PROPOSED ALGORITHMS FOR INCIPIENT FAULTS DIAGNOSIS OF OIL-FILLED TRANSFORMERS

By

Mostafa Mahmoud Ibrahim Abdo

A thesis submitted to the

Faculty of Engineering at Cairo University

In Partial Fulfillment of the

Requirements for the Degree of

MASTER OF SCIENCE

In

Electrical Power and Machines Engineering

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Under supervision of

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LIST OF PUBLICATIONS

1) Mostafa.M.Ibrahim, M.M.Sayed, and E.E.Abu El-Zahab, “Diagnosis of Power Transformer Incipient Faults Using Fuzzy Logic-IEC Based Approach,” Proceeding of the IEEE International Energy Conference, Dubrovnik, Croatia, 2014, Page(s): 258-261.

2) Mostafa.M.Ibrahim, M.M.Sayed, and E.E.Abu El-Zahab, “Artificial intelligence solution for incipient faults diagnosis of oil-filled power transformers”, Accepted for publication in the journal of electric engineering, will be available online by March 2016.

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LIST OF SYMBOLS AND ABBREVIATIONS

- **Chemical symbols**

H_2 : Hydrogen

CH_4 : Methane

C_2H_6 : Ethane

C_2H_4 : Ethylene

C_2H_2 : Acetylene

CO : Carbon monoxide

CO_2 : Carbon dioxide

O_2 : Oxygen

N_2 : Nitrogen

- **Abbreviations**

DGA :Dissolved gas analysis

FIS :Fuzzy inference system

FLA :Fuzzy logic approach

ANN :Artificial neural network

AFC :Actual fault condition

AI :Artificial intelligence

GA :Genetic algorithm

PD :Partial discharge

D1 :Discharge of low energy

D2 :Discharge of high energy

T1 :Thermal fault (T<300°C)

T2 :Thermal fault (300<T<700°C)

T3 :Thermal fault (T>700°C)

ABSTRACT

Power transformers are one of the most expensive and important equipment in power systems. Fault occurrence within a power transformer may lead to the interruption of the electrical energy to consumers.

A power transformer during operation is subjected to different stresses such as electrical stress and thermal stress which lead to liberation of gases from the hydrocarbon mineral oil. Dissolved gas analysis (DGA) is one of the most useful methods to detect power transformers incipient faults. There are different conventional DGA methods developed for analyzing these gases such as key Gas, Rogers Ratio, Dornenburg, International Electrotechnical Commission (IEC) Ratio, and Duval triangle. Artificial Intelligence (AI) can also be used to detect power transformers incipient faults.

In this thesis, two different proposed algorithms based on artificial intelligence techniques (fuzzy logic approach and neural network approach) are used to get the correct diagnosis of the incipient faults in order to avoid the drawbacks of the conventional DGA methods. In order to examine the accuracy of the proposed artificial intelligence fault diagnosis techniques, various power transformers DGA results are tested. The accuracy of each approach is then calculated and compared with the accuracy of the conventional DGA methods.

CHAPTER 1

INTRODUCTION

1.1 General

Power transformers have an essential impact in both the transmission and distribution of electrical energy. It is one of the very important oil-insulated components in power systems and its operational state determines the safety of the whole power system. Failure within a power transformer may lead to long interruption in electrical energy supply and need expensive repairs. Any incipient fault within a transformer must be detected as early as possible in order to prevent the transformer from more deterioration. Several diagnosis methods are developed in order to determine the various fault types occurring during transformers operation like arcing, partial discharge and hot spots.

Dissolved Gas Analysis (DGA) is considered an effective tool to diagnose the incipient fault within a power transformer. There are many conventional methods developed to determine transformer fault which are Key Gas method, Rogers Ratio Method, Dornenburg Ratio Method, IEC Ratio method and Duval Triangle method. However, these conventional methods have many disadvantages. One disadvantage is that conventional DGA techniques sometimes fail to determine the correct diagnosis of a power transformer due to the no matching codes for diagnosis due to the coding boundary and the sharp codes change. Another disadvantage is that conventional DGA techniques sometimes do not take into consideration some possible transformer conditions. Recently, many artificial intelligence (AI) methods have been developed in order to overcome the disadvantages of the conventional DGA methods.

1.2 Thesis objectives

The main objectives of the thesis can be summarized in the following points:

1. Studying the stresses that affect oil-filled power transformers and their effect on the insulating oil.
2. Studying the main conventional DGA techniques and their drawbacks.