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An Experimental Analysis to Check Accuracy of DGA Using Duval Pentagonal Method in Power Transformer

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Abstract

Analysis of Dissolved gas method is very sensitive and reliable method for detection of internal fault in power transformer. One of the most used method for DGA is duval triangle method. Duval triangle is not considering two combustible gases like, ethane C_2H_6, *and hydrogen* H_2. so, Duval triangle method has low accuracy for fault interpretation. Then, Duval pentagonal method is used for fault detection in power transformer. In this paper, we have get data for power transformer from Torrent Power Ltd. This experiment has done on various 20 power transformer rating of 15MVA,21kV/400kV. But, In this paper, We have shown six data of fault in case study and found fault by Duval Triangle method and Duval pentagonal method. Then, we will verify this fault interpretation with actual fault. And, we will see that Duval Pentagonal method have higher accuracy (above 80%) for fault interpretation.

Keywords—Dissolved Gas Analysis (DGA), Power transformers, fault diagnosis, Duval pentagon

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1. Introduction

Transformer is static electromagnetic device. Electrical, mechanical, chemical and environment effect the condition of the transformer. At initial stage, degradation of insulation occurs slowly. And as time passes, it will lead to failure of transformer. So, to overcome this situation, it required to continues operation. Power transformer should be very reliable and routinely be monitored [1]. The average life period of power transformer is around 30 years. Analysis of Dissolved Gas method is used for fault interpretation. It detects internal fault in power transformer [2]. So we can also maintain transformer action [3]. If we take small part of pure oil in transformer. It can determine which gases are available and level of quantity. It shows that the hydrocarbon gases produced at very fast rate of failure of organ are acetylene, methane, ethylene and ethane. Internal faults may in two classifications: short circuit fault and incipient fault. Internal incipient fault develops slowly, a gradual increment of the insulation by some causes. Transformer core puzzle is concentrate on insulation failure or shorted laminations. Other several fault in current transformer is due to oil leakage in tank, oil fouling or defilement from metal atoms and overloads. Recently, DGA is identify transformer, facilitating a proper asset management decision [5]. When an incipient fault happen, thermal or electrical, the generated energy breaks bonds of oil. Gases are generated. These gases are Ethane (C_2H_6), Carbon dioxide (CO_2) Hydrogen (H_2), Ethylene (C_2H_4), Methane(CH_4), Acetylene (C_2H_2), and Carbon monoxide (CO) and will generated if cellulose inclination is involved, depend on the classification and quantity of produced gases.

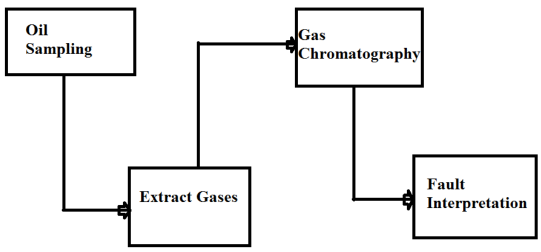

Figure 1: Methods for interpretation of gas data

Several methods have been used for detection of fault in transformer. These methods are key gas method, Rogers method, Doernenburg method, duval triangle method and duval pentagonal method[6]. Such new methods are Basic gas ratio method and artificial intelligence based methods. These methods include fuzzy logic, expert system, ANN. However, these methods are too complicated for making practical implementation in bigger range.

A. DGA methods:

1) Key main gas method:

This method is used for detection of dielectric breakdown in pure insulation oil of transformer. Partial discharge effect on oil but not on insulating paper. This method is mainly concentrate on hydrogen (H_2). PD contains 85% of hydrogen and 15% methane. Key gas and according to that which fault occurs in shown in table 1.

Table 1: Key main Gas method

Key gas	Fault type	Typical properties
C_2H_2	Thermal oil	Mainly C_2H_4
CO	Thermal oil and cellulose	CO, smaller quantity of hydrocarbon
H_2	Low energy discharge	$H_2$and C_2H_4
H_2 & C_2H_2	High energy discharge	CO is also involved

2) Total dissolved gas analysis method:

This method shows sum of all these Methane(CH_4), Acetylene (C_2H_2**)**, Ethylene (C_2H_4), Ethane (C_2H_6), Hydrogen (H_2). It uses different gas level or concentration and total quantity of TDCG method. Table 2 shows the TDCG concentration.

Table 2: TDCG concentration in ppm

Case	H_2	CH_4	C_2H_2	C_2H_4	C_2H_6
1	100	120	35	60	70
2	100-700	130-400	40-50	55-110	70-100
3	701-1800	450-1000	51-80	111-200	101-150
4	>1800	>1000	>80	>200	>150

Case 1: Below this condition level shows transformer operates properly.
Case 2: Within this range indicate more than normal combustible gas level. Above this specified levels should require additional checking.
Case 3: Within this range indicate high level of production of gases. Above this specified levels should require better additional checking.
Case 4: Exceeding this value shows very high decomposition of gases. If we operate this transformer continue, it failure of operation of transformer.

3) Doernenburs ratio method:

Dornenburg ratio include four gas ratios such as CH_4/H_2, C_2H_2/C_2H_4, $C_2H_2/CH_4$and $C_2H_6/C_2H_2$to show fault like as thermal fault, corona or low PD, and arcing or high PD shown in table 3.

Table 3: Doernenburg ration method for key gases

Sr.no.	CH_4/H_2	C_2H_2/C_2H_4	C_2H_2/CH_4	C_2H_6/C_2H_2	*Fault*
1	>0.1	<0.75	<0.3	>0.4	Thermal decomposition
2	<0.1	NA	<0.3	>0.4	PD
3	>0.1 to <1.1	>0.75	>0.3	<0.4	Arcing

4) Rogers method:

In Rogers ratio, We firstly get ratio of three gases like C_2H_2/C_2H_4, CH_4/H_2, and C_2H_4/C_2H_6 to indicate four probable faults interpretation as normal operation, HED, low temperature thermal, low energy discharge and arcing and shown in table 4.

Table 4: Rogers ratio method for key gases

Case	C_2H_2/C_2H_4	CH_4/H_2	C_2H_4/C_2H_6	Fault
1	<0.1	>0.1 to 1.0	<1.0	normal
2	<0.1	<0.1	<1.0	Low energy discharge
3	0.1 to 0.3	0.1 to 1.0	>3.0	High energy discharge
4	<0.1	>1.0	1.0 to 3.0	thermal <700 C
5	<0.1	>1.0	>3.0	Thermal >700 C

5) Duval triangle method:

This method uses percentage of three gases as CH_4, C_2H_4 and C_2H_2 which indicates faults like PD, high and low energy arcing and hot spots from thermal fault [7].

$$\% CH_4 = CH_4 / (CH_4 + C_2H_4 + C_2H_2)$$

$$\% C_2H_4 = C_2H_4 / (CH_4 + C_2H_4 + C_2H_2)$$

$$\% C_2H_2 = C_2H_2 / (CH_4 + C_2H_4 + C_2H_2)$$

For example: if All Gases value have 100 ppm.
Then, % CH_4= %C_2H_4 = %C_2H_2= 33.33%
So, Connect this all point by single midpoint. And region of this midpoint shows us fault occur in transformer. In this case, thermal fault occurs in transformer.

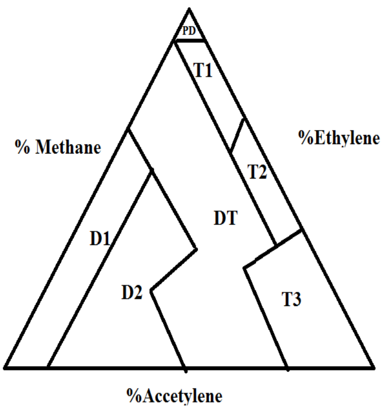

Figure 2: Duval triangle

Fault code is shown in table 5:

Table 5: Fault code

Code	Full name of fault
T1	Low energy thermal fault
T2	Medium energy thermal fault
T3	High energy thermal fault
D1	Low energy discharge
D2	High energy discharge
DT	Thermal fault
PD	Partial Discharge

6) Duval pentagonal Method:

The Duval Pentagon indication, the relative percentages of the five hydrocarbon gases like of Methane(CH_4), Acetylene (C_2H_2), Ethylene (C_2H_4), Ethane (C_2H_6), Hydrogen (H_2),analysed by DGA are first calculated [8,9].

The relative percentage of H_2 = (ppm of H_2) / (ppm of H_2+C_2H_4 +C_2H_2 +CH_4+ C_2H_6)
The coordinates (x_i, y_i) of all these of the five points are calculated. For the point on the C_2H_6 axis, the corner or nook between C_2H_6 and x axis are 18 degrees. The centre ("centroid") of the irregular polygon plotted from five points were calculated mathematically [10].

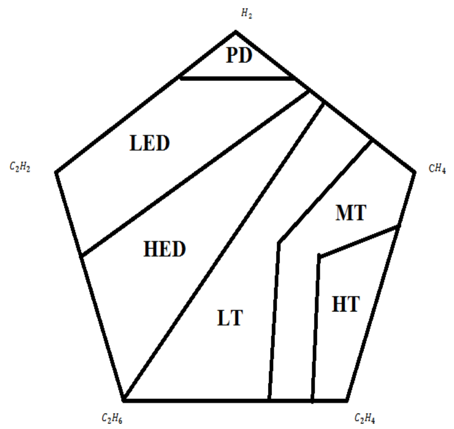

Figure 3: Duval pentagonal

2. Case Study

We have get data of gases in various power transformer 15MVA, 21kV/400kV from Torrent Power Ltd. We have shown some of it in table 6.

Table 6: Transformer 15MVA,21kV/400kVdata for fault detection

Case	H_2	CH_4	C_2H_4	C_2H_2	C_2H_6
1	120	140	120	0	30
2	3700	6400	7690	10	2400
3	125	680	900	20	290
4	120	10	5	25	30
5	140	95	60	80	10
6	240	17	40	5	0

Then we have done duval pentagon method and duval triangle method for detecting fault in these all cases. These received result is shown in table 7.

Table 7: Result in duval triangle and duval pentagonal method

Case	Fault by duval triangle	Fault by duval pentagonal
1	MT	LT
2	HT	MT
3	HT	HT
4	D1	LED
5	D2	HED
6	DT	LED

This result of fault by duval pentagonal method is compared with actual fault in power transformer table 8.

Table 8: Comparison between fault by duval pentagonal and actual fault in transformer

Case	Fault by duval pentagonal method	Actual fault
1	LT	LT
2	MT	MT
3	HT	HT
4	LED	LED
5	HED	HED
6	LED	PD

3. Conclusion

We have seen from result that fault interpretation by duval pentagonal is same as actual fault in transformer. So, this duval pentagonal method is very accurate for fault interpretation.

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