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A new approach of DGA interpretation technique for transformer fault diagnosis

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ABSTRACT

Dissolved Gas Analysis (DGA) is one of the most common techniques to detect the incipient faults in the oil-filled power transformers. In this paper, a new approach of DGA technique is proposed to overcome the conflict that takes place in the traditional interpretation techniques for transformer fault diagnosis. The new approach is based on the analysis of 386 dissolved gas samples data set that collected from the Egyptian electric utility chemical laboratory as well as from credited literatures. These data sets are used to build the technique model and also as a tested data set to get the technique's accuracy. The new approach DGA diagnoses the transformer fault types based on the gas concentration percentage limit of the sum of main five gases (Hydrogen (H_2), Methane (CH_4), Ethan (C_2H_6), Ethylene (C_2H_4), and Acetylene (C_2H_2)) and some suggested gases ratios depending on the sample data set analysis. The validation of the proposed approach of DGA technique is satisfied by comparing its results with the results of the IEC Standard Code, Duval triangle and Rogers methods for the collected data set. The results refer to the ability and reliability of the new approach in transformer faults diagnostic.

Introduction

Power transformers are vital, important and expensive components in electric power systems. The discontinuity of the power transformers is uneconomical and causes a great financial loss for the electrical utilities. Some factors affect on the transformer condition and lead to an increase in loading power transformer such as its ageing, rising energy consumption and liberation. Therefore, an increase in thermal, electrical and mechanical stresses of transformers will be developed. Hence, it is very important to have a suitable and effective evaluation of early detection of the incipient faults of power transformer conditions. Dissolved Gas Analysis (DGA) in oil is a widespread method that is used to identify the incipient faults in oil-filled power transformers. As a result of the electrical and thermal stresses, insulating transformer oil maybe decayed and several gases are released and dissolved in oil. These gases include hydrogen (H_2), methane (CH_4), ethane (C_2H_6), ethylene (C_2H_4), acetylene (C_2H_2), carbon monoxide (CO) and carbon dioxide (CO_2) in which their concentrations are expressed in part per million (ppm).

The most criteria that are commonly used for dissolved gas analysis to interpret the incipient transformer faults are Dornenburg method, Rogers' method, key gas method, Duval Triangle method, IEC standard Code [1–3]. The above-mentioned criteria use some gas ratios for fault diagnosis, and some of these methods compare gas concentrations to the specified levels to evaluate a transformer's condition. All these conventional methods are simple and easy to implement, but their diagnostic accuracy is still limited and very sensitive to uncertainties in DGA data. However, some problems according, to Duval Triangle method are due to detection failure with the partial discharge (PD) fault and furthermore some interference between thermal and electrical faults is found like in the area of electrical and thermal fault (DT). In IEC technique, the interference between low discharge energy (D1) and high discharge energy (D2) can lead to the mislead results [1]. The results obtained from Rogers's method are not concise in case of detecting all faults except the low thermal (T1) fault. In addition, some recent DGA techniques can't to separate between the low and medium thermal faults (T1 and T2) as in [4]. Generally, new gas diagnosis features are to be attained in order to improve the transformer condition monitoring [4].

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Table 1
The number of samples for each fault type.

Fault type	PD	D1	D2	T1	T2	T3	Overall
Lab samples	27	42	55	70	18	28	240
Literatures samples	16	27	60	11	6	26	146
Total	43	69	115	81	24	54	386

Table 2
Matching between IEEE std. and laboratory measurement of Key gases.

Fault type	PD	D1	D2	T3
IEEE standard	H_2	H_2	H_2+C_2H_2	C_2H_4
Laboratory	H_2	H_2	C_2H_2	C_2H_4

Nowadays, more efforts are exerted to build computational models to improve the traditional interpretation techniques using artificial Intelligence (AI) to analyze incipient fault in transformers. These AI methods are: Artificial Neural Network (ANN) [5,6], Fuzzy Logic [7,8], Support Vector Machine (SVM) [9,10], Expert System [11,12], Hybrid System [13,14] and Graphical Techniques [15,16].

In this paper, a new approach of the DGA is developed. It is based on both the concentration percentage of the dissolved gases to the sum of the main five gases and some gas ratios. The five main dissolved gases are Hydrogen (H_2), Methane (CH_4), Ethane (C_2H_6), Ethylene (C_2H_4), and Acetylene (C_2H_2). Each gas concentration is calculated as its percentage with respect to the total sum of the five selected gases. Six main faults are concerned, PD, D1, D2, T1, T2 and high thermal fault (T3). Each fault type is concluded, based on the limit of each gas concentration percentage and some of the proposed gas ratios. 386 samples are used to develop the new approach technique that 240 dissolved gas of the oil samples from the chemical laboratory of the electric utility in Egypt and the others are from literatures. A validation of the proposed approach technique is satisfied by comparing its performance with the most famous methods that are IEC Code, Duval Triangle, and Rogers' four ratios for these dissolved gases of the oil samples. The comparison refers to the ability of the new approach technique to diagnose the transformer faults according rather than the other methods.

Proposed DGA interpretation technique

Till now, the current interpretation techniques didn't give correctly accepted results for transformer fault detection; therefore, it is an open area for proposed idea to overcome the problems of those DGA techniques. The accuracy limit of the traditional DGA techniques is still a great issue to diagnose the transformer faults due to the electrical and thermal stresses. The proposed rules of the new approach DGA technique are developed based on data set samples from laboratory (electrical utilities in Egypt) and credited literatures. These rules depend on the concentration limit of each gas, according to each transformer fault type with some gas ratios to separate the interference between the fault types. The number of samples according to the fault type is explained in Table 1.

The total number of actual DGA data is 386 data samples. 240 data samples are collected from practical cases into the Egyptian Electricity Network. These practical cases were analyzed by advanced software that supplied with the DGA analyzer which used by the utility. This software is considered accurate and

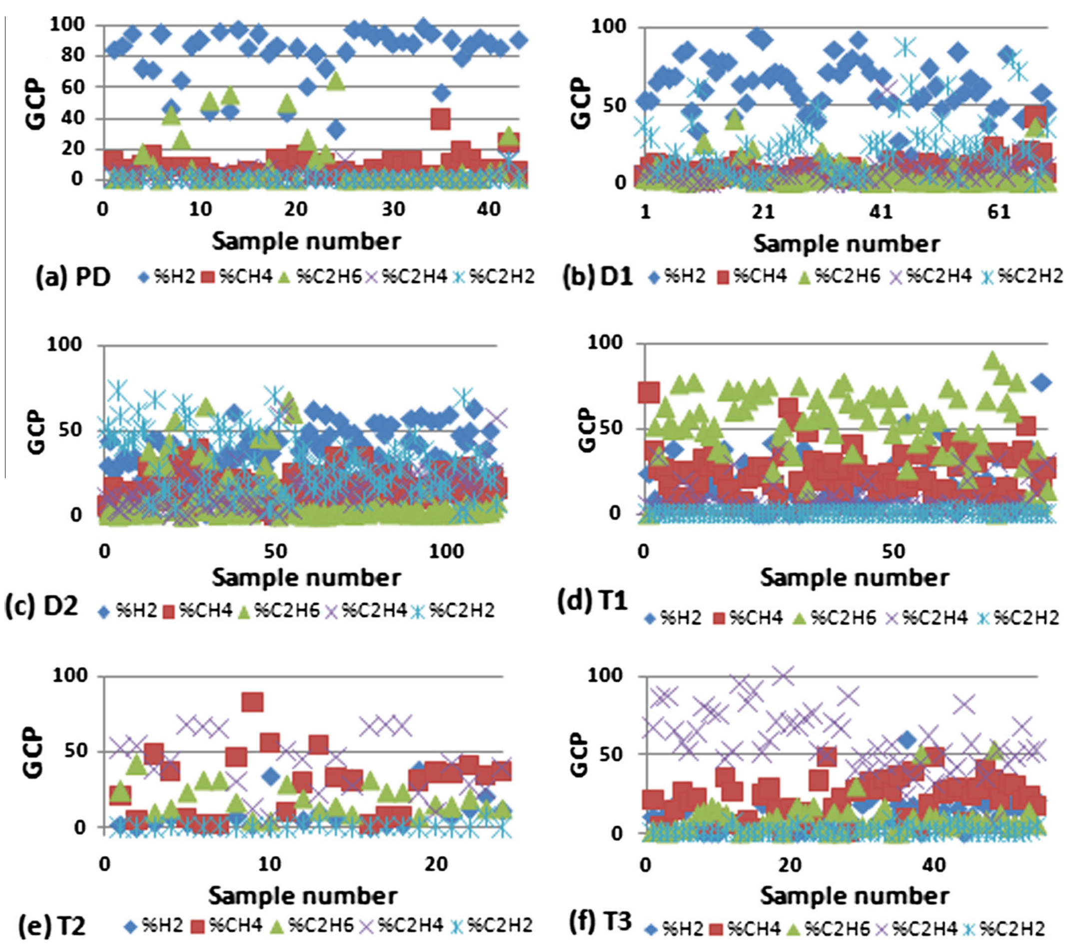

Fig. 1. Gas concentration percentage (*GCP*) for each fault type.