Collating the Critical Parameters of Reclaimed Transformer Oil & Vegetable Oil Using Antioxidants

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Abstract— Transformers are the most dynamic apparatus in electrical energy generation, transmission and distribution system. Conventionally, mineral oils are used as an insulating medium in transformers. It is used to prevent arcing, suppress the corona and improve the cooling. There is a need to change the oil after many years of use due to drop in property with respect to time. The used mineral oil is either recycled or sent to dump causing environmental effects of its removal. In this work, an attempt has been made to reclaim the used or aged transformer oil by using adsorbent like sepiolite and then enhance that oil by the treatment with the different antioxidants like gallic acid, propyl gallate, ascorbic acid. Then compare the results with the vegetable oil that are treated with antioxidants and adsorbent. Antioxidants are the materials which are mainly used to reduce the oxidation process occurs in the transformer oil. Properties such as Breakdown strength, viscosity, Flash point and Fire point are investigated.

Keywords—Used Transformer oil; vegetable oil; Antioxidants; Regeneration

I. INTRODUCTION

The transformer is the most important component in the power system. Transformers are made of solid and liquid insulation. The life span of transformer mainly depends upon the insulation that is made in transformer. Transformer oil, which is produced from mineral oil is non-volatile, non-biodegradable. The two different types of oils that are used in transformer for insulation purpose are Naphtha oil and Paraffin oil. Paraffin oil cannot be oxidized easily like as Naphtha oil because sludges in the naphtha oil are more soluble than paraffin oil. Although Paraffin oil oxidation rate is lower than that of Naphtha oil, but the oxidation product or sludge is insoluble. Paraffin oil is used in transformers because of its easy availability. Cooling of transformers is implied by transformer oil. The dielectric strength of the mineral oil is high, but it has a poor flash point and fire point. Mineral oil has lesser acidity when compared to vegetable oil. When compared to mineral oil, vegetable oil can easily and quickly biodegrade and also exhibit very low or no toxicity. This is due to dielectric fluids of vegetable oil does not contain polynuclear aromatic, volatile or semi volatile organics, halogens and other compounds which can be present in other dielectric fluids or mineral oil. Vegetable oil has better aerobic and anaerobic conditions when compared to mineral oil. By different pressing methods vegetable oils can be obtained from oil containing seeds, fruits or nuts. Apart from this mineral oil holds few demerits like high viscosity, high cost and high oxidative stability.

II. CURRENT EFFORT

For the sake of above mentioned problem, it is needed to formulate a different fluids with properties similar to mineral oil. Vegetable oils are used in food applications for many millennia. Natural and synthetic antioxidants are used as a high performance additives for vegetable oil. They are used to promote the performance more than traditional mineral oil and relevant to natural ester standards.

III. SPECIMEN DESCRIPTION

A. Oil samples

In this work used transformer oils in service of 12yrs were collected from the local sub-station. Then the properties of used transformer oils were measured tender by ASTM and IEC standards. Congruent to that refined form of sunflower oil, palm oil and soybean oil samples were collected from the market for calibrating the critical parameters.

B. Adsorbent

Adsorbents have the capacity to change fast moving electrons to slow moving electrons. Sepiolite adsorbent with oil under categorical conditions for the eviction of toxic metal contaminants. It is used for the purpose of bleaching(color removal) and to upgrade the critical parameters. Colloidal grades of the sepiolite must be dispersed into water or other liquid systems by using high-shear mixers. Once dispersed in the liquid, it forms a structure of randomly intermeshed elongated particles, which is maintained by physical interference and hydrogen bonding, and entraps the liquid, increasing the viscosity of the suspension.

C. Antioxidants

Antioxidants are the chemical agents which anticipate the attack of oxygen. Antioxidants are normally classified into primary antioxidants, secondary antioxidants, reducing agent, synergists, oxygen scavenger. They are used to prevent the oil from

oxidation process. Oxidation is the reaction of oxygen molecules with oil molecules and its margin to a maximization of viscosity and the creation of varnish, sludge and sediment.

Table I. OIL SAMPLES

Oil specimen	Symbol code
Used transformer oil	UTO
Sunflower oil	SFO
Palm oil	PO
Soybean oil	SO

IV. EXPERIMENT

D. Methodology 1

A 500ml of used transformer oil sample was taken in a 1000ml beaker and it should be heated up to 100ºC with the help of the heating chamber. Then the antioxidant of 2gm is mixed with the oil. Then the temperature should be maintained to the melting point of antioxidants. Then the setup is transferred to the magnetic stirrer and maintained it for 30 minutes at 750 to 800 rotations per minute (rpm) in which the temperature should be maintained between 60ºC to 90ºC. Then the treated sample was filtered using Whatman filter paper. Then it is transferred to the vessel for the measurements.

E. Methodology 2

A 500ml of vegetable oils like sunflower oil, palm oil, soybean oil were taken in a beaker. At the beginning these oils should be heated to remove the moisture content at the temperature of 100ºC. Then it should be brought to room temperature and the properties were measured according to standards. Then the oil is taken and then it is heated using a heating chamber to dissolve the antioxidant. Then the antioxidant of 2gm is mixed with the oil. Then the temperature should be maintained to the melting point of antioxidants. Then the setup is transferred to the magnetic stirrer and maintained it for 30 minutes at 750 to 800 rotations per minute (rpm) in which the temperature should be maintained between 60ºC to 90ºC.Then it is transferred to the vessel for the measurements.

V. SAMPLE DESCRIPTION

F. Breakdown voltage

The breakdown voltage was measured using the IEC 60156 Standard and the kit range up to 60kV. The test kit consists of two spherical electrodes of standard diameter and interspacing of 2.5mm. The oil should be filled in the cup above the electrode level. Five successive calibration of breakdown voltages are taken by time delay of one minute between each measurement. The average of five values is considered as the breakdown voltage of the samples.

G. Viscosity

The viscosity was calibrated using redwood viscometer under the ASTM D445 standard. Normally low viscosity of the oil results in higher flow rate and heat convection process. The viscometer consists of a silver plated oil cup with opening called an orifice of standard diameter. The 50ml of oil sample is filled in the test cup and by opening the orifice the sample is collected and the time required for collecting the sample is noted to find the kinematic viscosity of the sample. Viscosity should be decreased with increase in temperature.

H. Flash point and Fire point

The flash point and fire point of the samples was calibrated using pensky martin closed cup tester according to ASTM D93. The flash point can be identified by introducing a test flame in the opening on the surface which is provided. As same the fire point is also calibrated by continuing fire on the oil surface when the small test flame is aimed to the sample.

Table II. ANTIOXIDANTS COMPOSITION

Sample	Composition
Sample 1	UTO + 10gm sepiolite
Sample 2	UTO + 10gm sepiolite + 2gm ascorbic acid
Sample 3	UTO + 10gm sepiolite + 2gm gallic acid
Sample 4	UTO + 10gm sepiolite + 2gm propyl gallate
Sample 5	SFO + 10gm sepiolite
Sample 6	SFO+ 10gm sepiolite + 2gm ascorbic acid
Sample 7	SFO + 10gm sepiolite + 2gm gallic acid
Sample 8	SFO + 10gm sepiolite + 2gm propyl gallate
Sample 9	PO + 10gm sepiolite
Sample 10	PO + 10gm sepiolite + 2gm ascorbic acid
Sample 11	PO + 10gm sepiolite + 2gm gallic acid
Sample 12	PO + 10gm sepiolite + 2gm propyl gallate
Sample 13	SO + 10gm sepiolite
Sample 14	SO + 10gm sepiolite + 2gm ascorbic acid
Sample 15	SO + 10gm sepiolite + 2gm gallic acid
Sample 16	SO + 10gm sepiolite + 2gm propyl gallate

The above mentioned table shows the different composition of oil samples with antioxidants.

VI. RESULTS AND DISCUSSION

I. Breakdown voltage

The breakdown voltage of sample 4 is higher when compared to other samples. Fig.1 shows the breakdown voltage characteristics of various samples.

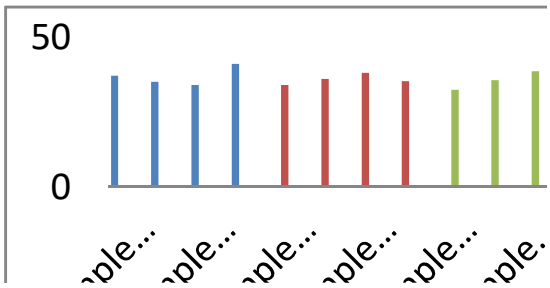

Fig.1 breakdown voltage of various samples

J. Viscosity

Viscosity of the oil should be decreased with increase in temperature.

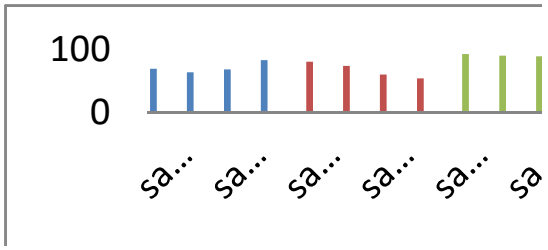

Fig.2 viscosity of various sample at room temperature

From above mentioned Fig.2 Sample 8 shows better results when compared to all other samples at room temperature.

After heating the viscosity of the oil is decreased. From the below given Fig.3 it is clear that the viscosity of the sample 2 is decreased when compared to all other samples.

From Fig.4 it is clear that the viscosity of sample 10 is decreased at 90ºC when compared to all other samples.

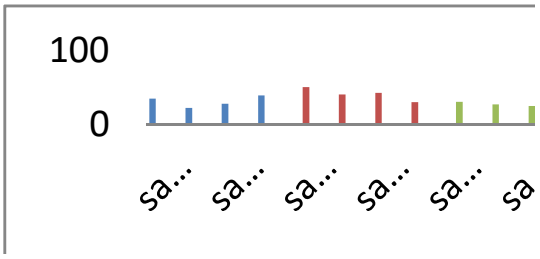

Fig.3 viscosity of various samples at 60ºC

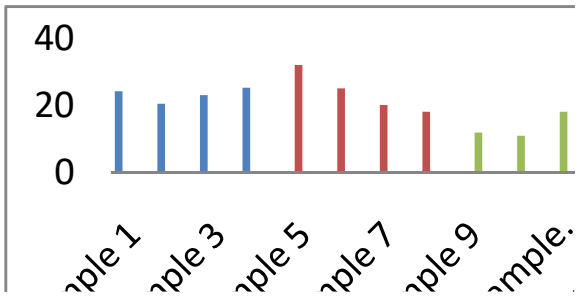

Fig.4 viscosity of various samples at 90ºC

K. Flash point and fire point

The flash point and fire point being an essential parameter in accessing the performance of liquid dielectrics.

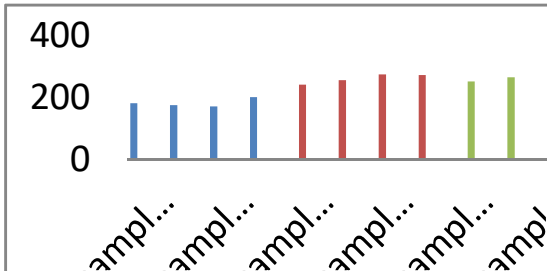

Fig.5 flash point of various samples

From the given Fig.5 and Fig.6 it is clear that the flash point and fire point of the sample 11 is better when compared to all other samples.

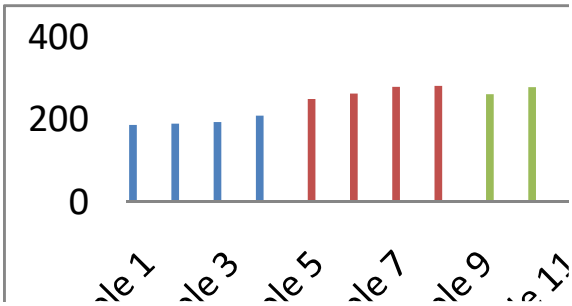

Fig.6 fire point of various samples

VII. CONCLUSION

The analysis is used to determine the performance of antioxidants with vegetable oil and used transformer oil(used mineral oil). The inclusion of antioxidants in oil improves the critical properties of oil. When compared to used transformer oil with antioxidants the vegetable oil with antioxidants gives better result. The operating cost is high when compared to mineral oil similarly that demerits are overcome by factors like slow ageing rate and less tendency towards formation of the gases. This leads to hazard free and zero rate of accidents. An overall analysis concludes that the vegetable oil using antioxidants is an appropriate substitution of mineral oil for power transformers.

VIII. FUTURE SCOPE

Analysis suggests that the unsafe nature of mineral oil can be altered with eco-friendly vegetable oil by adding suitable antioxidant compounds. Future work tends to measure the critical properties of vegetable oil with nanofluids. In addition to that critical parameters like acidity, specific resistance, interfacial tension can be given importance to enhance the life and stability of oil further.

REFERENCES

[1] Andrzej Sierota and Juris Rungis (1995), "Electrical Insulating Oils Part I: Characterization and Pre-treatment of New Transformer Oils", IEEE Electrical Insulation Magazine, February, Vol.11, No.1.

[2] Annelore Schaut, Stijn Autru, Anya De Rop and Steve Eeckhoudt (2012), "Effects of Irgamet30 as Additive in Transformer Oil" IEEE Transactions on Dielectric and Electrical Insulation, Vol.19, No. 1; February .

[3] Emmanuel O.Aluyor and Mudiakeoghene Ori-Jesu (2008), "The use of antioxidants in vegetable oils", African Journal of Biotechnology, Vol. 7, pp. 4836-4842.

[4] Karthik, Raja and Madavan (2012), "Enhancement of Critical Characteristics of Transformer Oil Using Nano Materials", Arabian J. Sci. Eng., Springer Publications, Vol. 3, No. 20, pp. 369-374.

[5] Krishna Kumar, Senthil Kumar and Ravindran (2014), "Investigation on Mixed Insulating Fluids with Nano Fluids and Antioxidants", International Conference on Advance in Electrical Engineering [ICAEE].

[6] Shigemitsu Okabe, Masanori Kohtoh and Tsuyoshi Amimoto (2010), "Suppression of Increase in Electrostatic Charging Tendency of Insulating Oil by Aging Used for Power Transformer Insulation", IEEE Transactions on Dielectrics and Electrical Insulation, Vol.17, No.01.

[7] Sulaiman AI-Zuhair, Hassan Noura and Abbas Fardoun (2011), "Using Activated Carbon from Waste Date-pits as an Adsorbent for Transformer Oil Regeneration", IEEE Transactions on Sustainable Technology (WCST), pp. 69-72.

[8] Shigemitsu Okabe, Masanori Kohtoh and Tsuyoshi Amimoto (2010), "Suppression of Increase in Electrostatic Charging Tendency of Insulating Oil by Aging Used for Power Transformer Insulation", IEEE Transactions on Dielectrics and Electrical Insulation, Vol.17, No.01.

[9] Zhou Zhou, Liu Kai, Wan Tao, Hu Xu, Qian Hui and Feng Bing (2012), "Rapid Determination of Oxidation Stability for Transformer Oils with Antioxidant", IEEE Transactions on Dielectrics and Electrical Insulation, Vol. 19, No. 5, pp. 1604-1608.