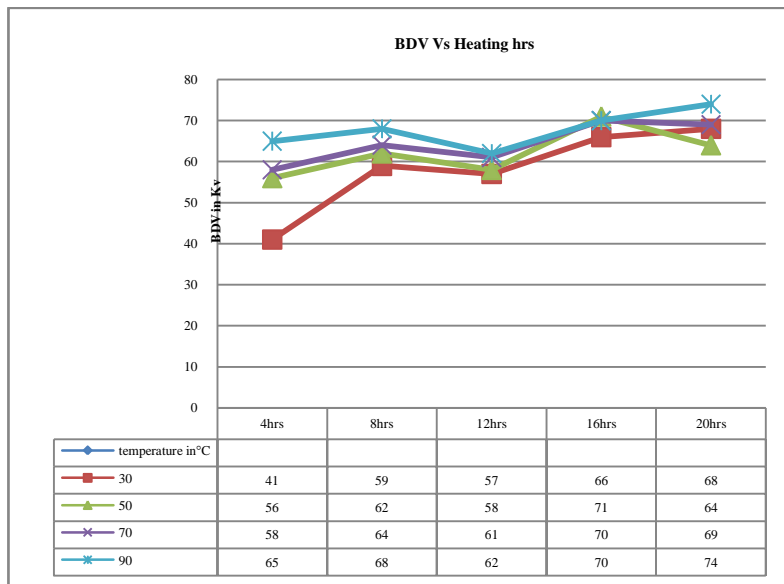
Tan delta measured using **ADTR-2K** kit. Tan delta is measure of imperfection in dielectric nature of transformer oil. Standard value of tan delta in mineral based oil is less than 0.005. The tan delta value gives an indication of the condition of oil sample.



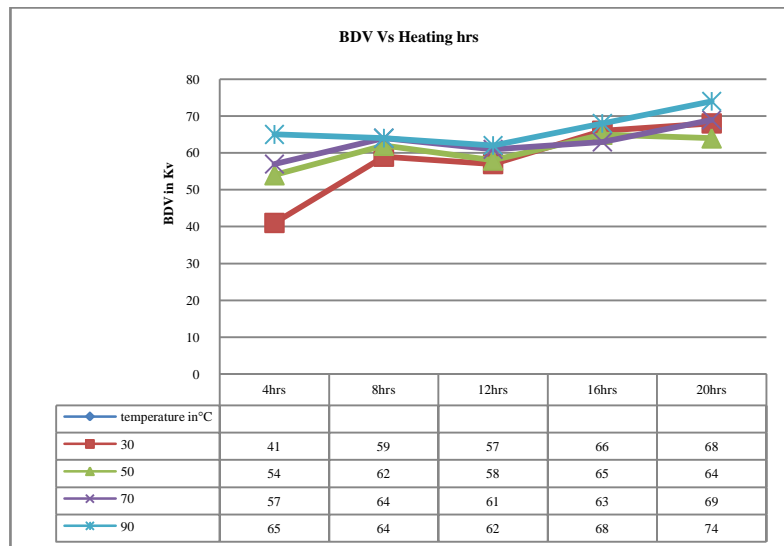
Fig: Automatic Tan-delta, Dielectric constant and Resistivity measurement kit

RESULT

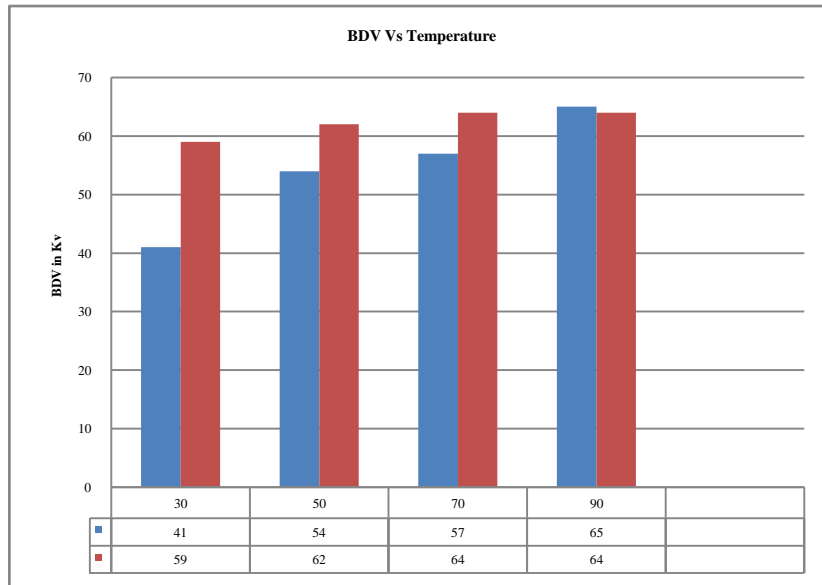
Rice bran oil



Transformer oil



Comparison between transformer oil and rice bran oil



CONCLUSION

The BDV of heated oils has improved compared to that of fresh oils this due to decrease in the removal of moisture content in the heated oils. The selected oil has better BDV at the higher temperatures compare to lower temperatures.

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