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'Futuristic Behaviour of Aging on Power Transformer Insulation Oil: A Review'

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Abstract: Oil immersed power electrical device being vital and extremely high-priced is main backbone and hub of power transmission & distribution system. Its failure not only causes its own damage however, directly have an effect on the protection, stability and desirableness of the facility grid system. An influence electrical device has to be tested sporadically for its protection and safe operation. These checks embody routine check, temperature rise check, non-conductor kind tests; short withstand check, sound level check, insulation observance tests, impulse check, field service check etc. Mineral oil is wide used as liquid insulation in high voltage instrumentation. Due to environmental issues, recently natural esters are thought of as naturally friendly liquid insulation candidates for prime voltage transformers. Heat and wetness were the most reasons for the degradation of the insulation layer and caused corrosion to the oil tank.

Keywords: Power Transformer, Insulation Oil, Breakdown Voltage (BDV), Moisture Contents, Resistivity, Tan Delta, Interfacial Tension And Flash Point

I. INTRODUCTION

THE power electrical device insulation gets degraded below a combination of thermal, electrical, chemical, mechanical, environmental stresses, etc. throughout its operation. These stresses cut back the non-conductor capability of an electrical device and increase the chance of failure. The conventional operating transformer has been subjected to any or all the on top of stresses (combined stresses) throughout its operation. The non-conductor diagnostic ways like Breakdown Voltage (BDV), moisture, tan δ, resistance, Interfacial Surface Tension (IFT), flash point, etc. is also thought of because the vital parameters for selecting the standing of the insulating oil. These ways provide an early indication of the modification within the non-conductor properties and provide the helpful data concerning the standard of the insulation. The aging process of electrical device oil that typically happens throughout the service of an electrical device could also be the explanation of the amendment of electric properties of the oil that will harm the insulation system. Common place specifications and testing ways for mineral insulating oil typically utilized in electrical equipment and transformers area unit reportable in [2–6]. As it is thought the oil characteristic depends primarily on the operative time, the transformers loading, WC, oil acidity and the dissolved gases, that have nice impacts on the electrical device oil Breakdown Voltage (BDV) [7]. Mathematical models of the aged oil electrical device acidity, BDV, and WC as operate of oil life time are reported [8–14].

II. LITERATURE REVIEW

J. Karzai [1] This paper presents results of Associate in nursing investigation of the electrification of varied varieties of thermally aged electrical device oil. The electrification measuring was administered during a system with a rotating disk. It's been discovered that the aging method causes quantitative and qualitative changes in oil electrification. These changes rely upon the kind of oil. *Suzuki T .et. Al* [2] Breakdown voltages of polymer oil during a sealed off instrumentation with gas were measured. It was found that the ac breakdown voltage increases with temperature once gas or air square measure used as gas. On the opposite hand, in vacuum the ac breakdown voltage doesn't depend on temperature, except at -20˚C. The impulse breakdown voltage was found to be temperature freelance. These results can be explained on the premise of breakdown initiation thanks to evolution of gas from the sample oil. *T. H. Aschwanden et al.,*[3] Recent advances within the application of non-traditional methods and procedures for off-line diagnosing and on-line observation of recent and service-aged power transformers area unit mentioned. Advanced off-line ways area unit based on the most operational stresses (electrical, mechanical, thermal) and on typical failure modes: measurement of Polarisation- And Depolarization Currents (PDC), electrical detection of Partial Discharges (PD) and activity of the transfer perform (FRA). A pilot installation of Associate in nursing on-line observation system on a strategically vital electrical device is delineating. The measured information of the intrinsically sensors (e.g. load, temperatures, gas and

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wetness in oil, overvoltage's) area unit analyzed using a model-based code approach with Associate in Nursing reconciling threshold to outline faulty conditions. *M. K. Pradhan* [4] Power and station transformers area unit among the dearer and important components of an influence system. in theory, making certain the dependability of power transformers could be a ballroom dance method, involving the detection of associate imminent failure in its formative stage thus on preclude harmful failures and if, for any reason, associate outage happens, evolving associate applicable replacement strategy of the unsuccessful units in an exceedingly minimum doable time. In diagnostic testing, physical parameters used as indices of imminent failure shall be sensitive to the quantity of ageing and shall possess a fairly high degree of correlation with non-conductor strength and mechanical strength. *Akbari A.et. al* [5] For optimum performance of the new generation of on-line drying systems for oil immersed power transformers that, are worked supported water absorption of plastic filters the dynamic of moisture equilibrium needs to be used for economical control of the system. Various ways like continuous or distinct methodology could also be accustomed dry the oil-paper insulation whereas has blessings and disadvantages rely upon the parameter we would like to be optimized and therefore the condition of electrical device that, has to be dried. Investigations supported the dynamic of wetness migration from oil to paper show that for on-line drying of electrical device the continual strategy dries the insulation system earlier than distinct methodology while distinct methodology wants less energy for cooling system. The optimum temperature is rely upon the wetness condition of the insulation system of transformer and should calculated exploitation dynamic analysis delineated during this contribution. *Gupta B.K. et. al* [6] The lifetime of oil-paper insulation depends critically on the moisture content in paper. Now a day no methodology is out there for direct measuring of wetness in paper insulation in transformers. This paper summarizes the results from a project for development of a technique for direct measuring of wetness in paper in oil-paper insulated electrical equipment. Many techniques were investigated for his or her suitability for this application. The infrared absorption was found to be the foremost promising technique. The effectiveness of the infrared technique was examined on model electrical device coils and on an influence electrical device, mistreatment optical fiber bundles for directing infrared emission. *F. M. Clark* [7] The rate of mechanical deterioration of polysaccharide insulation depends on the conditions of its use. Those factors of major importance area unit the temperature applied and also the presence of gas and moisture. Wetness even in little amounts greatly affects the mechanical stability of the polysaccharide insulation. In general, the mechanical lifetime of the insulation is reduced by half for every doubling in water content. Deterioration promoted by oxidization is most effective at temperatures below a hundred and twenty degrees centigrade and is accelerated by the presence of wetness. *Garcia B. Et. al* [8] Nowadays, there's associate increasing interest in victimization transformer observance systems. Some observance systems use models to predict the worth of bound variables. One in all the key variables to be monitored is wetness content in oil, as wetness has a high influence on electrical device exploitation. During this paper, the theoretical foundation of a model for observance wetness in transformer oil is reportable. The wetness Model estimates wetness content in electrical device oil underneath bound operating conditions. Comparing the worth of calculable wetness with the measured one, the model is in a position to observe failures manufacturing associate abnormal water content within the electrical device. The Model considers the equilibrium relations between paper and oil, the transients that crop up till the steady-state equilibrium is earned, and also the water increase caused by the insulating paper ageing. *Darveniza M.et.al* [9] -This paper investigates the effective diagnostic technique(s) for assessing the condition of insulation in aged power transformers. Variety of electrical, mechanical and chemical techniques was investigated. Several of those techniques are already utilized by the utility engineers and 2 relatively new techniques are projected during this paper. Results showing the effectiveness of that medical specialty are conferred and correlation between the techniques is conferred. Finally, deserves and suitableness of various techniques are mentioned during this paper. *N'cho J. S.et.al* [10] The result of the electrical stress on insulating oil was investigated during this paper. Changes in oil properties were observed once voltage application. The oil exposed to Estress, end in the formation of free radicals (primary decomposition), that is accountable for the degradation of the oil. The relations between applied voltage and oil properties like acidity, non-conductor dissipation issue, conductivity, turbidity, dissolved decay product and moisture show a uniform trend. The results indicate unambiguously that discharge encompasses a definite influence on oil decaying method. The secondary reaction ends in the formation of insoluble particles that in-turn end in a reduction within the free radicals. The reduction within the free radicals ends up in a rise insoluble particles that might result in the formation of hot spots. *Claiborne C. C.et. al* [11] The insulation fluid developed from high oleic vegetable oil sources was found to perform well in laboratory tests on the fluid itself and within the life tests on distribution transformers. It showed high biodegradability, elevated flash and hearth points, sensible oxidisation stability and endurance during life testing. Additional enhancements could also be desired, especially within the pour purpose. However, a unit cooled to - 37.4˚C performed satisfactorily throughout a heat run during a preliminary study. For application in alternative kinds of electrical equipment like capacitors and cables, the oil should be created gas engrossing. The employment of this fluid in EHV power transformers could need style changes related to heat transfer properties, and modifications in pumping the fluid thanks to its higher viscousness than regular transformer oil. For environmentally friendly distribution transformers, the oil seems to be an appropriate alternative as associate degree insulating fluid.

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III. PARAMETERS DISCUSSED

1. Breakdown Voltage: Breakdown Voltage (BDV) is one in every of the foremost necessary parameter to measure the condition of oil. It's indicative of solid impurities and wet content gift within the oil. Dry and clean oil commonly exhibits high BDV. However, high BDV doesn't essentially indicate absence of all the contaminants. The physical characteristics, like fluid viscosity, electro-convection, temperature, density and pressure complicate the analysis and modelling of the breakdown and physical phenomenon mechanisms [1]. It's assumed that the gas volume within the instrumentality is constant however with the increase in temperature, the pressure increase which causes the emission of gases that initiates the breakdown [2].

The graphical representation indicates that the BDV of transformers oil decreases step by step and bears a non-linear relationship with aging [3]. It's going to additionally cut back because of presence of wetness content, conducting impurities as a result of oxidisation of oil or it may flow from to extend within the size and range density of free particles generated, etc.

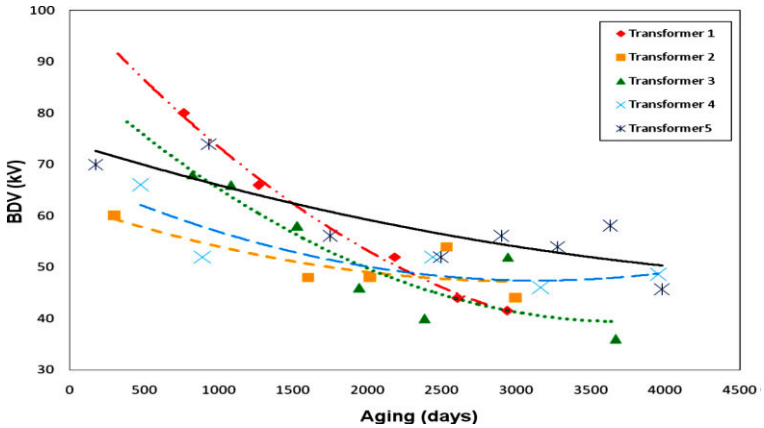

Figure 1. Influence of aging on BDV of power transformers (Nos. 1, 2, 3, 4 and 5)

2. Moisture: The presence of wetness in oil is very undesirable because it adversely affects the material properties of oil and solid insulation of electrical device. Once electrical device is full of oil, the paper absorbs the wetness from oil (due to absorbent nature of paper) poignant its insulating property and thereby reduces its life**.** The standard for wet measure area unit IS: 13567-1992 (2003), American customary ASTM D 1533-00 (2005), D 3277-95 (2001), IS 2362-1993 (1998). As per IS 335 the maximum worth of wet content is 50 ppm. The Karl Fischer instrument, model MA-101 B, spectra research laboratory was accustomed determine the wet content. This instrumentation could be a versatile instrument; totally chip based mostly and designed to live the wet content of oil samples. The results were calculated mechanically in ppm.

The influence of aging on wet of actual operating power electrical devices is diagrammatically diagrammatic in Figure 2. The wet in transformers 1 has higher ppm level it's going to result to the combined stresses on insulation of power electrical device wet content increase consistently with aging. The most reasons for wet content changes over the life cycle are: wet interactivity with atmosphere, further wet generation because of chemical reactions [4], transformer breathing, rotten of the plastic materials, aging phenomena, etc.

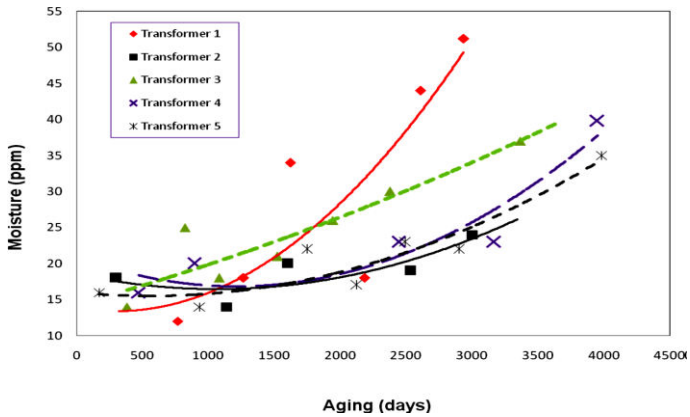

Figure 2 Influence of aging on moisture of Power Transformers (Nos. 1, 2, 3, 4 and 5)

The aforesaid wet content may be a life shortening parameter and has following result on the insulation system:

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- It will weaken the breakdown capability of the insulation system [5].
- It promotes native heating
- It reduces the overload capability of electrical device in emergency conditions [6].
- It accelerates the insulating deterioration method [5].
- It decreases the electrical and mechanical strength [7].
- Electrical or partial discharges will occur during a high voltage region thanks to a disturbance of the wet equilibrium [8].
- It will increase the electrical physical phenomenon, tan δ, etc.
- Once the oil in commission gets oxidised, acids are formed. These acids more increase the wet concentration in oil and initiate the degradation process.

3. Resistivity: It is fascinating to own electric resistance of oil as high as doable. The influence of aging on electric resistance at 90˚C for actual working power transformers is diagrammatically pictured in Figure 5. The electric resistance of electrical device a pair of is low and transformer five is high in Figure 5. In Figure half dozen, electric resistance of transformer eight is low. It indicates that thanks to combined stresses on oil, its electric resistance decreases bit by bit with aging due to presence of wetness, acidity, solid contaminants, etc [9]. High electric resistance reflects low content of free ions and ion-forming particles, and indicates an occasional concentration of conductive contaminants. The Indian customary IS 335-2005 and IS 6103:1971 was used for the measuring of the impedance. The automated dielectric constant, tan delta and impedance (ADTR-2K) take a look at set of Eltel create was used for measurement the impedance.

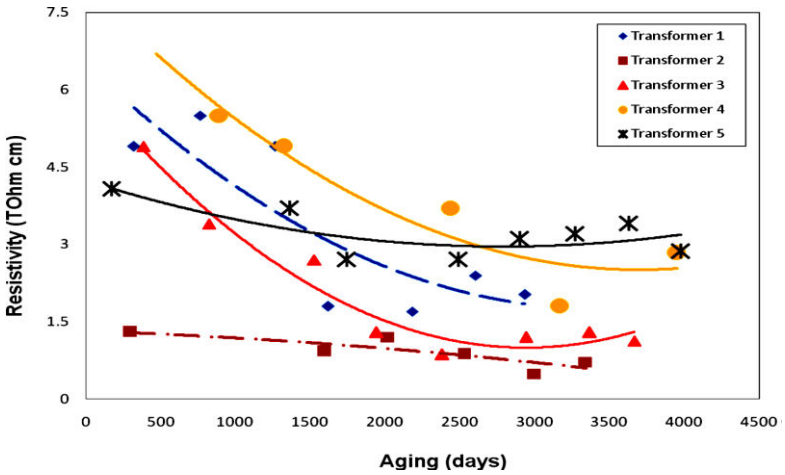

Figure 3. Influence of aging on resistivity (at 90˚C) of power transformers (Nos. 1, 2, 3,4 and 5).

4. Dielectric Dissipation Factor (tan-delta):

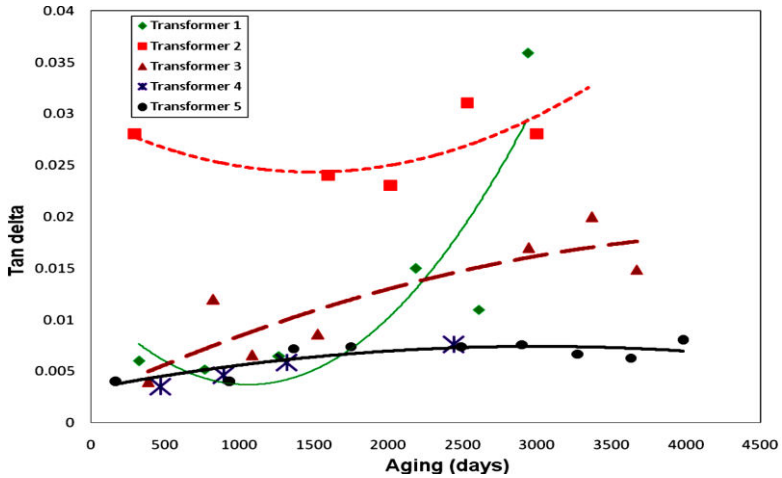

Figure 4. Influence of aging on tan delta (at 90˚C) of power transformers (Nos. 1, 2, 3, 4 and 5).

As per IS 6262-71, sensible quality of insulating oil could have tan delta of zero.002 (max). Figures seven and eight show the variation of tan delta with aging. The tan delta of electrical device two is high and of five is low as shown in

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Figure seven. In Figure eight, tan delta of transformer eight is high. It's evident within the figures that tan delta increases with aging thanks to combined stresses on power transformer. A high worth of tan-delta is a sign of presence of contaminants. it's going to ensue to production of oxidation made thanks to stresses or it's going to ensue to presence of soluble varnishes, resins, etc. there's typically a relationship between tan-delta and electrical phenomenon, both being affected by a similar contaminants. A decrease in electrical phenomenon is coupled with a rise in tan delta. The Automatic stuff constant, tan delta and resistivity (ADTR-2K) from Eltel is associate degree instrument used for measuring the electrical characteristics like tan delta, resistivity, capacitance, stuff constant, resistance of transformer oil. the facility (P) dissipated within the insulation as a result of stuff losses in associate degree alternating field is expressed as: $P=\omega CV^2 (\tan\delta)$

5. Interfacial Tension: The surface tension (IFT) of oil is needed to rupture the oil surface existing at associate interface. It is a measure of the degree of refinement and contamination of latest oil [10]. Surface tension (IFT) is very helpful for determining the presence of polar contaminants and oil decay product. Virgin oil typically exhibits high worth of interfacial tension. Surface tension reduces with aging under the impact of combined stresses, oil reaction, etc. The increase in reaction contaminants causes additional reduction in IFT. This could flow from to high affinity towards water and oil molecules.

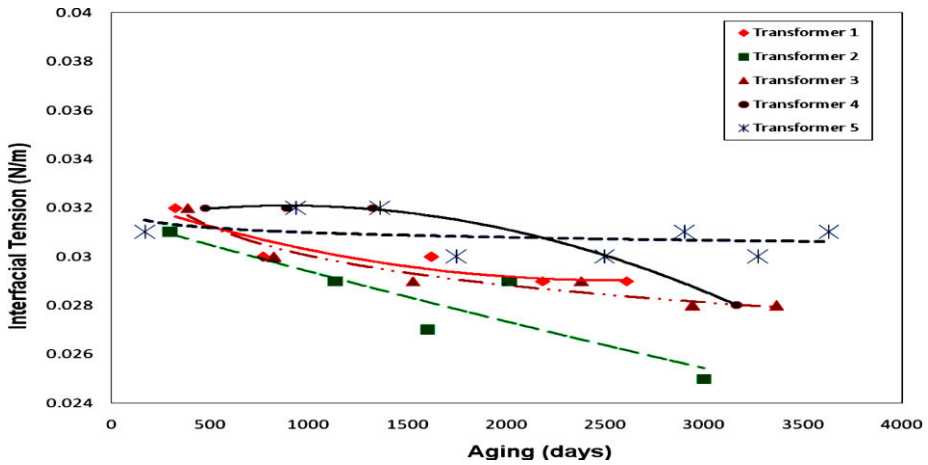

Figure 5. Influence of aging on IFT of power transformers (Nos. 1, 2, 3, 4 and 5).

6. Flash Point: It is fascinating that the oil ought to have terribly high flash purpose (>140 °C). It represents that the flash purpose reduces with aging beneath the impact of combined stresses. The flash purpose of transformer 1 is low in Figures 6, respectively; it should result to volatile flammable product present in oil, thanks to low relative molecular mass hydrocarbons, etc [11].

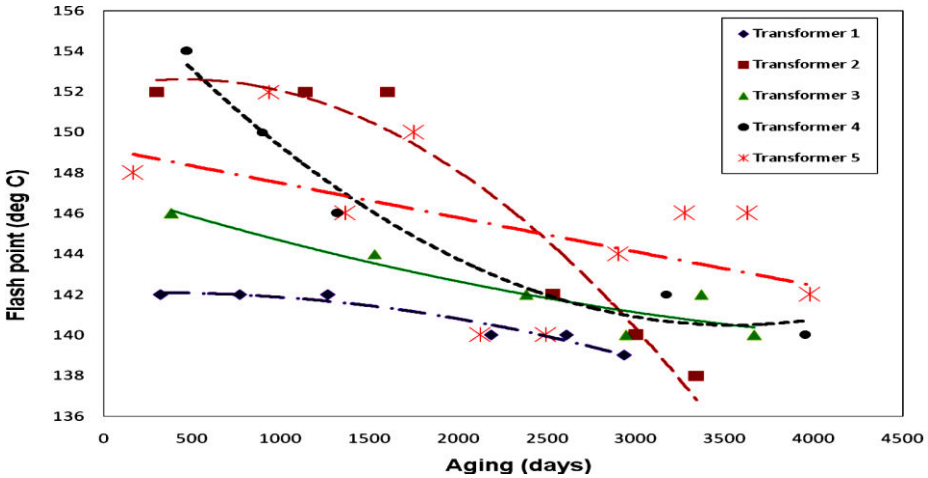

Figure 6. Influence of aging on flash point of power transformers (Nos. 1, 2, 3, 4 and 5).

IV. CONCLUSION

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This paper overviews the aging impacts on power transformers insulating oil like breakdown voltage (BDV), moisture, resistivity, tan delta, interfacial surface tension and flash purpose have been investigated beneath combined stresses caused by service aging. It's complete that the majority of the properties degraded with relevancy service aging. It's been discovered that transformer a pair of specially stands out as worse than the others, the reason is improper maintenance, improper cooling system style, thanks to presence of conducting impurities, wet contents, reaction of oil, is also thanks to increases in size and variety density of free particles, etc.

REFERENCES

[1]. J. Kedzia "Electrostatic properties of aged transformer oil" IEEE Transactions on Electrical Insulation, Vol. 24, Issue: 2, pp. 175-178 Apr 1989.
[2]. T. Suzuki, H. Hiramoto and M. Umeda, "Dependence of breakdown voltage of silicone liquid on temperature", IEEE Trans. Electr. Insul., Vol. 18, pp. 462–464, 1983.
[3]. M. K. Pradhan and T. S. Ramu, "Criteria for estimation of end of life of power and station transformers in service", IEEE Conf. Electr. Insul. Dielectr. phenomena (CEIDP), pp. 220–223, 2004.
[4]. B. Buerschaper, O. Kleboth-Lugova and T. Leibfried, "The electrical strength of transformer oil in a transformerboard-oil system during moisture non-equilibrium", IEEE Conf. Electr. Insul. Dielectr. phenomena, pp. 269–272, 2003.
[5]. A. Akbari, S. DehPahlevan and H. Borsi, "Analyzing dynamic of moisture equilibrium in oil-paper insulation in power transformers for efficient drying", IEEE Conf. Electr. Insul. Dielectr. phenomena, pp. 545–548, 2006.
[6]. B. K. Gupta, "Direct determination of moisture in solid oil-paper insulation", IEEE Int'l. Sympos. Electr. Insul., Vol. pp. 583–586, 1998.
[7]. F. M. Clark, "Factors affecting the mechanical deterioration of cellulose insulation", Trans. Electr. Eng., Vol. 61, pp.742–749, 1942.
[8]. B. Garcia, J. C. Burgos, A. M. Alonso and J. Sanz, "A moisture-in-oil model for power transformer monitoring - Part I: Theoretical foundation", IEEE Trans. Power Del., Vol. 20, pp. 1417–1422, 2005.
[9]. M. Darveniza, T.K. Saha, D. J. T Hill and T.T. Le, "Investigations into effective methods for assessing the condition of insulation in aged power transformers", IEEE Trans. Power Del., Vol. 13, pp. 1214-1223, 1998.
[10]. I. Fofana, J.S.N' Cho, Aka-Ngnui and A. Beroual, "Effect of electrical discharge on oil decaying process", Int'l. Conf. High Voltage Engg. And application (ICHVE), New Orleans USA 2010.
[11]. C.C. Claiborne, E.J. Walsh and T. V. Oommen, "An agriculturally based biodegradable dielectric fluid", IEEE Trans. Distribution Conf., Vol. 2, pp. 876 – 881, 1999.

BIOGRAPHY

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