An Investigation to Different Methods of Health Assessment in Power Transformers

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Abstract Power transformer is the critical device of the power system. As essential equipment, its operation plays a vital place in reliability of electrical power system. Important methodologies for accessing transformer health have been discussed in the present work.

Keywords Duval triangle · Health assessment · Ratio method

1 Introduction

Power transformer is the critical device of the power system. As essential equipment, its operation plays a vital place in reliability of electrical power system. It has an ability to change V–I levels to facilitate electrical power system in economic manner. Figure 1 shows the fault categorization as per IEC (std. 60599) and IEEE (std. C.57.104) standards [1].

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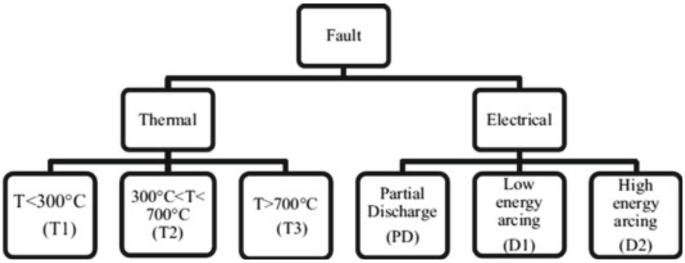

Fig. 1 Categorization of faults in power transformer

Flashover with power follow through can destroy the transformer, in which case the fault and evidence of damage will confirm, or indicate the cause of failure. In the latter case, if the flashover has taken place inside the tank, DGA results after failure indicate the severity of the fault. Broken or loose connections in winding, lead to a small arc, which burns the surrounding solid insulation and can result in transformer sudden failure. Deteriorated conductor insulation paper, i.e., as a result of a previous short of the transformer two adjacent turns and forming a closed loop around the main magnetic flux. This loop will melt down in seconds due to excessive high induced current flow. A broken, loose, or damaged draw rod in a bushing can cause sparking and arcing within the bushing tube and cause melt down of adjoining copper, producing gas. The buchholz relay may activate and disconnect the transformer from the system. In extreme cases, the bushing may explode and lead to fire.

In this paper, the key methodologies of combined DGA method (see block diagram in Fig. 2) for accessing transformer health have been discussed.

2 Ratio Methods

The ratio methods use gas ratios to find possible fault in the sample. The base of such methods depends upon the experience of the investigator by correlating the gaseous analyses with the fault type. The typical methods that comes under this category are as follows.

2.1 Doerneburg Ratio Method

It employs gas concentrations from which Ratios $R1$, $R2$, $R3$, and $R4$ are calculated. In this method, the values for these gases are first compared to special concentrations $L1$ given in Fig. 3 [2].

The ratios $R1$, $R2$, $R3$, and $R4$ are compared to restrictive limits, providing a fault diagnosis methodology as suggested in flowchart (see Fig. 4). This gives the

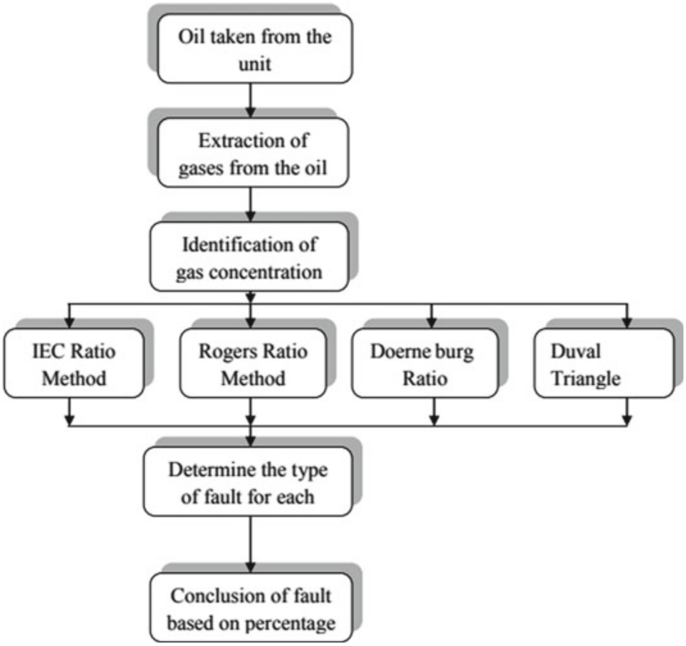

Fig. 2 Block diagram of combined DGA

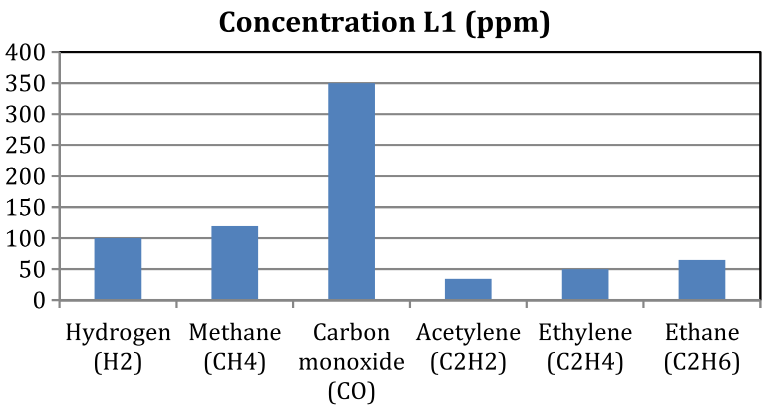

Fig. 3 Concentration limits of dissolved gases

restrictive values for ratios of gases dissolved in the oil and gases obtained from the transformer gas space or gas relay [3].

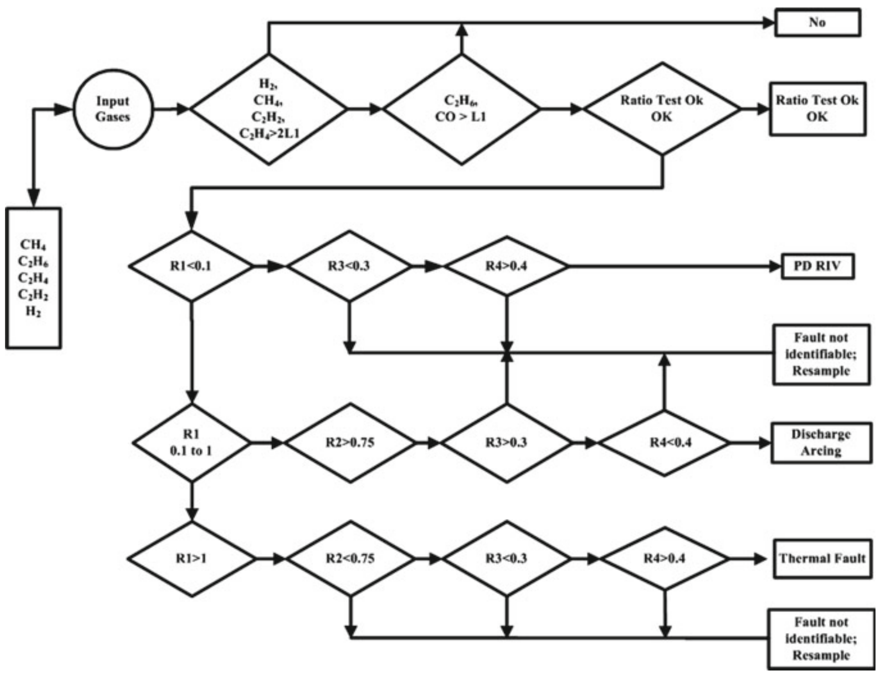

Fig. 4 Flowchart for Doerneburg ratio method

2.2 Roger Ratio Method

Herein, four gas ratios $R_1 = (CH_4/H_2)$; $R_6 = (C_2H_6/CH_4)$; $R_5 = (C_2H_4/C_2H_6)$; $R_2 = (C_2H_2/C_2H_4)$ are calculated, and faults are diagnosed based on a coding scheme and a methodology given in flowchart (see Fig. 5) [3].

2.3 IEC Ratio Method

Since the ratio *R*6 is a temperature indicator in RR method, it has been dropped here. Herein, the ratio codes have different ranges as illustrated in flowchart given in Fig. 6 [4].

3 Duval Triangle Method

This method is employed with transformers insulated with the help of oil and is considered to be one of the most accurate fault diagnosis tool that comes under DGA

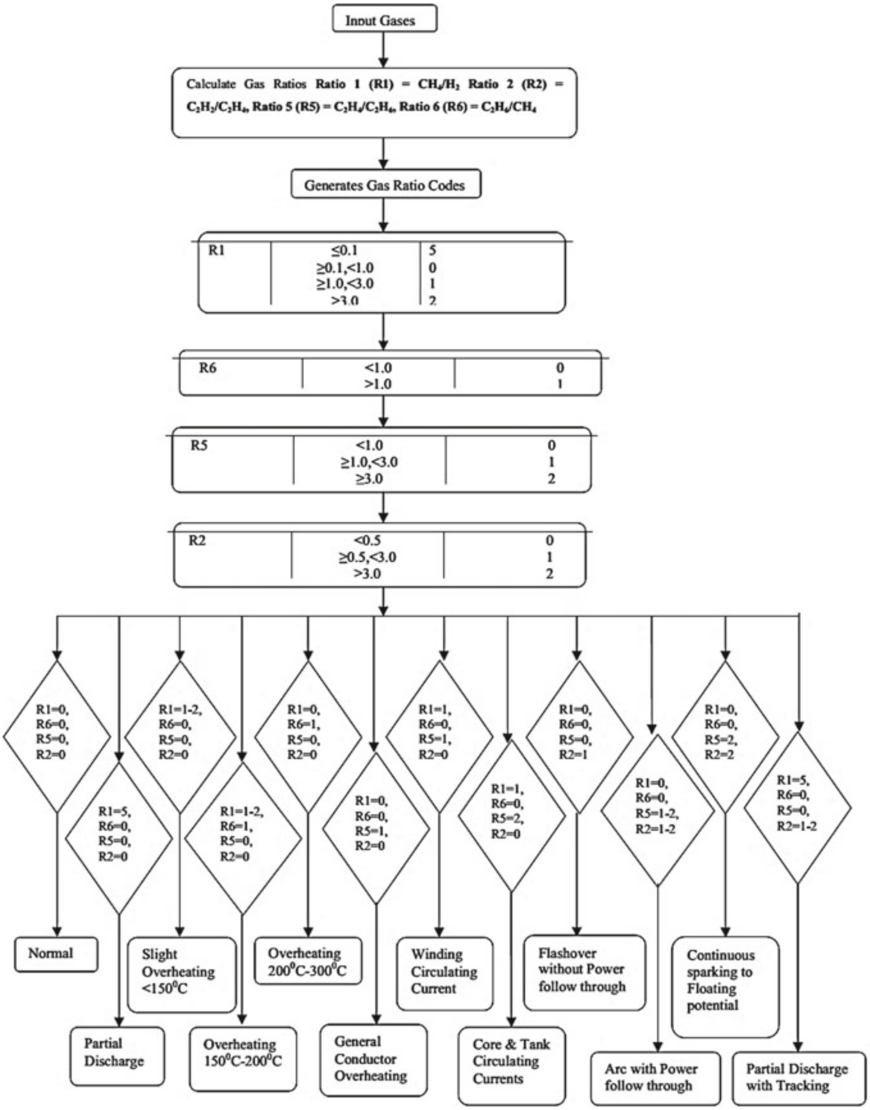

Fig. 5 Flowchart for Roger ratio method

[5]. This method uses methane, ethylene and acetylene as hydrocarbon gases only. The duval triangle is shown in Fig. 7.

where coordinates [6]:

$$\%C_2H_2 = \frac{100C_2H_2}{C_2H_2 + C_2H_4 + CH_4}$$

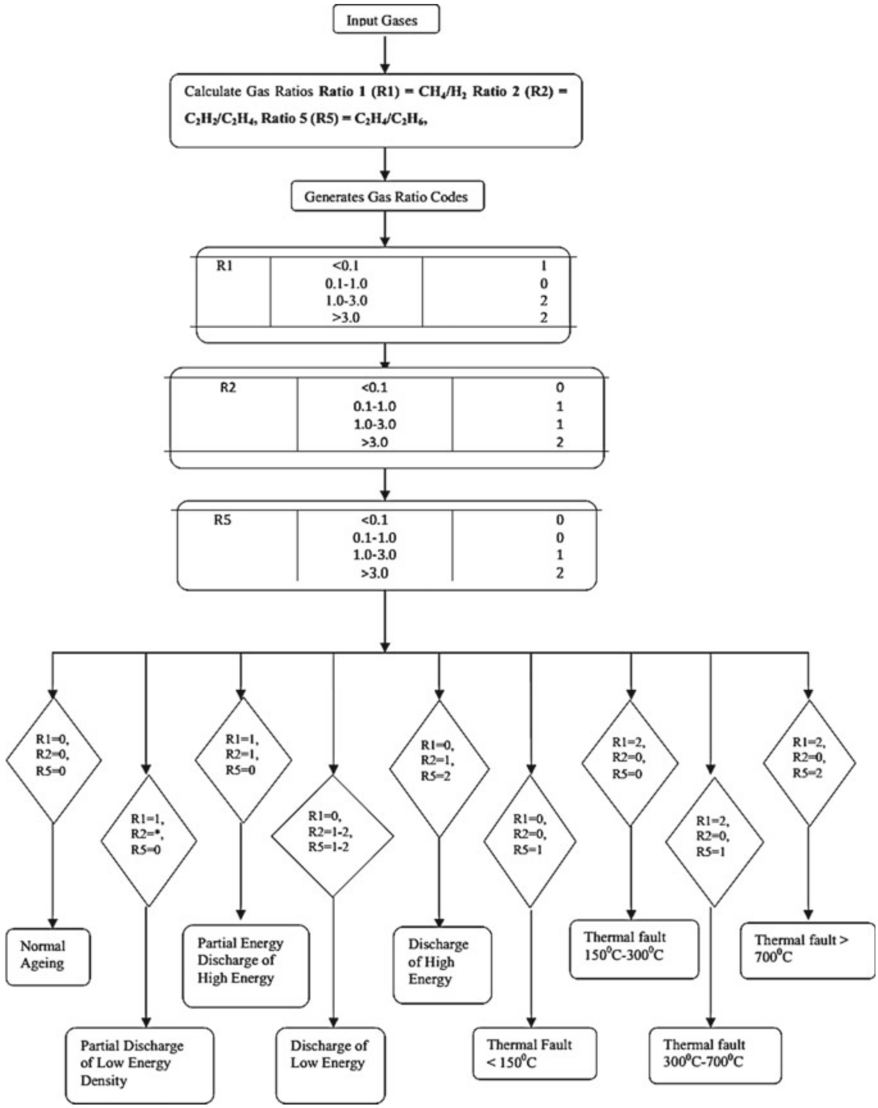

Fig. 6 Flowchart for IEC ratio method

$$\%C_2H_4 = \frac{100C_2H_4}{C_2H_2 + C_2H_4 + CH_4}$$

$$\%CH_4 = \frac{100CH_4}{C_2H_2 + C_2H_4 + CH_4}$$

The flowchart for this method is illustrated in Fig. 8.

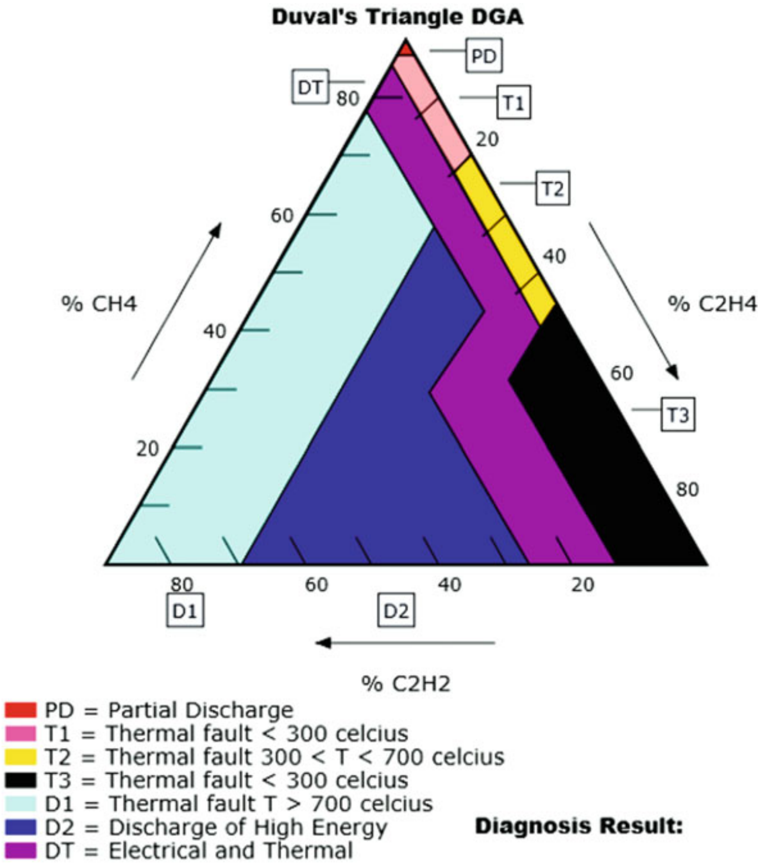

Fig. 7 Duval triangle

4 Conclusion

In this paper, a brief study has been carried out related to commonly used methodologies for power transformer health assessment. These techniques include a methodology-based monitoring system to take health tests of power transformers.

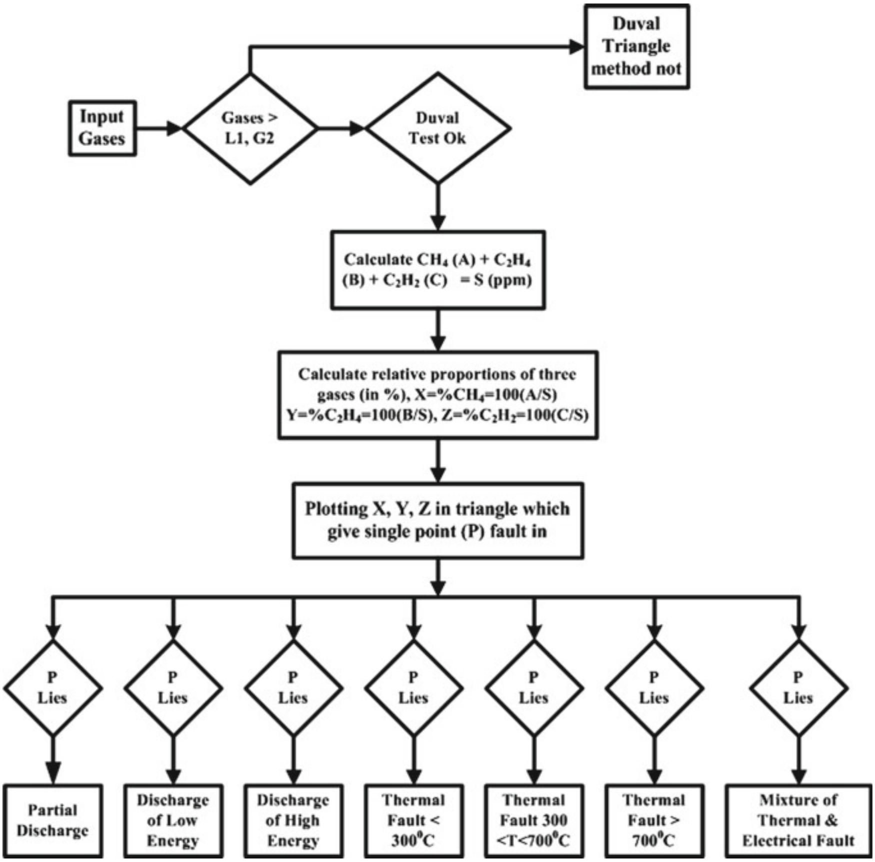

Fig. 8 Flowchart for duval triangle method

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