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Enrichment of used Transformer Oil using Activated Bentonite and Comparison of Various Transformer Oils with Vegetable Oil

R. Thanigaiselvan[1]* and T. SreeRenga Raja[2]

[1]Department of Electrical and Electronics Engineering, BIT Campus, Anna University, Tiruchurappalli-24, India
[2]Department of Electrical and Electronics Engineering, University College of Engineering, Anna University, Nagercoil, India

Abstract: The transformer is basic unit of distributed power generation system. The transformer uses oil as insulating medium to prevent the arcing, suppress the corona and improve the cooling. Traditionally the mineral oils are used as insulating oil for transformers. These oils are experiencing electrical, mechanical stress and chemical interaction with windings due to the high operating temperature throughout its presence in transformer. This causes the transformer oil to drop its property with respect to time. So there is need to change the oil after many years of use. The used oil either recycled or sent to dump causing environmental impact for its removal. In our present investigation the aged transformer oil is enriched by activated bentonite. In our investigation the vegetable oil is used instead of the traditional mineral oil. The used vegetable oil properties are reviewed once it's enhanced. The critical characteristics of insulating oil such as flash point, fire point, viscosity and Breakdown Voltage (BDV) is compared before and after enrichment. The result proves that the activated bentonite is certainly improving the property of the transformer oil for its reuse.
Keyword:*Transformer oil, Vegetable oil, Mineral oil and Transformer cooling.*

1. Introduction:

The mineral oil used as insulating oil in an electrical power transformers are commonly known as transformer oil. The transformer oil mainly severs two purposes in transformer. It acts as an insulator for transformer and also actsas coolant oil used to prevent the overheating of the transformer. The transformer mineral oil normally obtained from crude petroleum by distillation and subsequent treatment. Distant from main functionality the transformer oil serves the other two purposes as well. It preserves the core winding and avoids the cellulose based paper insulation to expose to the oxidation. The transformer mineral oils majorly classified into two categories Paraffin based transformer oil and Naphtha based transformer oil.

Paraffin based transformer oil is not easily oxidized compared with the naphtha based transformer oil. Due to that the sludge will be formed in the bottom of the transformer, which obstructs the cooling system of the transformer. The paraffin transformer oils having high pour point due to the presence on wax content. Although the paraffin oils having many disadvantages mentioned above, it is widely used due to its availability.

The transformer oil has three classifications of parameters namely, Electrical parameters, Chemical parameters and Physical parameters. The electrical parameters include Dielectric strength, Specific resistance

and dielectric dissipation factor. The water content, acidity and sludge are commonly known as chemical parameters of the transformer oil. The physical parameter includes inter facial tension, viscosity, flash point and pour point. Many of these above said parameters are decay with respect to a decade of time. The decay transformer oils have to be sent to dump or recycling. The dumping of transformer oil creates many environmental impacts. The recycling of the transformer oil reduces the impact on environment. Impact on the environment greatly reduced with replacing the mineral oil by vegetable oil as the transformer oil.

The rapeseed oil is widely available in India and having possible application as transformer oil to replace the mineral oil. The oils are easy to handle and dispose once its losses its property. The oxidation property of rapeseed oil better suits for using as transformer oil but it still lacks with the oxidation property of transformer mineral oil.

2. Related Works

There are many works available for the enhancement of mineral transformer oil which is listed and discussed below. The work explains the method to find the transformer oil were degraded under aerobic conditions in liquid culture using a mixed culture isolated from a soil contaminated with polychlorinated biphenyls and other hydrocarbons[1]. The reclamation of aged transformer oils by Fuller's Earth has been discussed in this work[2], the result shows that the reclamation is effective for the aged oil. The other work[3] provides the alternate use of vegetable oil as transformer oil to avoid the environmental impact and easy removal of age old oil. The ageing effect of paper insulation and resulting degradation performance of the transformer is studied in the work[4]. The transformer oil regeneration was carried out using adsorption on Activated Carbon(AC) produced from waste date-pits[5&6]. The reclamation of the aged transformer oil is discussed in the paper [7&8] and the vegetable oil performance with antioxidant is also discussed.

3. Methodology:

The used transformer oil samples are obtained from the local supply company from the transformer of 220/110KVA in-service for 5 years and 10 years.The Rapeseed oil used in the experimentation process is purchased from local vendors and treated before conducting the several tests explained below.

The base oil of required quantity was taken and moisture content was measured using the Karl Fisher iteration method according to ASTM D6304. The moisture content was removed by drying the oil with silica gel pellets in the ratio of 1 g of silica to 100ml of oil with a constant stirring of 500 rpm for 6 hours. The moisture content of oil was less than 10ppm after drying. The antioxidants used as additives were of the purity grades above 99% and for investigation purpose the weight of 2.5 grams and 5 grams with ratio of 1:1 was chosen. Each antioxidant of 2.5 grams and 5 grams (1:1) was directly dissolved in 500ml of the base oils. As there is no particular standard of temperature for mixing antioxidant with oil, we have maintained the room temperature with an increase up to 400C. The combinations of them were heated to a temperature of 400C. Then the mixing of antioxidant and base oil was carried out thoroughly by means of vigorous mechanical agitator like ultra sonicator. The additives were dissolved completely in base oils. Around forty samples were prepared according to standards and Table 5 shows the samples prepared with two base fluids and their combinations with antioxidants

4. Sample Preparation

The samples are prepared by taking 5 g of activated bentonite for 500 ml of base fluid 1 (aged transformer oil). The base fluid is heated up to a temperature of 100ºC by using oven and then activated bentonite is mixed with base fluid 1 by stirring process using bath ultra sonicator. Then the activated bentonite is removed by using whatman filter paper no. 42 According to ASTM D6304, the moisture content of oil was measured using Karl Fisher titration method. Then it was removed by adding silica gel pellets in the ratio of 1g to 100ml of oil and stirring with a speed of 550rpm for 5 hours using magnetic stirrer. After this process the moisture content of oil was less than 10 ppm. The table 1 shows the oil samples used for testing.

Table 1: Symbolic Codes of Oil Samples

Oil Specimen	Symbol Code
Used Transformer oil (5 years)	OT-5
Used Transformer oil with activated bentonite (5 years)	OTB-5
Used Transformer oil (10 years)	OT-10
Used Transformer oil with activated bentonite (10 years)	OTB-10
Fresh Transformer oil	NTO
Fresh Transformer oil with activated bentonite	NTOB
Fresh Vegetable Transformer oil	FVO

5. Experimentation:

The predefined standard test and protocols are available for a testing of transformer oil by "Standard Guide for Sampling, Test Methods, and Specifications for Electrical Insulating Oils of Petroleum Origin". As per ASTM the following tests were conducted.

a) Dielectric breakdown Test:

The dielectric breakdown test commonly known break down voltage test, this test results gives the insulating fluid ability to withstand the electrical stress. The oil sample is placed in a test cup and an AC voltage is impressed on it. The electrodes are two sphere heads of standard diameter and placed 2.5 mm apart.

The voltage is raised at a constant rate, until an arc jumps through the oil between the two electrodes. The voltage at which the arc occurs is considered the dielectric strength of the oil.

b) Flash point and Fire point test:

The flash point determines the tendency of the transformer oil to a form a flammable mixture with air under controlled laboratory conditions. The test provides one property of assessing the overall flammability hazard of a material. Flash point is used in shipping and safety regulations to define flammable and combustible materials. Consult the particular regulation involved for precise definitions of these classifications. Flash point can indicate the possible presence of highly volatile and flammable materials in a relatively nonvolatile or nonflammable material. For example, an abnormally low flash point on a test specimen of engine oil can indicate gasoline contamination.

The fire point is conducted for determining the lowest the temperature at which voltage of test flame causes the material to ignite and burn at least for 5 seconds under specified conditions of the test. Both the flash point and fire point tests are conducted under the controlled laboratory conditions.

c) Viscosity:

Saybolt Universal viscometer was used to measure viscosity of the samples. According to the standard ASTM D88, the size of orifice of viscometer was selected and the sample was taken in the brass cup provided for testing. After a 60ml of sample was filled in the cup, the oil was allowed to flow to the receiving flask by removing the cap and at the same time the timer was started to calculate the time taken for flow of sample. Viscosity is the key factor in the process of heat transfer by convection. The lower value of viscosity allows the higher rate of heat transfer in the apparatus like transformer.

6. Result:

The result of the above experimentation is represented as table and figures given below. The old transformer oil aged 5 and 10 years are treated with activated bentonite is compared with the new transformer oil and fresh vegetable oil. The new transformer oil is also treated with activated bentonite(5 grams) and comparison of the results tabulated and represented as a graph.

A. Dielectric breakdown Voltage

The dielectric breakdown voltage of the oil samples are measured and tabulated as given below. The New transformer oil and 5 years old transformer oil and 10 years old transformer oil is treated with activated bentonite is tested for dielectric breakdown voltage with IEC60156 standard. The measured values are tabulates as table 2, table 3 and table 4 and as shown in figure 1, figure 2 and figure 3. The table2 shows the breakdown voltage of 29, 30, 26 and 29 for new transformer oil, fresh vegetable oil, 5 years old transformer oil and 5 years old transformer oil treated with activated bentonite respectively.

The table3 shows the breakdown voltage of 29, 30, 24 and 28 for new transformer oil,fresh vegetable oil, 10 years old transformer oil and 10 years old transformer oil treated with activated bentonite respectively. The table4 shows the breakdown voltage of 29, 30 and 31 for new transformer oil, fresh vegetable oil and new transformer oil treated with activated bentonite respectively.

Table 2: Comparison of OT-5 before and after treatment with AB

Property	NTO	FVO	OT-5	OTB-5
Breakdown Voltage (kv)	29	30	26	29
Viscosity (cSt)	28	29	32	30
Flashpoint (^{0}C)	150	155	147	154
Firepoint (^{0}C)	160	165	156	161

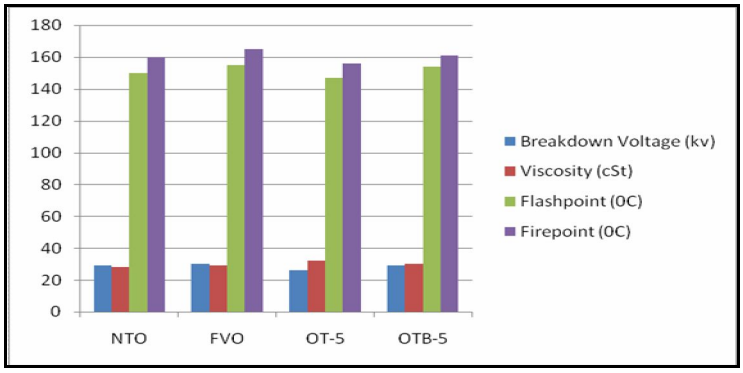

Figure 1: Comparison of OT-5 with other oils

B. Viscosity:

Viscosity of the oil samples are measured and tabulated and graphically represented and give in table 2, table 3 and table 4 and figure 1, figure 2 and figure 3 respectively. The viscosity of the oils are measured using the ASTM D445 standards. The table 2 gives the value of 28, 29, 32 and 30 for new transformer oil, fresh vegetable oil, 5 years old transformer oil and 5 years old transformer oil treated with activated bentonite respectively

The table3 shows the viscosity of 28, 29, 34 and 30 for new transformer oil, fresh vegetable oil, 10 years old transformer oil and 10 years old transformer oil treated with activated bentonite respectively. The table4 shows the breakdown voltage of 28, 29 and 27 for new transformer oil, fresh vegetable oil and new transformer oil treated with activated bentonite respectively.

Table 3: Comparison of OT-10 before and after treatment with AB

Property	NTO	FVO	OT-10	OTB-10
Breakdown Voltage (kv)	29	30	24	28
Viscosity (cSt)	28	29	34	30
Flashpoint (^{0}C)	150	155	145	153
Firepoint (^{0}C)	160	165	152	160

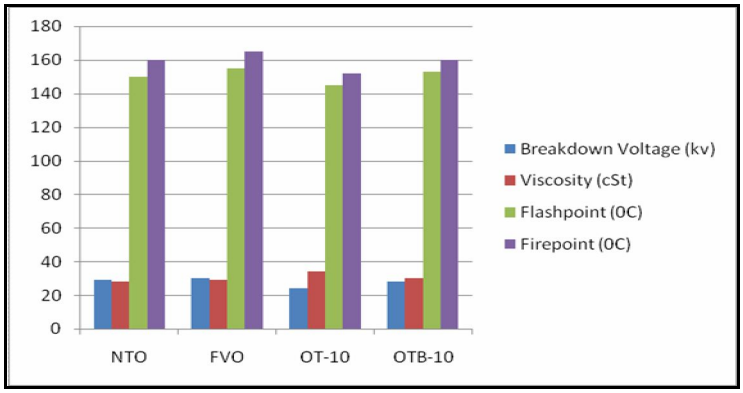

Figure 2: Comparison of OT-10 with other oils

C. Flash Point and Fire Point:

The flash point and fire point of the oil samples are measured and tabulated in the table 2, table 3 and table 4 and graphically represented as figure 1, figure 2 and figure 3 respectively. The flash point and fire point are measured using the standard ASTM D93. Table 2 gives the flash point value of 150, 155, 147 and 154 for new transformer oil, fresh vegetable oil, 5 years old transformer oil and 5 years old transformer oil treated with activated bentonite respectively

The table3 shows the flash point value of 150, 155, 145 and 153 for new transformer oil, fresh vegetable oil, 10 years old transformer oil and 10 years old transformer oil treated with activated bentonite respectively. The table4 shows the breakdown voltage of 150, 155 and 155 for new transformer oil, fresh vegetable oil and new transformer oil treated with activated bentonite respectively.

Table 2 gives the fire point value of 160, 165, 156 and 161 for new transformer oil, fresh vegetable oil, 5 years old transformer oil and 5 years old transformer oil treated with activated bentonite respectively

The table3 shows the fire point value of 160, 165, 152 and 160 for new transformer oil, fresh vegetable oil, 10 years old transformer oil and 10 years old transformer oil treated with activated bentonite respectively. The table4 shows the breakdown voltage of 160, 165 and 165 for new transformer oil, fresh vegetable oil and new transformer oil treated with activated bentonite respectively.

Table 4: Comparison of NTO before and after treatment with AB

Property	NTO	FVO	NTOB
Breakdown Voltage (kv)	29	30	31
Viscosity (cSt)	28	29	27
Flashpoint (^{0}C)	150	155	155
Firepoint (^{0}C)	160	165	165

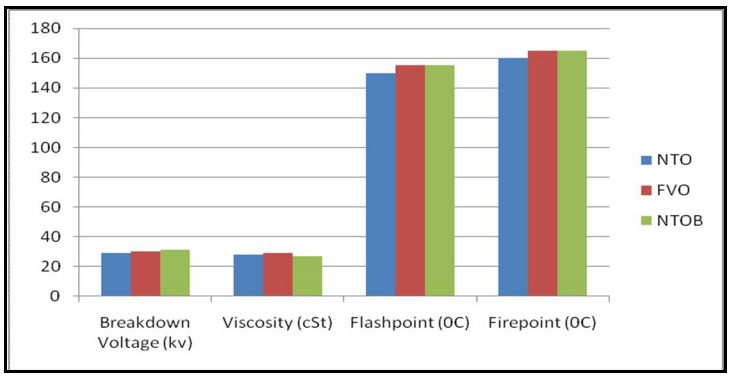

Figure 3: Comparison of NTOB with other oils

7. Conclusion

The property of the new mineral transformer oil, fresh vegetable transformer oil and 5 years old transformer oil and 10 years old transformer oil is given below.

The dielectric breakdown voltage is improved for the oil samples added with the activated bentonite. The 5 years old oil performs better compared 10 years old oil. The activated bentonite is certainly improving the breakdown voltage of the new transformer oil.

The viscosity of the oil is also improved, when it is treated with the activated bentonite. The flash point and fire point of the oils is also improved after it is treated with activated bentonite.

The fresh vegetable oil is also having the similar properties with the new transformer oil. The future investigation is required to study the performance of the vegetable oil treated with activated bentonite.

Reference:

1. Rojas-Avelizapa, N.G. , Rodríguez-Vázquez, R., Enríquez-Villanueva, F., Martínez-Cruz, J., Poggi-Varaldo, H.M., Transformer oil degradation by an indigenous microflora isolated from a contaminated soil,Proceedings of the 1998 4th International Symposium of the International Society for Environmental Biotechnology, 1999, Belfast, UK, Volume 27, Issue 1-2, Pages 15-26.
2. Sabau, J., On line reclamation of aged transformer oils,Proceedings of Electrical Insulation Conference and Electrical Manufacturing & Coil Winding Conference, Date 18-18 Oct. 2001, Cincinnati, Ohio.
3. S M Bashi, U. U Abdullahi, RobiaYunus and Amir Nordin, Use of Natural vegetable Oils As Alternative Dielectric Transformer Coolants, Journal - The Institution of Engineers, June 2006, Malaysia, Vol. 67, No. 2.
4. Patrick J. Baird, Henryk Herman and Gary C. Stevens, On-Site Analysis of Transformer Paper Insulation Using Portable Spectroscopy for Chemometric Prediction of Aged Condition, IEEE Transactions on Dielectrics and Electrical Insulation, August 2008,Vol. 15, No. 4.
5. Al-Zuhair, S. Al-Ain, Noura, H. ; Fardoun, A, Using Activated Carbon from waste date-pits as an adsorbent for transformer oil regeneration, IEEE World Congress on Sustainable Technologies (WCST), 2011, London.
6. Sulaiman Al-Zuhair, Hassan Noura and Abbas Fardoun, Utilization of Date-pits in Transformer Oil Chemical Regeneration, International Journal of Sustainable Energy Development (IJSED), March/June/September/December 2012,Volume 1, Issues 1/2/3/4.
7. A.Raymon and R.Karthik, Enhancement of Critical Parameters of Used Transformer Oil with Naturally Activated Bentonite and Investigation of Vegetable Oil Performance with Antioxidants, international Conference on Circuits, Power and Computing Technologies, 2013.
8. A.Raymon and R.Karthik, Reclaiming aged transformer oil with activated bentonite and enhancing reclaimed and fresh transformer oils with antioxidants, IEEE Transactions on Dielectrics and Electrical Insulation, Volume:22, Issue: 1, PP.548 – 555 Feb 2015.

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