

# Review on Incipient Fault Diagnosis for Power Transformer using Dissolved Gas Analysis Based on Fuzzy Three Gas Ratio Method

Ankita Rawat<sup>1</sup> Prof. Nisheet Soni<sup>2</sup>  
<sup>1,2</sup>Department of Electrical Engineering  
<sup>1,2</sup>S.R.I.T. Jabalpur

**Abstract**— Dissolved Gas Analysis is useful method to detect incipient faults in transformer [1-4]. Three ratio method is widely used for detection of incipient fault. When more than one fault exists in a transformer, these methods sometimes fail to diagnose. IEC Three Ratio Method is widely used, but in many cases this method can not accurately diagnose. Fuzzy Three Ratio Method; overcome the drawbacks of Conventional Three Ratio Method. Its drawback is when the ratio crosses the coding boundary, codes change sharply, but in reality the boundary should be fuzzied. This paper first propose the fuzzy membership functions for codes "zero", "one", "two", then it transfer the conventional logic "AND" and "OR" used in IEC three-ratio method into fuzzy logic and put forward the diagnosing steps of this method.

**Key words:** Power Transformer, Fault Diagnosis, DGA, Fuzzy three ratio method, Gas Concentration

## I. INTRODUCTION

Power transformer is subject to various thermal, electrical and mechanical stresses. These stresses can cause incipient faults, deterioration or even failure of power transformer. To prevent this timely fault detection via a suitable standard technique is must. Dissolved Gas Analysis (DGA) is an important tool for online monitoring of transformers of transformers [1-3]. Different standards are available such as the IEC 599 ratio codes, Rogers's ratio and Triangle ratio [1-3]. These ratio methods are efficient and simple to use. But there are some limitations in this method. In this method some of the faults are left unrecognized. Through the combination of fuzzy logic and IEC three ratio method, can overcome the problem of ratio method.

## II. DISSOLVED GAS ANALYSIS IN TRANSFORMER OIL

Most of power transformers are full with oil that aids several purposes. The oil is a dielectric medium which acts as insulator and as heat transfer agent. The incipient faults happening in transformers give proof very early in their improvement stages through transformer oil gas analysis. These faults can lead to the thermal degradation of the oil and paper insulation in the transformer. The composition and quantity of the gases generated depend on the types and severity of the faults, and regular monitoring and maintenance can make it possible to detect incipient flaws before damage occurs. The four main types of transformer faults are

- Arcing or high current breakdown,
- Low energy sparking, or partial discharges,
- Localized overheating, or hot spots, and
- General overheating due to inadequate cooling or sustained overloading.

- The most widely used ratio method for this purpose is the IEC Standard 60599 [5] which is depicted in Table 1 [1].

THE CODING RULE OF THREE-RATIO METHOD Ranges of gas ratio	Codes of different gas ratios		
	$C_2H_2/C_2H_4$	$CH_4/H_2$	$C_2H_4/C_2H_6$
<0.1	0	1	0
0.1-1	1	0	0
1-3	1	2	1
>3	2	2	2

Table 1: The Coding Rule of Three-Ratio Method

We are using Two methods for fault detection these are described below:-

### A. IEC Method

The diagnosing steps based on Conventional Three Ratio Method.

- 1) Step1: From the DGA report of the input oil sample, provide the values of concentration of different gases like Hydrogen (H<sub>2</sub>), Methane (CH<sub>4</sub>), Ethane (C<sub>2</sub>H<sub>6</sub>), Ethylene (C<sub>2</sub>H<sub>4</sub>), and Acetylene (C<sub>2</sub>H<sub>2</sub>) in ppm.
- 2) Step2: Calculate three ratios R1 = Acetylene (C<sub>2</sub>H<sub>2</sub>) / Ethylene (C<sub>2</sub>H<sub>4</sub>), R2 = Methane (CH<sub>4</sub>) / Hydrogen (H<sub>2</sub>), and R3 = Ethylene (C<sub>2</sub>H<sub>4</sub>) / Ethane (C<sub>2</sub>H<sub>6</sub>).
- 3) Step 3: According to Table 1, each ratio is quantized to a classification code 0, 1, or 2 The diagnosing steps based on Fuzzy Three Ratio Method
- 4) Step 4: For the conventional logic IEC diagnosis "AND" and "OR" based conditional statements are constructed for decision making with reference to Table 2, and the fault type out of the 9 listed faults is determined.
- 5) Step 5: For any non-decision diagnosis, tenth decision of 'Not diagnosable' is used.
- 6) Step 6: Results are displayed in graph window for gas content in ppm, respective IEC code and IEC based Conventional Three Ratio Method decision.

## III. FUZZY THREE RATIO METHOD

- 1) Step1: From the DGA report of the input oil sample, provide the values of concentration of different gases like Hydrogen (H<sub>2</sub>), Methane (CH<sub>4</sub>), Ethane (C<sub>2</sub>H<sub>6</sub>), Ethylene (C<sub>2</sub>H<sub>4</sub>) and Acetylene (C<sub>2</sub>H<sub>2</sub>) in ppm.
- 2) Step 2: Calculate three ratios R1, R2, R3.
- 3) Step 3: Calculate the three fuzzy membership functions of each ratio based on equations listed in above section.
- 4) Step 4: As for the conventional logic "AND" and "OR" used in the conventional IEC diagnosis, replace "AND" by "min", "OR" by "max", the fuzzy diagnosing vector F(i) where i = 1, 2, ..., 9 represent i<sup>th</sup> fault in Table 6 is determined by the following equations: [1-2][3][5]

$$F(1) = \min[\mu_{ZERO}(R1), \mu_{ZERO}(R2), \mu_{ZERO}(R3)]$$

$$F(2) = \min[\mu_{ZERO}(R1), \mu_{ONE}(R2), \mu_{ZERO}(R3)]$$

- $F(3) = \min[\mu_{ONE}(R1), \mu_{ONE}(R2), \mu_{ZERO}(R3)]$   
 $F(4) = \max(\min[\mu_{ONE}(R1), \mu_{ZERO}(R2), \mu_{ONE}(R3)] \min[\mu_{TWO}(R1), \mu_{ZERO}(R2), \mu_{ONE}(R3)] \min[\mu_{TWO}(R1), \mu_{ZERO}(R2), \mu_{TWO}(R3)] )$   
 $F(5) = \min[\mu_{ONE}(R1), \mu_{ZERO}(R2), \mu_{TWO}(R3)]$   
 $F(6) = \min[\mu_{ZERO}(R1), \mu_{ZERO}(R2), \mu_{ONE}(R3)]$   
 $F(7) = \min[\mu_{ZERO}(R1), \mu_{TWO}(R2), \mu_{ZERO}(R3)]$   
 $F(8) = \min[\mu_{ZERO}(R1), \mu_{TWO}(R2), \mu_{ONE}(R3)]$   
 $F(9) = \min[\mu_{ZERO}(R1), \mu_{TWO}(R2), \mu_{TWO}(R3)]$
- 5) Step 5: Compile fuzzy model & membership function to determine type of fault
  - 6) Step 6: Fault type out of the 9 listed faults is determined.
  - 7) Step 7: Results are displayed in graph window for gas content in ppm, and Fuzzy Three Ratio Method decision [2].

- [2] Hongzhong Ma, Zheng Li, P. Ju, Jingdong Han and Limin Zhang, "Diagnosis of power transformer faults on fuzzy three-ratio method," *2005 International Power Engineering Conference*, Singapore, 2005, pp. 1-456.
- [3] M. R. Ahmed, M. A. Geliel and A. Khalil, "Power transformer fault diagnosis using fuzzy logic technique based on dissolved gas analysis," *21st Mediterranean Conference on Control and Automation*, Chania, 2013, pp. 584-589.
- [4] S. A. Wani, M. U. Farooque, S. A. Khan, D. Gupta and M. A. Khan, "Fault severity determination in transformers using dissolved gas analysis(DGA)," *2015 Annual IEEE India Conference (INDICON)*, New Delhi, 2015, pp. 1-6.
- [5] Rahmatollah Hooshmand, and Mahdi Banejad, "Application of Fuzzy Logic in Fault Diagnosis in Transformers using Dissolved Gas based on Different Standards," in *Proceedings of World academy of science, engineering and technology*, Dec. 2006, vol. 17, ISSN 1307-6884, p

Sr.No.	Fault type	Codes of the ratios		
		$\frac{C_2H_2}{C_2H_4}$	$\frac{CH_4}{H_2}$	$\frac{C_2H_4}{C_2H_6}$
1	No fault	0	0	0
2	Partial discharge of low energy density	0	1	0
3	Partial discharge of high energy density	1	1	0
4	Discharge of low energy	1 or 2	0	1 or 2
5	Discharge of high energy	1	0	2
6	Thermal fault of low temperature < 150 C	0	0	1
7	Thermal fault of low temperature 150~ 300 C	0	2	0
8	Thermal fault of medium temperature 300~700 C	0	2	1
9	Thermal fault of high temperature > 700 C	0	2	2

Table 2: Classification of Fault Type through IEC Three-Ratio Method

#### IV. CONCLUSION

In this paper, the analysis of dissolved gas of the transformer is used to diagnose the faults in the transformer using IEC standard. By using fuzzy logic we can determine the category of fault happening in the transformer oil. The conclusions from the real cases explain that the nature of the insulating materials involved in the fault and the nature of the fault itself affect on distribution of dissolved gases. And with the help of ratio of these dissolve gases detect type of fault.

#### REFERENCES

- [1] Kunjal Jane, Prof. S. A Borakhade "Dissolved Gas Analysis in Transformer using Three Gas Ratio Method and Fuzzy Logic based on IEC Standard" *SSRG International Journal of Electrical and Electronics Engineering (SSRG-IJEEE) – volume 2 Issue 4 April 2015*