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# Study and Diagnosis of Key Gases to Detect the Condition Monitoring Of Oil Immersed Current Transformer

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***Abstract-The main function of a power system is to supply electrical energy at a reliable and high degree of quality condition. To achieve this transformers are thermally stressed which results in the chemical breakdown of some of the oil or paper cellulose molecules. These stressed conditions liberate different gases caused by the faults. In this paper the condition of oil immersed current transformer is analyzed with the help of DGA based on ANFIS.***

***Key Words*-Current Transformer, DGA, ANFIS, TDCG, Key Gases.**

## I. INTRODUCTION

Instrument transformers are the basic components of the EHV Substations& the power system as they are expected to be maintenance free. The reduction of the operating cost, enhancement of the availability of the generation, transmission and improvement in the supply of and service to the customer has put these equipments under severe stress [1]. Now a day oil immersed transformers used napthene oil as insulating medium. Current Transformers convert the primary current into low magnitude Secondary Current for application of metering & protection purposes. These series Component of the electrical system may stress due to temporary overload conditions and may involve certain degree of risk when it is neither being monitored nor controlled to prevent a possible damage [2]. Insulating material within these equipments breakdown to liberate gases within the unit the distribution of these gases can be related to the type of electrical fault and the rate of gas generation can indicate the severity of the fault. The interpretation of DGA for transformers is provided in IEC Standard 605-99-1999 and IEEE STD. C57, 104-1991.This paper deals with the condition monitoring of a CT, with the origins of the fault gases, methods for their detection and interpretation of their faults with key gas and TDCG method.

### *A. Fault Gases*

Corona (partial discharge), thermal heating and arcing are responsible for the occurrence of the fault gases. The most severe intensity of energy dissipation occur with the arcing , least with the partial discharge .These fault gases can be classified into three categories as-Hydrocarbons and hydrogen-methane (CH4), Ethane(C2H6), Ethylene(c2H4), Acetylene (C2H2), Hydrogen(H2). Carbon Oxides-Carbon dioxide(CO2), Carbon Monoxide(CO). Non fault gases- Nitrogen (N2), Oxygen (O2)[3,4].

## II. DISSOLVED GAS ANALYSIS

Dissolved Gas Analysis is the most sensitive and reliable technique used for observing the health of oil insulation check is a valuable technique in a preventive maintenance program and hence the life of CT can be extended [5]. It is a very important tool, for identification of aging effect of CT at very initial stage . The major gas produced is Hydrogen &the minor gas produced is Methane.

### A. *Dornenburg's Ratio method*

In this method the CH4/H2, C2H2/C2H4, C2H6/C2H2 and C2H2/CH4 are used that mentions the occurrence of the thermal fault; corona and arcing .this method is based on thermal degradation principles Dornenburg's Ratio Method utilizes ANS/IEEE Standard C57.104-1991.This is a complex method set on DGA. The implementation of which may result in 'no interpretation due to insufficient ratios ranges [6].

### B. *Roger's Ratio Method*

This method uses four gas ratios that are CH4/H2, C2H6/CH4, C2H4/C2H6 and C2H2/C2H4 for the fault diagnosis .This insulation oil of transformer has four conditions that are normal ageing, partial discharge with or without tracking, electrical and thermal faults of various degree of security. This method is based on thermal degradation principle and is included in ANSI/IEEE Standard C57-104-1991. The correlation of results of a much larger number of failure investigations with gas analysis of each case valid this method .There is diagnostic codes for the various faults and in this method ratio values do not fit with diagnostic codes and also no consideration is stated for gases below normal concentration and due to which the exact implementation of methods may lead to muddled result [7].

### *C. Key Gas Method*

Key gases are defined in the IEEE guide as "gases generated in oil-filled transformers that can be used for qualitative determination of fault types, based on which gases are typical or predominant at various temperatures." Table 1 indicates the key gas and fault related with it. Thermal oil-the principal gas is the ethylene. Thermal cellulose-the principal gas is the carbon monoxide. Electrical(partial discharge) principal gas is hydrogen. Electrical arcing-principal gas is acetylene[8]

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| KEY GAS METHOD (IEEE PC57.104 D11d) | | |
|---|---|---|
| KEY GAS | FAULT TYPE | TYPICAL PROPORTIONS OF GENERATED COMBUSTIBLE GASES |
| $C_2H_4$ | Thermal oil | Mainly $C_2H_4$<br>Smaller proportions of $C_2H_6$, $CH_4$, and $H_2$<br>Traces of $C_2H_2$ at very high fault temperatures |
| CO | Thermal oil and cellulose | Mainly CO<br>Much smaller quantities of hydrocarbon gases in same proportions as thermal faults in oil alone. |
| $H_2$ | Electrical Low Energy Partial Discarge | Mainly $H_2$<br>Small quantities of $CH_4$<br>Traces of $C_2H_4$ and $C_2H_6$ |
| $H_2$ & $C_2H_2$ | Electrical High Energy (arcing) | Mainly $H_2$ and $C_2H_2$<br>Minor traces of $CH_4$, $C_2H_4$, and $C_2H_6$<br>Also CO if cellulose is involved |

## III. TDCG CONDITION MONITORING

Total dissolved combustible gases method indicates the sum of H2, CH4, C2H4, C2H2, CO. Regular DGA can be helpful in resolving the performance index of a current transformer. Also an analysis can be done with its history data to detect its normal behaving with acceptable concentrations of gases. A four level method is developed to classify risks to transformer if there is no previous DGA history .This method uses separate gas concentration and total concentration of TDCG method. Table 2 shows the TDCG concentrations.

The four conditions are mentioned below-

*Condition 1:* TDCG below 720 indicates satisfactory operation of a current transformer. Any individual combustible gas exceeding specified levels needs additional investigation.

*Condition 2:* TDCG in this range indicates normal combustible gas level .Any individual combustible gas exceeding specified levels needs additional investigation.

*Condition 3:* TDCG in this range indicates high level of decomposition .Any individual combustible gas exceeding specified levels needs additional investigation.

*Condition 4:* TDCG in this range indicates excessive level of decomposition .continued operation will result in failure of current transformer.[9]

**Table 2 Dissolved Key Gas Concentration Limits PPM**

| | H2 | CH4 | C2<br>H2 | C2<br>H4 | C2<br>H6 | CO | CO2 | TDC<br>G |
|---|---|---|---|---|---|---|---|---|
| C<br>1 | 100 | 120 | 35 | 50 | 65 | 350 | 250<br>0 | 720 |
| C<br>2 | 100-<br>700 | 121-<br>400 | 36-<br>50 | 51-<br>100 | 66-<br>100 | 351-<br>570 | 250<br>1-<br>400<br>0 | 721-<br>1920 |
| C<br>3 | 701-<br>180<br>0 | 401-<br>100<br>0 | 51-<br>80 | 101<br>-<br>200 | 101<br>-<br>150 | 571-<br>140<br>0 | 400<br>1-<br>100<br>00 | 1921<br>-<br>4630 |
| C<br>4 | >18<br>00 | >10<br>00 | >80 | >20<br>0 | >15<br>0 | >14<br>00 | >10<br>00 | >463<br>0 |

## IV. RESULTS AND DISCUSSION

**Table 3 The Individual Gas Concentration of 10 Patterns**

| Pattern numbers | H2 | CH4 | C2H6 | C2H4 | C2H2 |
|---|---|---|---|---|---|
| 1 | 10778 | 1944 | 367 | 14 | 1 |
| 2 | 7 | 3 | 6 | 4 | 0.4 |
| 3 | 7 | 3 | 8 | 8 | 3 |
| 4 | 22 | 1 | 7 | 4 | 0.4 |
| 5 | 4 | 0.8 | 6 | 6 | 1 |
| 6 | 7 | 2 | 5 | 4 | 0.4 |
| 7 | 77 | 4 | 5 | 11 | 16 |
| 8 | 12 | 2 | 6 | 3 | 0.5 |
| 9 | 163 | 0.8 | 8 | 6 | 0.4 |
| 10 | 41 | 3 | 8 | 8 | 0.4 |

These samples were taken from current transformer of same ratings out of which in pattern 1 the hydrogen is increasing very excessively and is beyond the condition 4 which may result in the failure of the transformer.

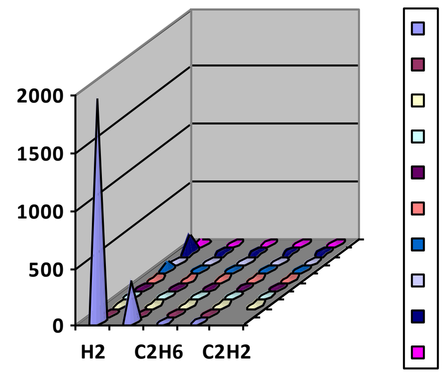


**Fig 1 The Graph Of These Patterns With Gas Ratios**

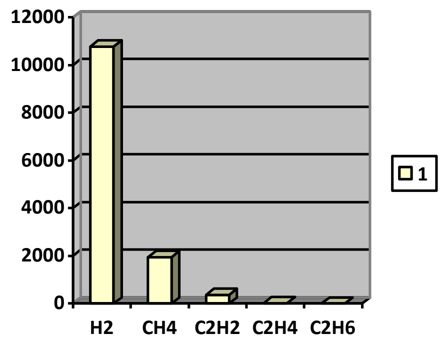


**Fig 2 Shows Pattern 1 Gases With Excessive Hydrogen.**

## V. CONCLUSION

On observing the variation of the key gases concentration of different current transformers irrespective of the year the key gases shows the condition of current transformers. The pattern 1 CT shows the excessive hydrogen and need to be replaced and serviced soon to avoid explosion due to H2. However DGA is the

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most reliable and effective tool for accessing the detection of fault at an early stage.

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