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DGA Based Incipient Fault Diagnosis of Transformer Using AI Technique

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Abstract - **In this paper, we focus on a Smart Fault Diagnostic Approach (SFDA) based on the integration of the output results of recognized dissolved gas analysis (DGA) techniques. These techniques are Dornenburg method, Electro-technical Commission standard (IEC) Code, the Central Electricity Generating Board (CEGB) Code based on Rogers' four ratios, Rogers method given in IEEE-C57 standard, and the Duval triangle. The artificial intelligence model will be constructed to monitor the transformer fault conditions.**

The fault decision of AI model will supply the proposed integrated SFDA. The integration between these DGA approaches will not only improves the fault condition monitoring of the transformers but also overcomes the individual weakness and the differences between the above methods. Toward a better diagnostic scheme, a new SFDA will be developed based on the integration of the most three appropriate DGA methods.

Keywords: DGA (dissolved gas analysis)

I. INTRODUCTION

Power transformers are the most important and expensive elements of electric power transmission substations. The accidents caused by transformer faults usually bring significant economic losses. Power transformers in utilities are highly valued items and take a long time for replacement. They are normally operated 24/7 and it's not easy to take out of service due to power system constraints. It is hard to monitor their condition throughout operation. When the mineral oil is suffered from high thermal and electrical stresses, it decomposes and gases are generated. One of the techniques of diagnosis of incipient faults which is mostly employed is the dissolved gas analysis (DGA) of transformer insulating oil.

When an incipient fault occurs, several consequence gases are generated and dissolved into the transformer oil, these gases are mainly hydrogen (H2), methane (CH4), acetylene (C2H2), ethylene (C2H4), ethane (C2H6), carbon monoxide (CO) and carbon dioxide (CO2) and the chemical analysis of these gases performed through a procedure called as Dissolved Gas Analysis (DGA). DGA is proved very accurate method all over the world for condition assessment of power transformer. Taking the concentration of various gases (CO, CO2, H2, C2H6, C2H4, C2H2 and CH4) incipient faults identified by various classical methods give different conditions for the same sample unit. Transformer oilprovides insulation, cooling, and helps extinguish arcs. Any degradation in the oil can lead to premature failure of the equipment. The most common type of oil used in transformers is of a mineral oil origin. So for DGA various methods have been explained to diagnose the different incipient faults.

Due to different intensities of energy dissipated by various faults, different patterns of gases are generated. Totally or partially dissolved into the oil, the amount and type of gases present in an oil sample make it possible to determine the nature of that particular fault. Thus, the DGA method is a widely used technique for fault diagnosis of transformer.

A. DISSOLVED GAS ANALYSIS

Transformer oil is disposed to undergo irreversible changes in its chemical and dielectric properties due to aging. Consequently, transformer oil may act as an information carrier whose condition may be related to condition of the transformer and as a result can determine the incipient fault in the transformer. Dissolved gas analysis (DGA) is a sensitive and reliable technique to identify the transformers incipient faults. The main advantage of this method is that the analyzing and sampling procedures are inexpensive and simple are carried out without de-energizing the transformer from service.

B. FUZZY LOGIC TECHNIQUE APPLIED TO DGA

Some conventional methods are used to detect incipient faults of transformers. The Artificial Intelligence (AI) can also be use to solve this problem. Many practical transformer operation problems can now be solved by using AI-based condition monitoring and assessment systems. In this paper, AI techniques are used to get the

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correct diagnosis of the incipient faults which are fuzzy logic (FL) and ANN. The basic structure of the fuzzy inference system is shown in Fig.1.

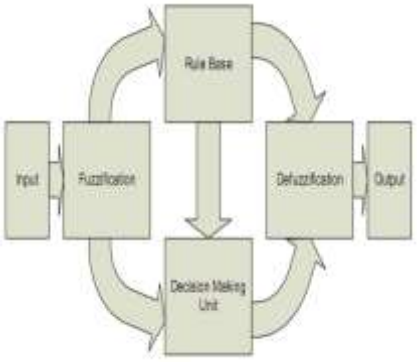

Fig. 1. The basic structure of the fuzzy inference system

Three successive process of the fuzzy logic analysis are fuzzification, fuzzy inference and defuzzification. Fuzzification converts a crisp data into a fuzzy input membership, the Gaussian membership function has been used. The Fuzzy inference draws conclusions from if-then linguistic statements. Fuzzy inference system that has been used is Mamdani type. The Max-Min composition techniques have been used. The logical (AND) is replaced with the minimization operator and the logical (OR) is replaced by the maximization operator. Defuzzification then converts the fuzzy output back into the crisp outputs. The aggregation of the output is `max` and the defuzzification is done by using the middle of maximum method.

II. OBJECTIVES

Data analysis, by using different AI methods, classifies the incipient faults. To assume particular data for calculating classification accuracy. Calculating number of iterations. Comparing output with predetermined output.

III. PROBLEM FORMULATION

There are several faults which occur in transformer and they severely affect the performance of the system.
1. PD Assessment
2. Arcing
3. Oil Overheating
4. Electrical Discharge
5. Cellulose Overheating
6. Oil Contamination from diverter switch of LTC
7. Consumption of oxygen
8. Oil overheating at 150-300˚ C
9. Temperature increase due to overheating

There are several DGA interpretation methods for power transformer faults, but some methods give different fault types than others. This may cause a problem for engineers to diagnose the fault type in power transformers. A smart fault diagnostic approach (SFDA) system has been proposed to overcome the problem of conflict among the interpretation methods.

IV. METHODOLOGY/ PLANNING OF WORK

A. SMART FAULT DIAGNOSTIC APPROACH (SFDA)

Decision-making can be considered as a experimental process resulting in the selection of a belief or a course of action among several alternative possibilities. Every decisionmaking process produces a final choice that may or may not prompt an action. Decision-making is the research of identifying and choosing alternatives based on the values and preferences of the decision maker. Decision-making may be considered as one of the central activities of management and is a large part of any process of implementation. The proposed SFDA to identify the fault occurring in transformer will follow the decision-making concept as in shown Fig. 1.

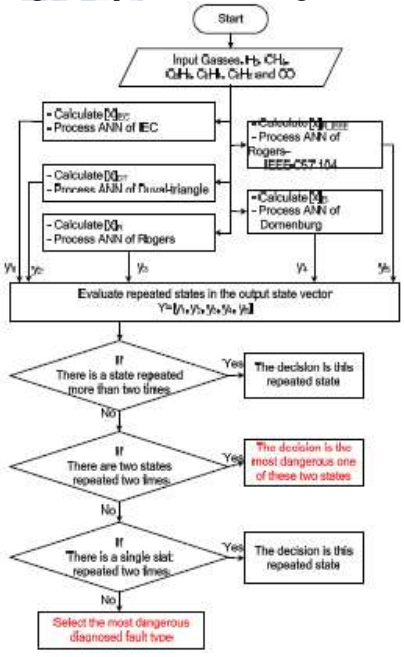

Fig 1 The proposed block

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Figure 1 shows the flowchart for the inputs to the system using the dissolved gases (H2, CH4, C2H6, C2H4, C2H2 and CO). The different ratios for each method are calculated, which are considered the input to each neural network model. The output from each method is determined and collected as an input to the decision system Y vector as depicted in Figure.

Then, the decision procedure was as follows. If there were more than two outputs having the same fault type estimation then the decision would be the estimated dominant fault. Otherwise, if there were two fault types estimated two times as the output from the different input, then the decision would be the most dangerous one of these two states in order to avoid the risk of transformers working under the worst cases. Otherwise, if there was a fault type estimated two times, the fault would be the one at the highest repeated fault estimation. Otherwise, the fault estimation by each input would be different than the other, in which there is not state repetition. Accordingly, the fault estimation is set to the most dangerous one.

CONCLUSION

Fuzzy systems work with rules that express theimprecision and approaches of the real world. Fuzzy sets are formulated through the specialists' experience or based on methodologies already consolidated in the literature, and can interpret the data according to the nature of the problem, as can be seen in this paper. The proposed fuzzy system presented a satisfactory performance in the identification of the transformer insulation condition based on the data of DGA, as the fuzzy analysis is highlyapplicable to the problem because it not only uses theinformation of the more recent chromatography analysis as the criteria already consolidated in technical standards, but it also considers information on the evolution of the gas levels throughout time.

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