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ORIGINAL ARTICLE

## Principal Components Analysis and Adaptive Decision System Based on Fuzzy Logic for Power Transformer



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**Abstract** Power transformers are the most critical part of power electrical system, distribution and transmission grid. The oil and the insulation system (paper properties) degradation have many chemicals inside them, they are the result of an initial problem that can be predicted. The research has established the intelligent diagnosis system based on principal component analysis (PCA) and adaptive decision system based on fuzzy logic permits to realize a dissolved gas analysis (DGA) to predict incipient fault diagnosis by different methods, to obtain deterioration rates and health index, besides it allows to analyze the degree of polymerization (DP) for the remaining life of the equipment. The classification accuracy of the proposed method with PCA and fuzzy logic intelligent system is 97.2% for normal equipment and 98.13% for failure events. The proposed method is quite interesting for the readers and the concern researchers in the area of fuzzy mathematics and power transformers.

**Keywords** Principal component · Fuzzy logic · Gas analysis · Power transformers · Remaining life

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## 1. Introduction

Today, become us the era of high speed machining, maintenance plans and condition monitoring techniques are samples of the general activities that can be applied to any equipment, however this methods and particular condition, for power transformers are different from those applied to other substation equipment. A lot of power transformers are working close to 40 years, and the adverse effect of aging equipment is the impact of the global unavailability of electricity service. The Fuzzy integral equations (FIE) and Fuzzy Differential equations have been rapidly growing in recent years and the application of numerical method to nonlinear fuzzy method permits to use this techniques to obtain a complex model [1]. However, aging equipment remains a great challenge for the electrical industry, especially in energy cluster, the need to increase the competitiveness of the countries' economies and the emergence of new competitors in the business. Actually, it has an important development, many researchers are writing about Fuzzy parameters on the modeling of cables, insulations properties, the authors have obtained a flexible tool, and it establishes a model of the properties with good approach in experimental values with this methodology [2]. The assessment procedures are similar the medical diagnosis method, which is a decision problem of several variables. Where information from various sources needs to be combined, seamlessly weighted and correlated in order to arrive at a single conclusion, with a method hybrid multi-attribute [3] permit to solve this analysis, to obtain an intelligent diagnosis on power transformers [4]. In this paper, an intelligent diagnosis system based on principle component analysis (PCA) and adaptive fuzzy logic program is used to analysis the gas and insulation, using the chemical component of oil and paper degradation. In here, the component of Michel Duval methodology and the document CIGRE TB-296 Recent Developments in DGA Interpretation [5], monitoring this components: carbon monoxide (CO), carbon dioxide (CO<sub>2</sub>), ethylene (C<sub>2</sub>H<sub>4</sub>), ethane (C<sub>2</sub>H<sub>6</sub>), hydrogen (H<sub>2</sub>), methane (CH<sub>4</sub>), acetylene (C<sub>2</sub>H<sub>2</sub>), nitrogen (N<sub>2</sub>), oxygen (O<sub>2</sub>) and Furan, are extracted by calculating nine gases and this interactions with this dimensions [6]. It can be reduced to 3 components using PCA, to correct diagnosis performance, the correct diagnosis performance of PCA and fuzzy logic program is calculated in 107 equipment. Being the linchpin power transformers for the links between electrical transmission grids, it is important to establish the effect of maintenance and correlate durability and support different types of stress lifetime. When older equipment was renewed in the past, the main reason for change was the growth of the load, originated overcoming their operational limits, rather than to reach the end of the lifetime of the equipment thus were removed from service before reaching their technical life. But now the condition has change, by now there are a lot of old power transformers working.

The main aim of this study is assisting to the special assessment team about diagnosis of power transformer oil and paper (Kraft) condition and remaining life. The equipment specialist can be compared the diagnosis performances of PCA – fuzzy logic program method and existing diagnosis method: Laborelec method, Dornembu IEC 60599, Duvai method, ABNT IEC 599/78, CIGRE CS15. Principal component analysis (PCA), adaptive fuzzy logic program is reviewed in Chapter 3.

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