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Estimating the Vital Parameters in Transformer Oil Using Soft Computing Technique

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ABSTRACT

Power transformers are the costliest equipment in power system. Transformer may get failed by the failure of insulation system. Monitoring the transformer is essential to keeping continuity in power distribution. Goal of presented work is to predict the transformer oil critical parameters with low cost for monitoring purpose of transformer. In this project one of the soft computing technique, artificial neural network have been constructed to predict different critical transformer oil parameters. The prediction is performed through modeling the relationship between the predictable parameters and critical parameters. The process of predicting these oil parameters statuses is carried out using various configurations of neural networks. First, a multilayer feed forward neural network with a back-propagation learning Algorithm was implemented. Subsequently, a cascade of these neural networks was deemed to be more promising according to the correlation between the parameters.

Keywords : PCB, ASTM, Neural Network, ANN, Feed Forward and Back Propagation Neural Network

I. INTRODUCTION

Most of the research involving transformer oil prediction is geared towards predicting the transformer insulation status. Few studies have been conducted to estimate the transformer characteristics like water content and breakdown voltages. The prediction is performed through modeling the relationship between the measurable parameters and the critical parameters. The process of predicting these oil parameters statuses is carried out using various configurations of neural networks. First, the correlation between the parameters is mathematically deduced to find the error value. And A multilayer feed forward neural network with a back-propagation learning algorithm was implemented. Subsequently, a cascade of these neural networks was deemed by the correlation to be more promising, and four variations of a three-stage cascaded were tested. The first configuration takes four inputs and outputs four parameter values, while the other configurations have four neural networks, each with two or three inputs and a single output; the output from some networks are pipelined to some others to produce the final values. Both Configurations are evaluated using real-world training and testing data and the accuracy is calculated across a variety of hidden layer and hidden neuron combinations.

Testing transformer oil involves taking a sample of the oil and sending it to a laboratory for the results. The cost of only testing the oil will be high. Thus, it would be very helpful if the values of the transformer oil tests could be predicted. For monitoring the transformer, the 75% of accuracy of predicting the transformer oil parameters will be sufficient to state the oil condition. And so here, by the correlation between the transformer oil parameters, the critical parameters can be predicted through the trained artificial neural network. It can reduce the cost of the test to predict the oil parameters.

II. METHODS AND MATERIAL

A. Transformer Oil

Nowadays mineral oil is used in transformer to provide both insulation and cooling system. Some transformers, particularly indoor units are filled with a synthetic fluid, such as silicon-temp or Askeral(PCB fluid).

Properties of Transformer Oil

The reliable performance of mineral oil depends on certain characteristics, such as high dielectric strength, sufficient less viscosity, less water content, high flash and fire points[3]. Transformer oil has some important parameters regarding to the properties, applications as physico-chemical properties (aspect color, density, water content and acidity), electrical properties (discharge voltage and dielectric losses), and thermal properties (viscosity, flash point and fire point).

Some of the parameters are in description,

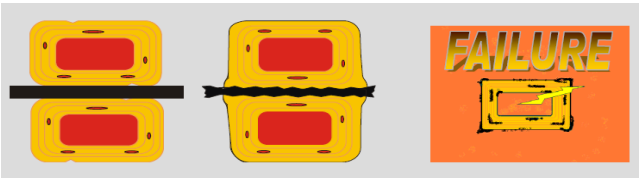
Moisture Content

Water or moisture can be introduced into the oil by leaking gaskets, poor handling techniques, oil degradation. In the transformer oil, increase in moisture content reduces the insulating properties which lead to dielectric break down. And high absolute amount of water hikes the insulation paper ageing in transformer. And also increases the corrosion in core and tank.

The moisture content in oil can be determined by coloumetric Karl Fischer titration method. the fundamental principle behind the method is based on Bunsen reaction between iodine and sulphur dioxide in an aqueous medium.

Acid Number

Just like lubricating oils transformer oils can also get oxidized under influence of huge amount of oxygen and temperature. Oxidation products are usually acidic in nature.



Increased acidity oil has a damaging effect on the cellulose paper which furthermore exacerbates oil breakdown.Neutralization number or acid number in transformer oil can be determined by titration method.

Break Down Voltage

Dielectric strength of oil is a measure of the oil's ability to withstand electrical stress without failure. Some of the causes for reducing break down voltages in transformer oil are increasing water content, sediment, existence of conducting particles and oil degradation[5].

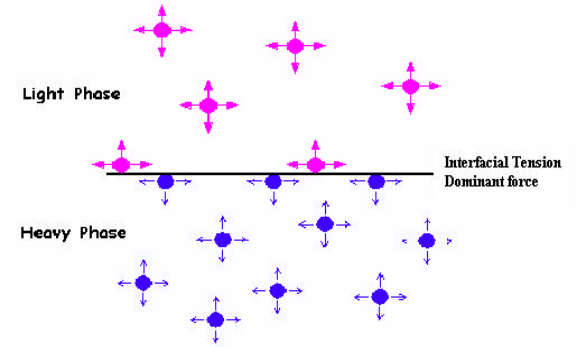
Determination method of AC break down voltage in mineral oil is recommended by ASTM D-1816 and IEC 156. Determination can be performed by the break down voltage measuring kit.

Interfacial tension:

Interfacial tension is the surface tension of a sample of the oil carefully floated on top of a layer of water. The more hydrophilic the oil becomes, the lower the value of the surface tension between the two liquids. The interfacial tension of transformer oil is related to its deterioration[13].

IFT can be measured by interfacial densitometer. This test method covers the measurement of the interfacial tension between mineral oil and water, under non-equilibrium conditions.

Color



The oil color and its aspect are very important visual characteristics for the oil analysis. This test is achieved by a colorimeter according to ASTM D-1500 standard. This test checks turbidity, cloudiness, suspended particles and color. New oil has a color rating of 0.5 and is bright and clear.

Tan delta and Resistivity

The Tan Delta value gives an indication of the Condition of the oil sample. There are several Reasons, due to

which the Tan Delta value may be affected – such as moisture, dissolving of some of the transformer varnish, insulating material etc[5]

The TDM-4000 is an automated instrument for measuring the electrical characteristics of transformer oil, insulating liquids & other Insulating material samples. The TDM-4000 Measures Capacitance, Dielectric Constant (Î), Dielectric Loss, Tan Delta (Dissipation Factor), Resistance & Resistivity of the test sample.

Mathematical Analysis

Statistical methods are used to analysis the data which are collected or from past profile. And they can be related by the formulas by using regression principle in statistics.

Correlation Principle

The concept of 'correlation' is a statistical tool which studies the relationship between two variables and Correlation Analysis involves various methods and techniques used for studying and measuring the extent of the relationship between the two variables.

Correlation Coefficient

One of the most widely used statistics is the coefficient of correlation 'r' which measures the degree of association between the two values of related variables given in the data set [15]. It takes values from + 1 to – 1. If two sets or data have r = +1, they are said to be perfectly correlated positively if r = -1 they are said to be perfectly correlated negatively; and if r = 0 they are uncorrelated. The coefficient of correlation 'r' is given by the formula.

$$r = \frac{n\sum xy - \sum x \sum y}{\sqrt{\left(n\sum x^2 - (\sum x)^2\right)\left(n\sum y^2 - (\sum y)^2\right)}}$$

Regression Formulae

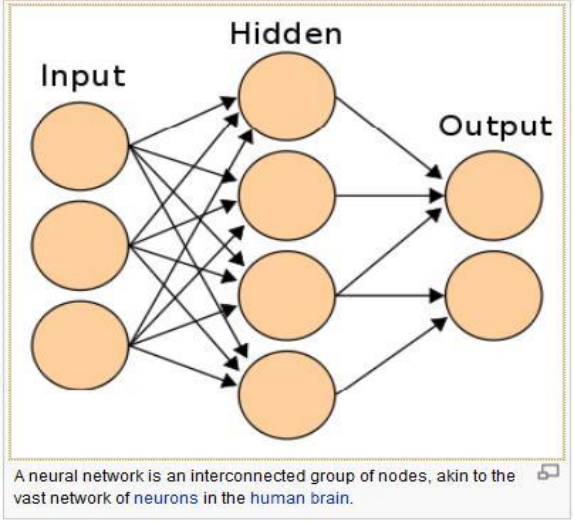
Regression analysis is a mathematical measure of the average relationship between two or more variables in terms of the original units of the data. Regression analysis, in general sense, means the estimation or prediction of the unknown value of one variable from the known value of the other variable.

III. RESULTS AND DISCUSSION

Artificial Neural Network

An artificial neural network is a system based on the operation of biological neural networks, in other words, is an emulation of biological neural system. Artificial neural networks are non-linear data driven self-adaptive approach as opposed to the traditional model. They are powerful tool for modeling especially the underlying data relationship is unknown.

Feed Forward Neural Network



A neural network is an interconnected group of nodes, akin to the vast network of neurons in the human brain.

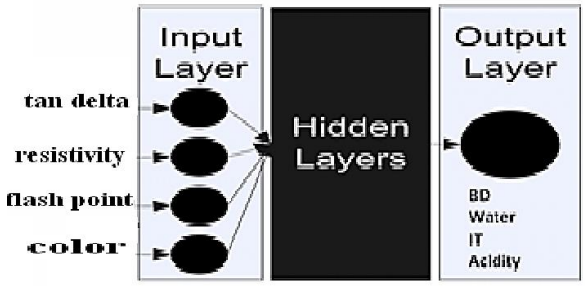
Multi-layer networks are a popular and important subclass of neural networks. Because of their simple dynamics, which stems from a lack of feedback paths, these networks are inherently table. Also, the existence of powerful learning and adaptation algorithms for these networks makes them even more attractive from an engineering point of view. Supervised learning schemes on feed-forward multi-layer networks, such as back error propagation**,** are particularly attractive for applications such as pattern and speech recognition, waveform classification, etc.

Back Propagation Learning Algorithm

The Back Propagation (BP) learning algorithm is used in this study to train the multi-layer feed-forward neural network. Signals are received at the input layer, pass through the hidden layer, and reach to the output layer, and then fed to the input layer again for learning. The learning process primarily involves the determining of connection weights and patterns of connections. The BP neural network approximates the non-linear relationship between the input and the output by adjusting the weight values internally instead of giving the function expression explicitly. Further, the BP neural network can be generalized for the input that is not included in the training patterns. The BP algorithm looks for minimum of error function in weight space using the method of gradient descent. The combination of weights that minimizes the error function is considered to be a solution to the learning problem.

Cascaded feed Forward Network

A cascade of these neural networks was deemed to be more promising, and four variations of a three-stage cascade were tested. The first configuration takes four inputs and outputs four parameter values, while the other configurations have four neural networks, each with two or three inputs and a single output; the output from some networks are pipelined to some others to produce the final values. Both configurations are evaluated using real-world training and testing data and the accuracy is calculated across a variety of hidden layer and hidden neuron combinations.



IV. CONCLUSION

The value of oil break down, interfacial tension, acidity and water content can be predicted using various configurations of artificial neural networks technique. The values of oil parameters such as resistivity,tan delta,flash point and color can be given as the inputs to the ANN because of the high correlation between the tan delta and interfacial tension, resistivity and break down voltage. Finally the high accuracy level of transformer oil critical parameters such as interfacial tension,water content,acid number and break down voltage can be attained through various configuration of neural networks.

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