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ANALYSIS OF TRANSFORMER OIL USING IMAGE PROCESSING

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ABSTRACT
For a power system to work reliably, the role of transformers is critical. Health of the transformer mainly depends on its insulation. Among the different insulating material used in transformers, mineral oil is the most widely used as insulating medium in oil filled transformers. Transformer oil is a mixture of hydrocarbons which can tolerate high temperature and is an excellent insulator. It not only serves as insulator but also as a coolant. Besides this it suppresses sparking, arching and corona. Oil degrades because of gases dissolved in it due to the occurrence of various faults and deterioration with respect to age. Increase in dissolved fault gases concentration in oil, results in oil losing its effectiveness; this will influence the transformer performance. Hence, to prevent the transformer failure, oil analysis is very essential and there are several methods to diagnose the health of the oil. Various tests like Dissolved Gas Analysis (DGA), Electrical Diagnostics etc. can evaluate the transformer health but this method is very vast, dangerous during oil transaction and lengthy. Image processing based analysis is quick software based analysis to determine quality of transformer oil. The image is acquired via camera it is preprocessed using Median and weinner2 filters to filter out the white Gaussian and salt and pepper noise. Using histogram modification technique the image quality is enhanced for better visibility and analysis. Entropy technique is used to extract different oil properties like Neutralization Number, dissipation factor etc. to determine the performance of transformer oil.

INDEX TERMS: *Transformer oil, Image processing, Linear Regression method.*

I. INTRODUCTION

Transformer is a static device which transforms electrical energy from one circuit to another without any direct electrical connection and with the help of mutual induction between two windings. It transforms power from one circuit to another without changing its frequency but may be in different voltage level. The working principle of transformer depends upon Faraday's law of electromagnetic induction. Mutual induction between two or more winding is responsible for transformation action in an electrical transformer. Transformer oil is a refined mineral oil obtained from the fractional distillation of crude petroleum. It is then treated to remove impurities and to obtain the most desirable properties to make it suitable as an insulating and cooling liquid. Dielectric properties of oils are determined mainly by the dielectric loss tangent. Dielectric strength of transformer oil is mainly determined by the presence of fiber and water, so the mechanical impurities and water in oils must be completely absent. Low pour point (-45 °C and below) is necessary to preserve their mobility at low temperatures. To ensure effective heat dissipation transformer oil should have a viscosity at least point not less than 95,125,135 and 150 °C for various brands. The primary enemies of the transformer oil are oxidation, contamination, and excessive temperature. Oil degrades because of gases dissolved in it due to the occurrence of various faults and deterioration with respect to age. Increase in dissolved fault gases concentration in oil, results in oil losing its effectiveness; this will influence the transformer performance. Variation in transformer performance will ultimately effect on power supplying company's revenue and consumers.

Hence, to prevent the transformer failure, oil analysis is very essential and there are several methods to diagnose the health of the oil. Currently, in the practice of chemical diagnostic criteria, it has the following significant observation such as dangerous to operate during oil transaction, time consuming and expensive. As per the literature and practice of electrical system, oil changes have been modifying the color as time varies. Here, the prominent oil characteristics are Acidity, Interfacial Tension (IFT), power factor and tanδ. They are quite interrelated to each other. Due to the ageing of the oil, these two properties values also remarks through the change. Increasing of acidity will raise the tanδ of the oil. In view of the overcoming the pitfalls of conventional practice, the most convenient strategy through appearance based automation with the help of Image Processing concept is applied. An explorative experiment has been conducted with image processing technique namely Texture Entropy, subsequently compared the performance with conventional methods.

II. CAUSES OF TRANSFORMER FAILURE

It is generally believed that the failure occurs when a transformer component or structure is no longer able to withstand the stress imposed on it during operation. During the course of its life, the distribution transformer as whole has been suffering the impact of thermal, mechanical, electrical, chemical and electromagnetic stress during normal and transient loading conditions. The normal causes of transformer failure are:

A. Insulation Failures

Insulation failures are the leading cause of failure in the study. This category excludes those failures where there was evidence of a lightning or a line surge. There are actually four factors that are responsible for insulation deterioration they are pyrolosis (heat), oxidation, acidity, and moisture. But moisture is reported separately. The average age of the transformers that failed due to insulation was 18 years.

B. Design / Manufacturing Errors

This category includes conditions such as loose or unsupported leads, loose blocking, poor brazing, inadequate core insulation, inferior short circuit strength, and foreign objects left in the tank.

C. Oil Contamination

This category pertains to those cases where oil contamination can be established as the cause of the failure. This includes sludging and carbon tracking.

D. Overloading

This category pertains to those cases where actual overloading could be established as the cause of the failure. It includes only those transformers that experienced a sustained load that exceeded the nameplate capacity.

E. Fire / Explosion

This category pertains to those cases where a fire or explosion outside the transformer can be established as the cause of the failure. This does not include internal failures that resulted in a fire or explosion.

F. Line Surge

This category includes switching surges, voltage spikes, line faults/flashovers, and other T&D abnormalities. This significant portion of transformer failures suggests that more attention should be given to surge protection, or the adequacy of coil clamping and short circuit strength.

G. Maintenance / Operation

Inadequate or improper maintenance and operation were a major cause of transformer failures, when you include overloading, loose connections and moisture. This category includes disconnected or improperly set controls, loss of coolant, accumulation of dirt & oil, and corrosion. Inadequate maintenance has to bear the blame for not discovering incipient troubles when there was ample time to correct it.

H. Lightning

Lightning surges are considerably fewer in number than previous studies we have published. Unless there is confirmation of a lightning strike, a surge type failure is categorized as “Line Surge”.

I. Moisture

The moisture category includes failures caused by leaky pipes, leaking roofs, water entering the tanks through leaking bushings or fittings, and confirmed presence of moisture in the insulating oil.

III. QUALITY ANALYSIS OF TRANSFORMER OIL

There are numerous investigating methods to determine the transformer oil quality. Chemical method is most enlightening technique to examine the oil properties. To evaluate the oil properties, chemical method is sub divided in to two types namely DGA and Oil analysis [5]. DGA furnishes information about fault in transformer and oil analysis assesses the oil properties like NN, viscosity, tanδ, IFT and power factor. Fig 1 shows the block diagram of traditional and proposed method of oil evaluation. To determine the acidity of oil, potentiometric titration with potassium hydroxide is used and for tanδ measurement Schering Bridge is utilized. These conventional diagnostic methods are devouring much time to estimate the oil properties. To overcome the disadvantages of traditional method, an image processing technique of Entropy method is proposed.

The image processing technique involves preprocessing of the taken image of transformer oil in which first the noises are removed using median and weinner2 filter and histogram enhancement technique is used for better visibility. Now entropy which is the statistical measure of randomness is calculated which depends mainly on the deterioration of the taken oil sample. Thus using regression method from the knowledge of entropy and learned data the state properties of oil can be predicted.

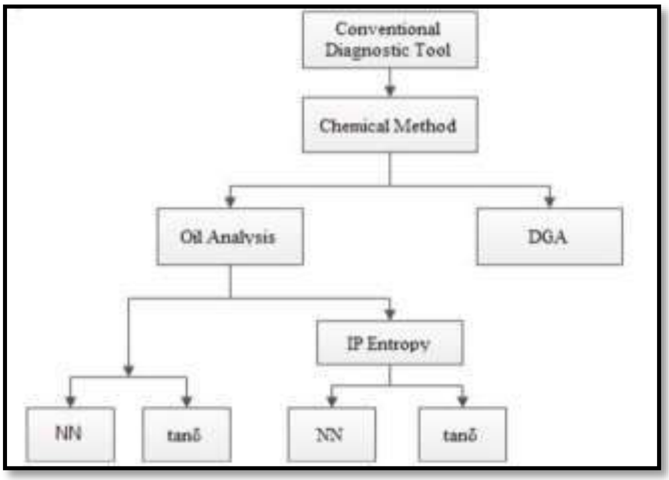

Fig. 1 Block diagram of conventional and proposed diagnostic method

A. Entropy Technique For Oil Property Determination

As oil gets aged color and texture of the oil changes, at the same time some of the properties related to oil also change. In this work Acidity and tanδ of oil is calculated from image processing approach called Entropy. Entropy can be described from below equation ,

E= -sum(a.*log2(a))

Where 'a' contains the histogram counts

Entropy measures the randomness statistically. Entropy accounts for indicating the texture of an input image. Acidity calculation is done on the basis of straight line formula, because when the samples Ageing v/s Acidity graph is drawn, a slope exists. The NN values can be estimated from below equation ,

NN = Ac * y +c

Where, NN = Neutralization Number c = constant = 0.013; y = years; Ac = Acid constant

Acid constant value can be obtained from below equation,

Ac = (Fnn−Inn)/Ty

Where, Fnn = Final neutralization number from standard test
Inn = Initial neutralization number from standard test
Ty = Total number of years
Ac = {0.013 $0 \leq Ty \geq 14$, 0.0159 $15 \leq Ty \geq 25$}

Two Ac values are taken to acquire the NN, the reason behind this is that the acidity is not constantly enhancing.

tanδ or Dissipation factor can be calculated from equation (4)

tanδ = y*k

Where, $y \neq 0$ (fresh oil ageing is taken as 1)
k = constant
k = {0.0021 $0 \leq Ty \geq 14$
{0.00719 $15 \leq Ty \geq 25$

Power factor of the oil can be calculated from below equation,

Power factor = $sqrt(\tan^2\delta / (1+\tan^2\delta))$

To acquire both NN and tanδ of transformer oil, ageing year of oil is essential. Equation (6) is used to calculate y value from Entropy of the image

y = (E1 − E0) / k1

where;
E0= Entropy of the fresh oil
E1 = Entropy of the oil sample (old)
k1 = 0.046

The following is the algorithm to process an image using entropy method,

Evaluation of NN and tanδ of Transformer oil by Entropy method

1 .Load the image
2. To remove noise use median and weinner2 filters.
3. Enhance the image using histogram modification technique.
4. Find the Entropy (E).
5. Declare k1 and determine y.
6. Check for $y \geq 14$.
7. If y is less than 14 years, set Ac = 0.013 for NN and set k2 = 0.0021 for tanδ calculations.
8. If 15<y<25, set Ac=0.0159 and k2 =0.00716 to compute tanδ and acidity.
9. If y >25, result will show error.

The first step is of image processing. The microscopic image obtained from oil sample contains noises which can interrupt in image processing detection and may leads to erroneous results. Noise is presence of any unwanted signal which degrades the image signal. Noises can be generated from apparatus or from environment.

The main types of noises in microscopic images of oil sample are:

❖ Gaussian white noise: It is a randomly fluctuated white noise. These noises can be removed by median filter and wiener filter. Median filter takes pixel values from the surrounding of a particular point and returns the average of all in to the point. Weiner filter works on the principle of least squares. Suppose an distorted image M is given which after restoration gives value R but undistorted image be M. closeness of R to M can be measured by ,
$\sum(mij - rij)^2$
Thus minimum error can be found out by least square method. This is used to remove Gaussian noise.

❖ Salt and pepper noise: This is also referred to as impulse noise as is characterized by sudden high amplitude yet for short disturbance which results in increasing the pixel values to a high level at some points. This is scattered randomly.

It is an important preprocessing tool which results in appreciate visual conception and helps in further processing of image. This is subjective i.e. the different methods to be applied is application dependent. The key functions are:

Step 1: Deblurring of an image.
Step 2: Sharpening of an image.
Step 3: Improving brightness and contrast of an image.
Step 4: Proper edge highlighting etc.

In the microscopic images the majority of pixels possess a luminescence less than average which results into poor visual effect. Histogram modification is a tool which pixels will be rescaled to values where there is a well distinguish between their pixel values and thus better to analyze it.

B. Linear Regression Method

Linear regression is a method which models for establishing relationship between an independent variable(s) and a dependent variable. Mainly linear regression is divided into two parts: simple regression and multiple regression. Simple regression establishes the relationship between one independent and one dependent variable. Multiple regression models relationship between multiple independent variables and one dependent variable.

Linear regression is nothing but a linear predictor where the model parameter are found out by learn data set and using these parameters the unknown values are estimated. Linear regression has enormous practical application as it is very simple to estimate the unknown parameters and thus very easy to predict the unknown values.

Most often the variable(s) upon which our prediction is based is called predictor variable referred to as 'X' and the variable whose value we want to find out is called criterion variable. In linear regression method we want to find the best fitted curve which is referred as regression line. The best fitted line is the line from which error of all the points on an average is small. This error is minimized by least square method. This method establishes a line from which the sum of the squares of the error of all points is the least.

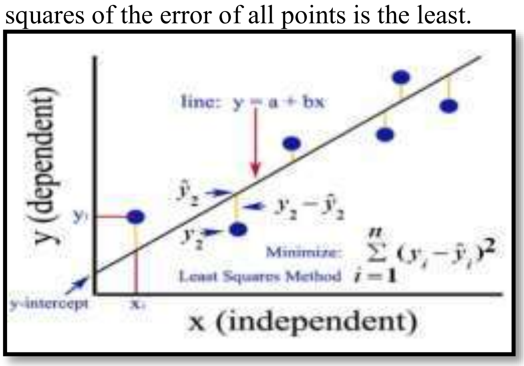

Fig. 2 Linear Regression Curve

IV. FAULT ANALYSIS IN TRANSFORMER OIL

Transformer oil is a mixture of a number of gases, thus the analysis of decomposition of transformer oil is quiet complex. Basically first step is the breakdown of C-H and C-C bonds which results into active H atom and other hydrocarbon fragments. These are prone to with each other to form H2, CH4, and C2H6 etc. Facilitated by temperature this further undergoes decomposition and rearrangement to form C2H4, C2H2 etc.

Here two methods are applied to find the kind of fault from the concentration of H2, CO, C2H2, CO2, C2H4, C2H6, CH4, N2 and O2. These are as follows:

A. Key Gas Analysis Method

This analytic method is useful to detect the fault caused by presence of a single gas predominantly. The range of ppm level presence of a particular gas leads to different characteristic faults in transformer oil. This method indicates the fault level from the comparison of the concentration of the key gas with the reference.

Table 1 Different conditions for key gas analysis method

Gas	Normal Condition	Abnormal Condition	Interpretation
H2	<150 ppm	>1000 ppm	Arching, Corona
C2H6	<10 ppm	>35 ppm	Overheating (local)
CH4	< 25 ppm	>80 ppm	Sparking
C2H4	< 20 ppm	>100 ppm	Overheating (Severe)
N2	1 to 10%	N.A.	N.A.
CO2	< 1000 ppm	>15000 ppm	Overloading (Severe)
O2	0.2 to 3.5%	0.03%	Combustibles
CO	< 500 ppm	>1000 ppm	Overloading (Severe)

B. IEC Basic Ratio Method

Though there are many gases to indicate different faults in transform primarily there are 5 gases (H2, CH4, C2H6, C2H4, and C2H2) which can indicate almost all kind of fault. In this method these 5 gases are taken into consideration. This method compares the ratio of gases with the reference ratio to detect the kind of fault exist in transformer oil. Here only 3 ratios are important: CH4/H2, C2H2/C2H4, and C2H4/C2H6.

Table 2 Different conditions for IEC basic ratio method

Fault Type	C_2H_2/C_2H_4	CH_4/H_2	C_2H_4/C_2H_6
Normal	< 0.1	0.1 to 1.0	<1
Low energy density partial discharge	Not significant	< 0.1	<1
Thermal fault <150ºC	< 0.1	0.1 to 1.0	1-3
Thermal fault 150ºC - 300ºC	< 0.1	>1	<1
Normal	< 0.1	0.1 to 1.0	<1
Low energy density partial discharge	Not significant	<0.1	<1
Thermal fault <150ºC	< 0.1	0.1 to 1.0	1-3

V. IMAGES OF TRANSFORMER OIL

The following are images after preprocessing of images,

Fig 3 Fresh Tr. oil

Fig 4 Three year aged Tr. Oil

Fig 5 9 Yr aged Tr. oil

Fig 6 12 Yr. aged Tr. Oil

Fig 7 14 Yr. aged Tr. oil

Fig 8 16 Yr. aged Tr. Oil

Fig 9 17 Yr. aged Tr. oil

Fig 10 18 Yr. aged Tr. Oil

Fig 11 21 Yr. aged Tr. oil

Fig 12 25 Yr. aged Tr. Oil

CONCLUSION

Image processing technique for transformer oil analysis is software based analytic technique which is fast, reliable and user friendly. The image quality can be enhanced for better visibility and analysis through histogram modification techniques. Entropy technique was used to find out different oil properties like NN, dissipation factor, power factor etc. to determine the performance of transformer. Subsequently, image processing provides an easy and fast method to check the transformer health from the image of transformer oil.

REFERENCES

1. *Sidram,M,H. and Hegde,S."A Novel Approach of Transformer Oil Quality Analysis Using Image Processing",IOSR Journal of Computer Science (IOSR-JCE), 2014.*
2. *Sherif S. M. Ghoneim, Sayed A, Dissolved gas analysis as a diagnostic tool for early detection of transformer faults, Advances in Electrical Engineering Systems, 2014, 152-156.*
3. *Naveen Kumar Sharma, Prashant Kumar Tiwari, and Yog Raj Sood, Review of Artificial Intelligence Techniques Application to Dissolved Gas Analysis on Power Transformer, International Journal of Computer and Electrical, Engineering, 3(4), August 2013, 577- 581.*
4. *Ghoneim, S.S. M.," Dissolved Gas Analysis as a Diagnostic Tools for Early Detection of Transformer Fault", Advances in Electrical Engineering Systems (AEES), 2012.*
5. *Amritpal Singh, and P. Verma, A Review of Intelligent Diagnostic Methods for Condition Assessment of Insulation System in Power Transformers, IEEE International Conference on Condition monitoring and Diagnosis, Beijing, China, 2008.*
6. *Waniya Reena Roben, Wardole Kirti Nagesh, and Prof. H.A.Warkar, "Transformer Oil Quality Analysis using Digital Image Processing", International Engineering Research Journal (IERJ) Volume 2 Issue 2 Page 575-579, 2016, ISSN 2395-1621.*