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Transformer Insulation degradation studies by Dissolved Gas Analysis

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Abstract

The alternate liquid dielectric is the need of the hour. Several investigators tried with diverse of eatable and non-edible oils for the insulation and cooling of distribution transformers. Conventionally, standard test method is used for predicting the oil's electrical, physical and chemical properties. However, now days researchers are conducting a spectroscopic analysis of oil samples along with conventional test. Because of, spectroscopic analysis is best choice for evaluating tolerate ability of solid and liquid insulating material which can be used as insulating materials for transformer. The paper, critical study has been performed on transformer insulating oil by Dissolved gas analysis. From, the review found that DGA analysis is an essential method which is used to predict the stability of insulating material under up normal condition by evaluating gas emission form transformer oil sample, respectively. What is more, DGA is accurate and effective methods that of others.

Keywords: Transformer, Liquid dielectrics, Biodegradable, Cellulosic Insulation.

I. INTRODUCTION

The solid insulation like Kraft paper and press board is used in transformer. These consist mainly of cellulose fibers composed of a polymeric chain of cellulose; it is formed from D-glucose monomers. The deterioration rate of cellulosic materials depends on operating heat of transformer. Among them, the temperature is adversely reduced lifetime of solid insulation. Since it drastically affects the property of insulating medium. Hence, conditional monitoring technology is adapted to transformer for increasing the remaining life span [1].Due to thermal stress, solid insulation gets degraded; it also released by-products such as CO, CO2, H2O and furan derivatives, respectively, in the oil. Furthermore, mechanical integrity of solid insulating material was calculated by measuring the tensile strength of cellulose insulation. However, cellulosic insulating materials have a crystalline structure; these crystalline structures are analyzed with the help of XRD which gives more reliable results. This manuscript an effective condition and monitoring technique such as DGA analysis has been reviewed since on compared to all other method DGA is very easy and accurate method for forecasting transformer condition, respectively [2], [3].

The manuscript has three sections, in section 1 introduction, historical development of liquid dielectrics and the failure rate of transformer corresponding to temperature. Then, in section 2. A broad study been through on recent trends on dissolved gas analysis of green insulating oil. Subsequently, section 3, concludes the main feature of DGA analysis, which can be used for analysis the oil characteristics.

II. DGA Analysis on Insulating Oil

K. S. Kassi et al. conducted DGA on a hybrid hard cloistering material dipped in mineral oil; the results were compared with cellulose insulation immersed in mineral oil. The experimental analysis was carried out as per ASTM D6802. The hybrid insulation formed from 120g of cellulose paper and 54 gm of aramid paper is used. Also, 180 gm of cellulose paper is used as a conventional insulation system for a comparative analysis. Both the oil samples are immersed in 1000 ml of mineral oil with catalyst. Then, these samples are admitted to overheating process at 115 °C for 1000 hours. Besides that, these samples are under overheating process. The long term thermal aging DGA analysis shows that the generation of CO and CO2 is somewhat higher in cellulose insulation material when immersed in mineral oil. However, the generation of CO and CO2 is much higher in cellulose insulating material immersed in mineral oil due to pyrolysis or oil degrades aging products. Perhaps, aramid insulating paper has high thermal and oxidation stability characteristics, as well as it is resistant to hydrolysis process, resulting in lower emission of CO and CO2 [4].

The accelerated thermal aging test on natural ester and mineral oil for estimating the amount of combustible gas present in the oil. At first, oil and paper samples are pre-processed to remove the unwanted moisture components present in the test samples. Subsequently, natural ester and mineral oil are sealed in glass tube separately. These glass tubes

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are placed in an oven at 120 °C for 2800 h. As expected, the sample containing merely oil exhibits very low level of combustible gases than the oil with solid insulating material and catalyst. For the first 1280 hrs of sampling periods, emission of CO2 in natural ester with paper is sharply increased; after that, it remains constant. In contrast, CO2 level rapidly increased during all aging periods in case of mineral oil aged with paper. Furthermore, mineral oil sample contains more amount of dissolved hydrocarbon gas than natural ester oil. CO2 and C2H6 are used as key gas indicators for predicting the quality of oil since these concentrations are much higher in both the oil samples [5].

The performed a DGA on mineral oil, FR3 and camellia oil at the temperature range from 90 °C to 800 °C. Upto 300 °C temperature rise, camellia and FR3 generated a significant amount of C2H6 than mineral oil, which is the key gas indicator of thermal fault occurring on FR3 (C2H2 and H2 in the case of camellia). During low thermal faults, mineral oil generates significant amount of H2 and CH4, which act as a lower thermal fault indicator, but above 300°C operating temperature, significant CH4 followed by C2H4 which is acting as a key gas indicator of high thermal faults An author simulated Partial Discharge on Ricinnus Oil for DGA. By lap setup, the applied voltage was increased to 18 kV; Partial Discharge was occurring in Ricinnus Oil where in mineral oil 17 kV only it's occurred. At the instant of Partial Discharge, TCG of Ricinnus oil is 16.1 where mineral oil is 15.7 but it's lower than IEEE specification. The ratio of gas concentration between C2 H2/C2H4 and C2H4/C2H6 of Ricinnus Oil is 0.71 and 1.2, respectively. Apart from CH4 the generation of C2H4, C2H6, C2H2 in mineral oil is slightly lower than Ricinnus Oil which is infers that's the total combustible gas generation is higher in Ricinnus Oil that mineral oil but its value is acceptable limits [6].

Ivanka Hohlein-Atanasova performed a DGA on Transformer and Tap changer for estimating the amount of carbon oxides; the oil samples are placed in head space visala with air ingress flow at 150°C for 164 hours of sampling periods. Among the oil samples, Synthetic ester exhibits huge amount of CO and CO2 under the combination of with and without catalyses added, where Natural Ester oil exhibits lower quantity of CO and CO2 with and without catalysts. Non-inhibited oils produced slightly higher amount of CO than that of others, and the emission of CO2 is very less for the oil with catalysts when compared to the sample without them. Also, Natural Ester oil exhibits nearly 5000 ppm of C2H6 than other samples. In generation unit, transformers have higher values of CO2/CO where station transformers have lower values [7].

N.A. Muhamad et al. simulate Partial Discharge, Arching and overheating faults on Bio degradable oil and mineral oil for DGA. The Partial Discharge fault was created using Point-Point and point plane electrode combinations on vegetable oil and mineral oil. At the instant of Partial Discharge, with the help of point to plane electrode combinations, significant amount of H2 and CH4 are generated in vegetable oil, while in mineral oil, only H2, was generated. Mineral oil generates acetylene 33 times higher than the normal limit at plane to plane electrode combination. During arching test, biodegradable oil generates more than 200 ppm of H2, where mineral oil generates 150 ppm of acetylene; it's the maximum value of all the gases. During Over heating fault both oils are generating a significant amount of C2H6, followed by H2, but biodegradable oil generates more than twice the amount of dissolved gases than mineral oils. Also, DGA on Natural Ester oil, Synthetic Ester oil and Mineral Oil samples with and without Pressboard. During Aging periods, synthetic ester oil generates a higher amount of CO and CO2 than that of Natural Ester and mineral oil. Before 100 °C of operating temperature, Synthetic Ester and Natural Ester oils are exhibiting lower amount of H2, which is significantly increased after 110 °C where mineral oil exhibits lower amount of H2 during all temperature rises. Upto 70 °C, all oil samples are exhibiting very low amount of CH4. The emission rate of C2H6 in Natural Ester has significantly increased with the rise in temperature, where other oil samples show a very low amount of C2H4. The CO and CO2 emissions of all oil samples with press board are significantly higher than oil samples without it. Synthetic ester oil with press board exhibits a higher amount of CO and CO2 followed by mineral oil and Natural Ester with press board [8],[9].

Table 1 Dissolved Gas Limitations on Healthy Transformer [10]

Gas	<4 years	<10 years	>10 years
CH_4	70	150	300
C_2H_4	150	200	400
C_2H_6	50	150	1000
C_2H_2	30	50	150
H_2	150	300	300
CO	300	500	700
CO_2	3500	5000	12000

Table 2 Rogers Gas Ratio [11]

Case	Typical fault	C_2H_2/C_2H_4	CH_4/H_2	C_2H_4/C_2H_6
PD	Partial Discharge	NS	<0.1	<0.2
D1	Discharge of low energy	>1	0.1-0.5	>1
D2	Discharge of high energy	0.6-2.5	0.1-1	>2
T1	Thermal fault(<300°C)	NS	>1	<1
T2	Thermal fault(300-700°C)	<0.1	>1	01-Apr
T3	Thermal fault(>700°C)	<0.2	>1	>4

Table 5 Limit Concentration of Dissolved Gases [12]

Key gas	L1 Concentrations

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	(ppm)
Hydrogen(H_2)	100
Methane(CH_4)	120
Carbon monoxide(CO)	350
Acetylene(C_2H_2)	35
Ethylene(C_2H_4)	50
Ethane(C_2H_6)	65

III. CONCLUSION

The degradation rate of solid and liquid insulating material is merely found by dissolved gas analysis. When Kraft paper is thermally stressed in insulating oil, it exhibits significant amount of CO and CO2. However, when the aging temperature exceeds 130°C, the emission rate of CO and CO2 is low in case of solid insulating material immersed in ester oil as compared to mineral oil and systemic ester oil. Carbon monoxide acts as a key gas indicator for thermal aging of insulating oil. Besides that, the ratio of CO2/CO acts as a key gas indicator for thermal degradation of solid insulating materials. FR3 oil is generating significant quantity of ethane under thermal faults, so it acts as a key gas indicator. The concentration of fault gases is accurately estimated by Photo-acoustic spectroscopy; nevertheless, its prediction is significantly affected by external gas pressure and vibration. Additionally, IEC gas ratio, Doernenburg, Rogers, IEC ratio and Duval triangle are commonly worldwide used for diagnosis of transformer. But, these methods provide divergence results for same oil. The accuracy of headspace gas extraction method is high when compared to Topler method. FTIR analysis shows that degradation rate in mineral oil is higher than that of vegetable oil. Furthermore, it found new chemical components appear on the spectrum which is due to oil molecules are involves chemical reaction.

IV. References

[1] George K. Frimpong, T. V. Oommen. Roberto Asano Cellulose Insulation in Natural Ester and Mineral Oil.IEEE Elect. Insul. Mag., 2011; 27(5): 36- 48.

[2] T. Mariprasath1, V. Kirubakaran2, “A Critical Review on the Characteristics of Alternating Liquid Dielectrics and Feasibility Study on Pongamia Pinnata Oil as Liquid Dielectrics”, Elsevier, Renewable & Sustainable Energy Reviews, Vol.65, pp.784–799, 2016.

[3] Muhammad Arshad, Syed M. Islam, Significance of cellulose power transformer condition assessment, IEEE Transactions on Dielectrics and Electrical Insulation, vo.8, no.5, pp.1591 – 1598, 2011.

[4] L. E. Lundgaard, W. Hansen, S. Ingebrigtsen, Ageing of Mineral Oil Impregnated Cellulose by Acid Catalysis, IEEE Transactions on Dielectrics and Electrical Insulation, vol.15, no.2, 2008, pp.540 - 546.

[5] Manoj Mandlik, T. S. Ramu, Moisture aided degradation of oil impregnated paper insulation in power transformers, IEEE Transactions on Dielectrics and Electrical Insulation, pp.21 no.1, 2014, pp.186 - 193.

[6] Umar Khayam, Abdul Rajab. Dielectric Properties Partial Discharge Properties and DGAof Ricinnus Oils as Biodegradable Liquid Insulating Materials.IEEE Intern. Conf. on Condition Monitoring and Diagnosis.2012: 1249-1252.

[7] Ivanka Höhlein-Atanasova, Rainer Frotscher. Carbon Oxides in the Interpretation of DGA in Transformers and Tap Changers. IEEE Electr. Insul. Mag., 2010;26:22-26.

[8] N.A. Muhamad, B.T. Phung. DGA of Faults in Biodegradable Oil Transformer Insulating Systems.IEEE Intern. Conf. Condition Monitoring and Diagnosis.2008:663 – 666.

[9] M. Augusta G. Martins, A. R. Gomes. Comparative Study of the Thermal Degradation of Synthetic and Natural Esters and Mineral Oil: Effect of Oil Type in the Thermal Degradation of Insulating Kraft Paper.IEEE Electr. Insul. Mag., 2012:28(2); 22-28.

[10] Sukhbir Singh, M. N. Bandyopadhyay.DGA technique for incipient fault diagnosis in power transformers: A bibliographic survey. IEEE Elect. Ins. Maga.,_ 2010: 26;41 – 46.

[11] S. A. Ward, “Evaluating transformer condition using DGA oil analysis”, IEEE Intern. Conf. Electr. Dielectric Phenomena, pp. 463–468, 2003.

[12] V. Miranda, A. R. G. Castro. Improving the IEC table for transformer failure diagnosis with knowledge extraction from neural networks. IEEE Trans. Power Del., 2005; 20(4): 2509–2516.