International Journal on Emerging Technologies **2**(1): 26-30(2011) **ISSN : 0975-8364**

Intelligent Diagnostic Method for Life Analysis of Transformer

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(Received 15 January, 2011, Accepted 15 Feburary, 2011)

ABSTRACT: Transformers are critical and capital intensive assets for utility industry. It is broadly accepted that the life of a power transformer is the life of the oil/ paper insulating system, also the fact that most failures in their final on electro-mechanical base such as a short circuit condition or a mechanical failure. The ageing of insulation in Transformers is influenced by short term and long term over loads, intensity of short circuit, incidence of lightning, and internal faults. The ageing behavior is likely to be different for different types of transformers. The life span of the transformer, thus, depends initially on the design, and quality of manufacture, and later on service conditions and maintenance standard these factors vary considerably and affect the useful span of service life which therefore needs to be taken into account for residual life assessment. During the natural ageing of transformers, the insulation of winding, which is cellulose paper, deteriorates. Cellulose insulation degrades due to heating or electrical Breakdown, resulting in the production of furfural derivatives, which dissolve in oil. Hence, the chemical analysis of the Transformer oil gives evidence of changes that are taking Place in the winding insulation during operating. Deterioration in transformer cellulose decreases both its electrical and mechanical strength. In this paper a novel fuzzy based algorithm has been developed for life analysis of power transformer and implemented on three samples of transformer oil.

Keywords: Transformer oil, Paper insulation, Electrical breakdown, Aging analysis, Fuzzy logic

I. INTRODUCTION

In power transformer paper ageing is a process involving both chemical and physical changes causing a loss of both mechanical and electrical strength. Deterioration of both the paper and transformer oil is caused by oxidation accelerated by high temperatures, air and moisture. The oil oxidation will lead to acids and par oxides production. These compounds are introduced into the transformer oil. The main requirements of insulating oil are to provide insulation, to withstand electric stresses imposed in service as the oil has high dielectric strength and low dissipation factor, to transfer heat and to provide cooling.

The oil must have low Acidity (Neutralization Value) to eliminate the risk of sludge formation and corrosion. Anti Oxidant Additives (inhibitors) such as 2, 6-di-tertbutyl-p-cresol (DBPC) slows down the oxidation of oil. The content of antioxidant in oil depletes during the service life of the oil and therefore it is important to monitor .Oil are grouped in to three classes depend upon antioxidant content as uninhibited, trace inhibited and inhibited. The Breakdown Voltage should be sufficiently high to provide dielectric strength to prevent oil under electrical stresses. The oil must not contain levels of Contamination by an individual Metal. The Density of oil has to be low enough to ensure that ice cannot float on the oil surfaces at very low temperatures and cause internal flashover. The Dielectric Dissipation Factor (the tangent of loss angle and commonly referred to as tan delta) has to be sufficiently low to ensure that the dielectric losses are small and that the oil thus provides satisfactory insulating properties. The oil must have high Interfacial Tension (IFT) to ensure the absence of polar compounds in the oil and suitability of oil for use as insulating material. Unused mineral insulating oil of the same class, the same groups are considered to be mixable and compatible with each other. The oxidation stability of the oil must be high to reduce oxidation process in service, which degrades the oil, producing sludge and acids. These can reduce the effectiveness of cooling and cause general internal deterioration and eventual failure. The oil must have a low Particle Size and Count and low fiber content. Such contaminants reduce the electric strength of transformer oil. The oil must have undetectable Polychlorinated Biphenyl (PCB) content to meet the requirements of healthy and safety legislation. The oil must have low Polycyclic Aromatic (PCA) carbon content to meet the requirements of healthy and safety legislation. The Pour Point is related to viscosity and needs to be low enough to ensure that oil flows satisfactorily under low temperature conditions. The oil must have low sculpture content and contain no corrosive *S* enough to ensure the oil flows under all temperature (particularly low) conditions thus providing necessary cooling and arc quenching properties of various insulating fluid options, available to user, mineral insulating oil has for the vast majority of situation proven to be most cost effective choice and meets the above functional requirements.

In this analysis we collected oil sample for life analysis of power transformer. The rating of Power Transformer was 40 MVA, 132/33kV. Following tests have been performed on sampled oil.

Chemical tests: 1. Acidity test

Electrical tests: 1. Breakdown Voltage test, 2. Resistivity analysis, 3. Particles Analysis test.

II. BRIEF DESCRIPTION OF TESTS TO BE PERFORMED

A. Analysis of suspended particles size

In case of deteriorated or waste oil their may be some dissolved particles. The larger the size and no of conducting particles decrease the break down voltage Spectrex laser particle Counter utilizes the principle of "near angle light scatter"; a revolving laser beam passes through the walls of a glass container of a flow-thru cell. When it is directed through a central "sensitive zone" the PC-2200 not only counts the particle in suspension, but tabulates their size as well.

B. Acidity analysis

Acidity of oil is a measure of the acidic constituents in the oil. Its value, negligible in an unused oil, increase as a result of oxidative ageing and as a general guide for determining when an oil should be replaced or reclaimed, provided suitable rejection limits have been established and confirmation is received from other tests. Oil with high neutralization value affects the winding & paper. Normally the transformer have uninhibited oil. Sometimes inhibited oil is used. The inhibitor works so that it breaks the chain reaction by which sludge & acid are produced. If sludge is produced in oil, the oil changes color and become darker and turbid. The sludge can be removed by means of filtration but if sludge formation has it would increase with time. The oil exchange should preferably be carried out when transformer is warm and oil viscosity is low. Transformer oils deteriorate with time. High operating temperatures, the presence of oxygen and water combined with the catalytic action of the materials within the transformer, result in oxidation and cracking of the oil. The by-products of oxidation are acidic and the long-term effect of these by-products results in an exponential increase in deterioration of the transformer and its oil. The resulting sludge build-up reduces the cooling effects of the oil driving the whole decay mechanism at an increasingly accelerated rate. New transformer oils contain practically no acids if properly refined. The acidity test measures the content of acids formed oxidation. The oxidation products polymerize to form sludge which then precipitates out. Acids react with metals on the surfaces inside the tank and form metallic soaps, another form of sludge. Sludging has been found to begin when the acid number reaches or exceeds 0.4, and 0.4 is considered to be the normal service limit. New oil has as acid number of less than 0.05. The acid number (formerly referred to as neutralization number) equals the milligrams of KOH (potassium hydroxide) required to neutralize the acid contained in 1 gram of oil. For this study we have used 702 SM Titrino.

C. Resistivity test

The resistivity of a liquid is a measure of its electrical insulating properties under conditions comparable to those of the test. High resistivity reflects low content of free ions and ion-forming particles and normally indicates a low concentration of conductive contaminants. These characteristics are very sensitive to the presence in the oil of soluble contaminants and ageing products. Resistivity is normally carried out at ambient temperature but useful additional information can be obtained if the test is carried out at ambient and a higher temperature such as 90°C. Unsatisfactory results at both temperatures indicate a greater extent of contamination than a poor value at the lower temperature only, and the oil is therefore less likely to be restored to a satisfactory level by drying and low temperature filtration.

D. Breakdown strength test

Breakdown test are normally conducted using test cells. For testing pure liquids, the test cells used are small so that less quantity of liquid is used during testing. The electrodes used for breakdown voltage measurements are usually spheres of 10 to 20cm in diameter with gap spacing of about 0.4-1 cm. The gap is accurately controlled by using a micrometer. Sometimes parallel plane uniform field electrode systems are also used. Electrode separation is very critical in measurements with liquids, and also the electrode surface smoothness and the presence of oxide films have a marked influence on the breakdown strength. The test voltages required for these tests are usually low, of the order of 50-100kV, because of small electrode spacing. The breakdown strengths is obtained in pure liquid of the order of 40KV/4 mm - 100 KV/4mm.

III. AGEING DIGNOSIS OF POWER TRANSFORMER USING FUZZY LOGIC

A. Overview of fuzzy logic

A fuzzy expert system is an expert system that uses a collection of fuzzy membership functions and rules, instead of Boolean logic, to reason about data. The rules in a fuzzy expert system are usually of a form similar to the following

If x is low and y is high then z = medium

where *x* and *y* are input variables (names for know data values), *z* is an output variable (a name for a data value to be computed), low is a membership function (fuzzy subset) defined on *x*, high is a membership function defined on *y*, and medium is a membership function defined on *z*. The antecedent (the rule's premise) describes to what degree the rule applies, while the conclusion (the rule's consequent) assigns a membership function to each of one or more output variables. Most tools for working with fuzzy expert systems allow more than one conclusion per rule. The set of rules in a fuzzy expert system is known as the rule base or knowledge base. The block diagram of fuzzy system is as shown in Fig.1.

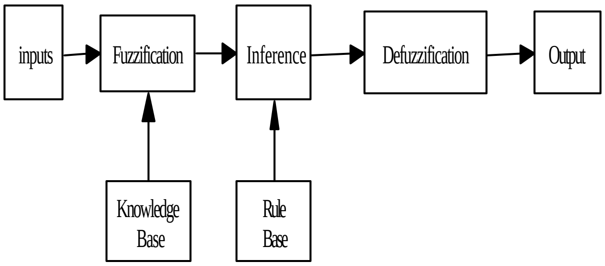

Fig. 1. Block diagram of typical fuzzy logic system and the general inference process.

The general inference process proceeds in four steps.

1. Fuzzification: Under fuzzyfication the membership functions defined on the input variables are applied to their actual values, to determine the degree of truth for each rule premise.
2. Inference: Under inference, the truth value for the premise of each rule is computed, and applied to the conclusion part of each rule. This results in one fuzzy subset to be assigned to each output variable for each rule. Usually only MIN or PRODUCT is used as inference rules. In MIN inference, the output membership function is clipped off at a height corresponding to the rule premise's computed degree of truth (fuzzy logic AND). In PRODUCT inference, the output membership function is scaled by the rule premise's computed degree of truth.
3. Composition: Under composition, all the fuzzy subsets assigned to each output variable are combined together to form a single fuzzy subset for each output variable. Again, usually MAX or SUM is used. In MAX composition, the combined output fuzzy subset is constructed by taking the point wise maximum over all of the fuzzy subsets assigned to variable by the inference rule (fuzzy logic OR). In SUM composition, the combined output fuzzy subset is constructed by taking the point wise sum over all of the fuzzy subsets assigned to the output variable by the inference rule.
4. Defuzzification: Finally the (optional) defuzzification is used when it is useful to convert the fuzzy output set to a crisp number. There are more defuzzification methods than you can shake a stick (at least 30). Two of the more common techniques are the CENTROID and MAXIMUM methods. In the CENTROID method, the crisp value of the output variable is computed by finding the variable value of the center of gravity of the membership function for the fuzzy value. In the MAXIMUM method, one of the variable values at which the fuzzy subset has its maximum truth value is chosen as the crisp value for the output variable.

IV. RESULTS AND DISCUSSION

Presence of dissolved particles, acidity and resistivity has serious impact on the asset performance and life, ignoring one could mislead the estimation. The fuzzy logic modeling and analysis has been carried out to get better asset's remanant life estimation. Fig.2. represents FIS editor showing 3-input variables and 1-output variable, figure 3, 4 and 5 represents the acidity, particle size and resistivity represents membership function plot for input variable and figure.6 represents the membership function plot for output variable age. The rule view in Fig.7 is showing remanant life of the power transformer.

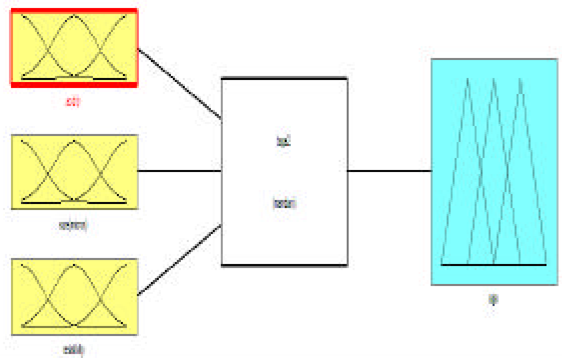

Fig. 2. FIS Editor showing 3-input variables and 1-output Variable.

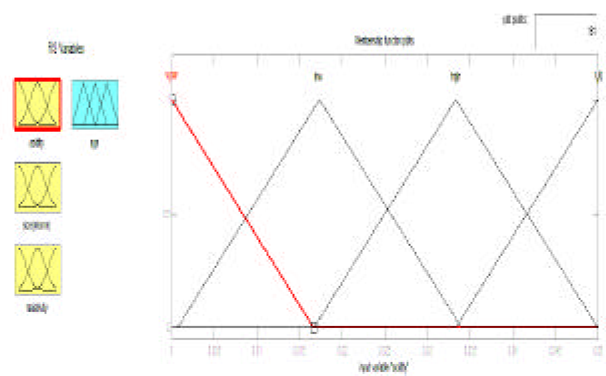

Fig. 3. FIS Editor Showing membership function plot of acidity.

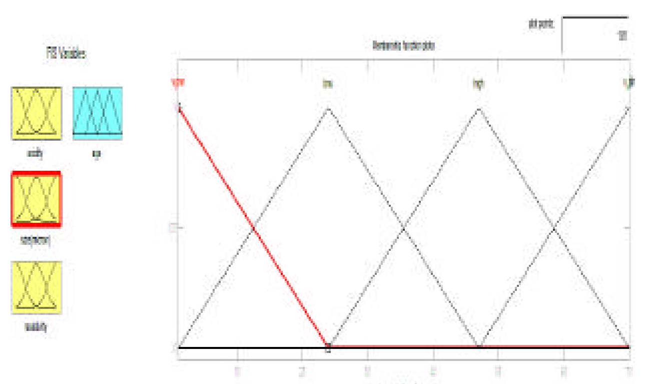

Fig. 4. FIS Editor Showing membership function plot of particle size.

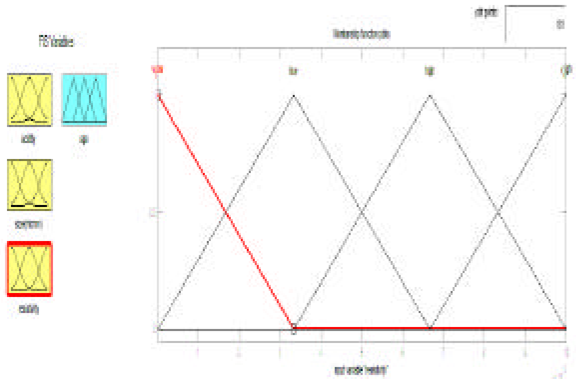

Fig. 5. FIS editor showing membership function plot of resistivity.

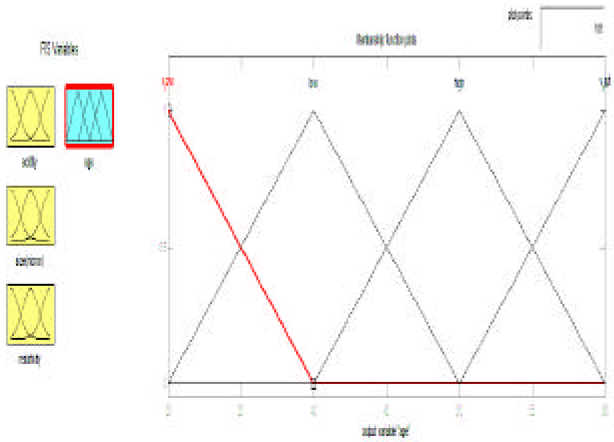

Fig. 6. FIS editor showing membership function plot of age.

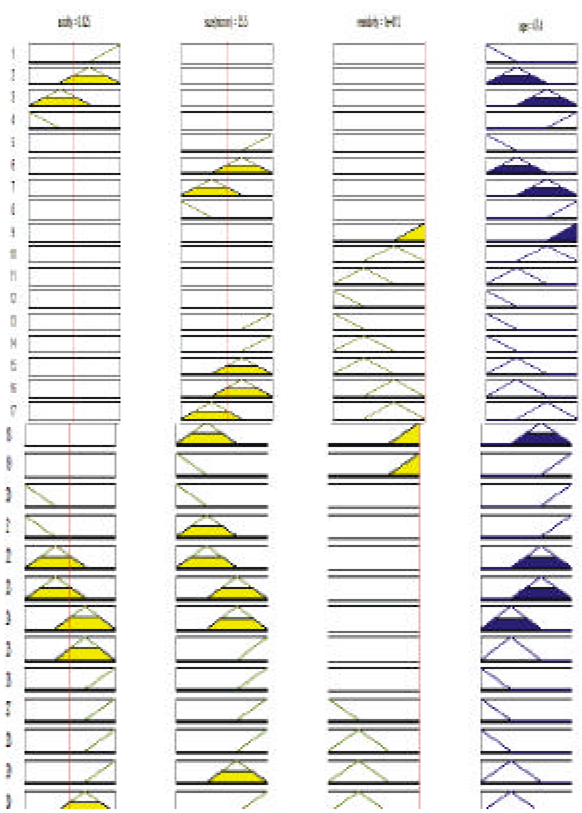

Fig. 7. Rule view.

The resistivity of a liquid is a measure of its electrical insulating properties under conditions comparable to those of the test. High resistivity reflects low content of free ions and ion-forming particles and normally indicates a low concentration of conductive contaminants.

High acidity leads to advanced degradation and sludge formation. This in turn can lead to power cooling conditions and higher temperature leading to shorter lives. The oil must have a low Particle Size and Count and low fiber content as the presence of such contaminants, especially in the presence of moisture, can considerably reduce the electric strength.

The life estimation model of transformer presented here with the use of fuzzy logic controller. The fuzzy method has been proposed in this work due to its simplicity and accuracy.

V. CONCLUSION

The transformer life is extended, and the risks are eliminated by Residual life Assessment. The user in meeting system demand, satisfactory operation of large power transformers can be achieved only if the condition of the coolant oil is maintained. Considerable experience exists worldwide where lack of attention to oil condition has led to shorter operational lives.

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RFERENCES

[1] Instruments for On-line Monitoring of Transformers by V. Mentlík et.al in International Conference on Renewable Energies and Power Quality (ICREPQ'09) Valencia (Spain), 15th to 17th April, 2009

[2] Conduction and Breakdown Mechanisms in Transformer Oil by Michael Butcher et.al in IEEE Transactions on Plasma Science, VOL. 34, NO. 2, April, 2006, pp 467-475.

[3] Insulation Condition Assessment of Power Transformers Using Accelerated Ageing Tests by Mohammad MIRZAIE et.al in Turk J Electrical Engg & Computer Science,Vol.17, No.1, 2009

[4] Ageing diagnosis and lifetime estimation for power transformer Dong Ming, Zhou Ming G E et.al proceeding of the XIVth International Symposium on High Voltage Engineering Tsinghua University Beijing, China-(G-075), pp 1-5, August 25-29, 2005.

[5] Dielectric strength of aged transformer oil experimental studies & statistical analysis of breakdown voltage H Z Dong et.al. Proceeding of the XIVth International Symposium on High Voltage Engineering Tsinghua University Beijing, China (C-10) pp 1-5, August 25-29, 2005.

[6] Condition Assessment of the cellulosic insulation fro power transformer taken out for service Muns Peter Gurner et.al. Proceeding of the XIVth International Symposium on High Voltage Engineering Tsinghua University Beijing, China (F-06) pp 1-5, 25-29, August, 2005.

[7] Power transformer Aging and Life Extension by Muhammad Arshad, Sayad M.Islam, and Abdul Khalique in 8th international Conference o Probabilistic methods applied to Power Systems, Iowa University, Ames, Iowa, pp 498-501, September 12-16, 2004.