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MODERN APPROACH FOR CONDITION MONITORING OF POWER TRANSFORMERS USING DISSOLVED GAS ANALYSIS

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ABSTRACT

The transformer oil plays very important role to maintain healthy operating condition of transformer. When any fault occurs in the transformer due to different effects the formation of different gases takes place in the transformer oil. Dissolved Gas Analysis (DGA) has most proved accuracy method for condition assessment of power transformer. This gives prior information regarding mineral oil degradation level and generated dissolved gasses in mineral oil and concentration of dissolved gases by using Gas Chromatography. Taking the concentration of key gases (CO, CO2, CH4, C2H6, C2H2, H2 and C2H4) incident faults identified by various classical techniques gives different conditions for the same sample unit. In this work considered the point, which discussed in above line and design combine of all five diagnosis methods for better accuracy results to diagnosis of incipient faults. There are more than 6 known different methods of DGA fault interpretation technique. Every method varies according to their techniques. A series of combined interpretation methods that can determine the power transformer condition faults in one assessment is therefore needed. This paper presents to combine five DGA assessment techniques; Doernenburg Ratio Method Rogers Ratio Method, IEC Basic Ratio Method, Duval Triangle method and Key Gas Method.

Keywords: DGA, Fault studies using DGA, Fault Studies on Software, Short Circuit Analysis using DGA, and Transformer health check by DGA.

I. INTRODUCTION

In mineral oil filled transformers, the degradation of the oil is a major concern [1]. Insulation materials degrade at higher temperatures in the presence of oxygen and moisture. The degradation from thermal stress affects electrical, chemical, and physical properties of the oil [2]. There has been a growing interest in the technique to diagnose, determine and decide the condition assessment of transformer insulation. This is primarily due to the increasingly aged population of transformers in utilities around the world [3]. Each of the known techniques has its own method of assessing the condition of transformers. Dissolve Gas Analysis (DGA) is one of the most recent techniques developed to diagnose the fault condition on oil filled insulation transformers. There are more than 6 known different methods of the DGA fault interpretation technique so there is the likelihood that they may vary in their interpretations. This could lead to inconsistent conclusions on the condition of the transformer and thus it is necessary to arrive at a reliable decision on each transformer so as to take the correct and appropriate maintenance action. A series of combined interpretation methods that can determine the power transformer condition faults in one assessment is therefore needed. In this paper, system for five DGA assessment techniques is presented and discussed because some of the methods are similar with near equivalent gas ratios [4]. The analysis of these diagnostic techniques on fault interpretation to determine a common comprehensive fault analysis is also presented. The five techniques are the Rogers Ratio Method, IEC Basic Ratio Method, Duval Triangle method, Doernenburg Ratio Method and Key Gas Method. When they are used separately, they are likely to be less accurate than when combined. The five diagnostic techniques above are presented separately and this is followed by the computer program and the analysis of the computer result to compare the fault interpretations.

II. COMMON TYPE OF FAULTS AND KEY GASES IN DGA

Different diagnostic techniques have been developed for DGA interpretation. These methods attempt to map the relations between gases and fault conditions, some of which are obvious and some of which may not be apparent. The evaluation has been simplified by looking at key gases and the associated condition as discussed in Table 1.

Sr. No.	Gases present in oil	Interpretation
1	Nitrogen plus 5% or less oxygen	Normal operation
2	Nitrogen, carbon monoxide, and carbon dioxide	Transformer winding insulation overheating; key gas is carbon monoxide
3	Nitrogen, ethylene, and methane - some hydrogen and ethane	Transformer oil is overheated; minor fault causing oil breakdown. Key gas is ethylene
4	Nitrogen, hydrogen, small quantities of ethane and ethylene	Corona discharge in oil; key gas is hydrogen
5	Same as #4; with carbon dioxide and carbon monoxide	Corona involving paper insulation; key gas is hydrogen
6	Nitrogen, high hydrogen and acetylene; minor quantities of methane and ethylene	High-energy arcing; key gas is acetylene
7	Same as #6 with carbon dioxide and carbon monoxide	High-energy arcing involves paper insulation of winding; key gas is acetylene

Table 1 Gases and its Interpretation

III. CLASSICAL METHODS TO DIAGNOSE TRANSFORMER FAULTS

When thermal or electrical stresses, which affect the insulating oil and cellulose material in transformers, are higher than the normal permissible value, then certain combustible gases, referred as fault gases, started to be produced inside the transformer. The most significant fault gases produced by oil decomposition are H2 (Hydrogen), C2H6 (Ethane), C2H4 (Ethylene) and C2H2 (Acetylene) as well as Carbon monoxide (CO) and carbon dioxide (CO2) which produce from decomposition of insulated paper (Cellulose). The type of the faults [corona, arcing discharge (both electrical faults) and overheating (thermal fault)] as well as their severity, play an important role in producing different combustible gases. Based on DGA, many interpretative methods have been introduced to diagnose the nature of the incipient deterioration occurred in transformer. Over the years, several techniques have been developed to facilitate the diagnoses of fault gases such as Dornenberg method [5], Roger's ratio method [3], Key gases method [5] and Duval Triangle method [4] as well as IEC Basic Ratio Method.

3.1 Dornenburg Ratio Method

The Dornenburg method utilizes four calculated gas ratios to indicate a single fault type from three general fault types. This procedure requires significant levels of the gases to the present in order for the diagnosis to be valid. The four ratios and their diagnosis values are given [17]. Dornenburg method uses five individual gases or four-key gas ratios, which are:-

Sr. No.	**Ratios**	**Gases**
1	R1	CH4/H2
2	R2	C2H2/C2H4
3	R3	C2H2/CH4
4	R4	C2H6/C2H2

Table 2 Dornenburg Ratios

3.2 Roger's Ratio Method

This method was further modified into an IEC standard [3], [18]. The original Rogers ratio method uses four gas ratios which are CH4/H2, C2H6/CH4, C2H4/C2H6 and C2H2/C2H4 for diagnosis. The refined Rogers method uses two tables: one defined the code of the ratio, and the other defined the diagnosis rule. The ratio C2H6/CH4 only indicated a limited temperature range of decomposition, but did not assist in further identification of fault. Therefore, in IEC standard 599, the further development of Roger's ratio method, was deleted. Roger's ratio method and IEC 599 have gained popularity in industrial practices. However, it may give no conclusion in some cases. This is the "no decision" problem.

3.3 Key Gas Analysis

The Key-Gas analysis method could present damage levels of the power transformer and its cause by analyzing the levels of combustible gases. The gas levels for this method are given in Table .3 The method defines the level of damage by considering all of the total combustible gases, which can be classified in different ranges.

Gas	**Normal**	**Abnormal**	**Interpretation**
H2	<150 ppm	>1,000 ppm	Arcing, Corona
CH4	<25	>80	Sparking
C2H6	<10	>35	Local overheating
C2H4	<20	>100	Serve Overheating
CO	<500	>1,000	Serve Overheating
CO2	<1,000	>15,000	Serve Overheating
N2	1-10%		N.A
O2	0.2-3.5%	N.A>0.5%	Combustibles

Table .3 Combustible gas in key gas analysis .

3.4 Duval Triangle Method

The Duval Triangle was first developed in 1974. Three hydrocarbon gases only (CH4, C2H4 and C2H2) are only used. These three gases are generated as a result of increasing the level of energy necessary to generate gases in transformers in service. Figure 2 indicates the Triangle method. In addition to the 6 zones of individual faults (PD, D1, D2, T1, T2 or T3), an intermediate zone DT has been attributed to mixtures of electrical and thermal faults in the transformer**.**

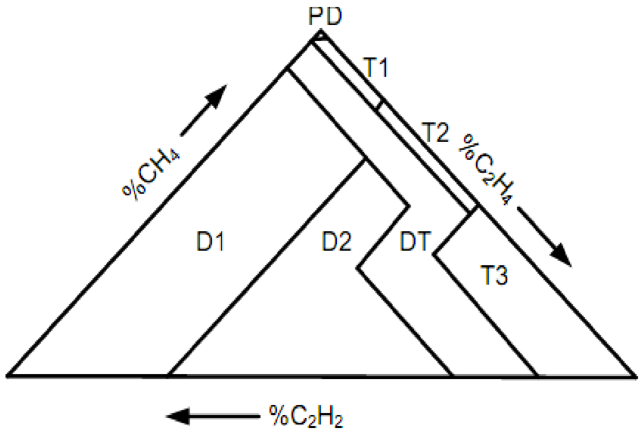

Fig: 1 Duval triangle as a diagnostic tool to detect the incipient faults in transformer

(T1 the zone of low thermal fault <300o C, T2 the zone of medium thermal fault 300o C<T<700o C, T3 the zone of high thermal fault >700o C, D1 discharge of low energy arcing, D2 discharge of high energy arcing, DT attributes to mixtures of electrical and thermal faults and PD indicates partial discharge)

3.5 IEC Basic Ratio Method

This method originated from the Roger's Ratio method, except that the ratio C2H6/CH4 was dropped since it only indicated a limited temperature range of decomposition [6] as shown in Table 4 and 5. The faults are divided into nine different types.

Ratio	**Code**
C2H4/C2H6	A
CH4/H2	B
C2H4/C2H6	C

Table : 4 IEC Basic Gas

Case	**Characteristic Fault**	**A**	**B**	**C**
PD	Partial discharges	NS1	<0.1	<0.2
D1	Discharge of low energy	>1	0.1 -0.5	>1
D2	Discharge of high energy	0.6-2.5	0.1-1	>2
T1	Thermal fault t<300°C	NS1	>1 but NS1	<1
T2	Thermal fault 300°C<t<700°C	<0.1	>1	1-4
T3	Thermal fault t>700°C	<0.22	>1	<4

Table 5 IEC Basic Code

IV. CONCLUSION

In this paper different five methods are compared the accuracy and predicted results between each method utilizing both manual calculation and software calculation. The test concludes that the accuracy of fault-analysis classifications increased the accuracy of DGA methods by 20%. The no prediction result had been reduced down to 0% rather than using one single DGA method. The matlab software also demonstrates that the DGA analysis faster since only the gas input data is required to arrive at a valid prediction.

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