Improvement in Power Transformer Intelligent Dissolved Gas Analysis Method

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***Abstract*—**Non-Destructive evaluation of in-service power transformer condition is necessary for avoiding catastrophic failures. Dissolved Gas Analysis (DGA) is one of the important methods. Traditional, statistical and intelligent DGA approaches have been adopted for accurate classification of incipient fault sources. Unfortunately, there are not often enough faulty patterns required for sufficient training of intelligent systems. By bootstrapping the shortcoming is expected to be alleviated and algorithms with better classification success rates to be obtained. In this paper the performance of an artificial neural network, K-Nearest Neighbour and support vector machine methods using bootstrapped data are detailed and shown that while the success rate of the ANN algorithms improves remarkably, the outcome of the others do not benefit so much from the provided enlarged data space. For assessment, two databases are employed: IEC TC10 and a dataset collected from reported data in papers. High average test success rate well exhibits the remarkable outcome.

***Keywords*—**Dissolved gas analysis, Transformer incipient fault, Artificial Neural Network, Support Vector Machine (SVM), K-Nearest Neighbor (KNN)

I. INTRODUCTION

POWER transformers are always under the impact of electrical, mechanical, thermal and environmental stresses that degrade their insulation quality. To avoid the power failure, periodically monitoring of the conditions of transformers is necessary. Results of early detection of fault are large savings in operation and maintenance costs and preventing any premature breakdown/failure.

There are routine maintenance procedure for power transformers such as dissolved gas analysis (DGA), moisture analysis in transformer oil [1, 2], oil breakdown voltage test, the tan (delta) test, resistivity test, acidity test, sludge test, interfacial tension test and partial discharge (PD) acoustic emission sensing. Among these methods, DGA is an effective one for the early detection of incipient faults [3].

It is well known that overheating, arcing, partial discharge, winding circulating currents, and continuous sparking are the main factors in deteriorating transformer condition. These phenomena develop certain dissolved gaseous in the insulation oil. The gases include hydrocarbons such as: methane (CH4), ethane (C2H6), ethylene (C2H4), acetylene (C2H2) and others such as: hydrogen (H2), carbon dioxide (CO2), and etc.

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The gases are extracted from the oil under high vacuum and analyzed by Gas Chromatograph, to get each gas concentration separately. By interpretation of the gas contents, the developing faults in the power transformers can be diagnosed.

Many diagnostic criteria have been developed to establish relationships between the gases and the fault conditions, which some are obvious and some are not (hidden relationships). The gas concentrations, generation rates, specific gas ratios, and the total combustible gas are important parameters for interpreting the result of DGA. But the actual diagnosis must also consider other information of transformer such as size, volume of oil, type of transformer etc. Therefore, much of diagnostic relies on experts to interpret the results correctly.

To automatize the procedure of power transformer fault classification, several algorithms have been studied. Presently, the conventional ratio methods, statistical schemes and artificial-intelligence (AI) methods are the major interpreting approaches. The conventional ratio methods mainly include Rogers Ratios [4], Duval Triangle [5], and IEC Ratios [6]. Since conventional ratios' boundaries are sharp, they are unable to provide interpretation for every possible combination of ratio values [7].

The Artificial Neural Network methods have also been used to explore the nonlinear and complex relation between the gases concentration and the type of faults. Multilayer back propagation (MLP) [8], [9], self-organizing map network [10], Adaptive Back-propagation learning algorithm [11] and Extension NN [12, 13] are among them. ANN training suffers from trapping in local minima; therefore evolutionary training algorithms have got deserved attention in this field [7], [14], [15]. Other methods that have been investigated are wavelet decomposition [15], SVM [15], KNN [15] and fuzzy learning vector quantization network [16], [12].

In this paper SVM, KNN and ANN are considered for fault classification. The data sets are IEC TC10 and database 1, a collection of data gathered from many research papers. It is observed that the number of faulty patterns for each class is not equal and enough for well training of intelligent schemes. As a remedy, the bootstrapping technique is employed to equalize the number of faulty patterns for each class of the transformer condition. The results show that the method based on ANN takes more advantage of the bootstrapped input and renders remarkable improvement in the performance while the other two methods do not show such advances.

In section 2 the three classification methods are briefly reviewed. Section 3 discusses data preparation and pre-