COMPARISON BETWEEN DUVAL TRIANGLE AND DUVAL PENTAGON METHOD FOR DISSOLVED GAS ANALYSIS OF POWER TRANSFORMER

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DEDICATION

To my beloved parents, siblings,
lecturers and friends

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ABSTRACT

Power transformers are the highest value of the equipment installed in high-voltage substations, comprising up to 60% of total investment. There is a need for economic and financial reports to be provided to make asset decisions and ensuring balance between investment, maintenance costs and operational performance. Health index (HI) is the most common approach used in determining the condition of the transformers. It is a tool that process information by creating a score that describe the condition of an asset. A comparative analysis is made between HI calculation models that allow the evaluation of the condition of a power transformer. Through this index it is possible to objectively determine the condition of power transformers to make maintenance or reinvestment decisions. Thus, it is possible to detect possible risk assets preventing them from failing, allowing an increase in the life time. Several studies have examined different power transformer condition assessment and life management techniques. These techniques include measuring or monitoring of dissolved gas analysis (DGA) using Duval Triangle method. DGA technique is a reliable method and widely used to detect incipient faults which may occur in transformers such as partial discharge, thermal fault and electrical fault. This paper will focus on DGA using Duval Triangle & Pentagon method. The objective of this paper is to compare and identify between Duval Triangle and Duval Pentagon methods which may provide more accurate interpretation of DGA test result. This comparative study is based on real data provided by Malaysia utility company. The analysis using Duval Pentagon method give the accurate fault analysis and exactly same as the interpretation given by IEC 60599 Standard. An accurate fault analysis using Duval Pentagon Method give a better output of life time prediction, types of possible faults and recommendations for future maintenance action can be achieved.

ABSTRAK

Alatubah kuasa adalah peralatan nilai tertinggi yang dipasang di pencawang voltan tinggi, yang terdiri daripada sehingga 60% daripada jumlah pelaburan. Terdapat keperluan untuk laporan ekonomi dan kewangan yang disediakan bagi membuat keputusan aset dan memastikan keseimbangan antara pelaburan, kos penyelenggaraan dan prestasi operasi. Indeks kesihatan (HI) adalah pendekatan yang paling biasa digunakan dalam menentukan keadaan alatubah. Ia adalah kaedah yang memproses maklumat dengan membuat skor yang menggambarkan keadaan aset. Analisis komparatif dibuat antara model perhitungan HI yang membolehkan penilaian alatubah kuasa. Melalui indeks ini keadaan alatubah kuasa boleh ditentukan secara objektif untuk membuat keputusan penyelenggaraan atau pelaburan semula. Oleh itu, risiko kegagalan aset dapat dikesan awal serta membolehkan peningkatan dalam jangka hayat aset. Beberapa kajian telah membuat penilaian berdasarkan keadaan alatubah dan teknik pengurusan jangka hayat bagi pelbagai jenis alatubah yang berlainan. Teknik-teknik ini termasuk pengukuran atau pemantauan analisis gas terlarut (DGA) menggunakan kaedah Duval Triangle. Teknik DGA adalah kaedah yang boleh dipercayai dan digunakan secara meluas untuk mengesan kerosakan awal yang mungkin berlaku dalam alatubah seperti pelepasan separa (PD), kerosakan haba dan kerosakan elektrik. Kajian komparatif ini akan memberi tumpuan kepada DGA menggunakan kaedah Duval Triangle & Duval Pentagon. Objektif kajian ini adalah untuk membandingkan dan mengenal pasti antara kaedah Duval Triangle dan Duval Pentagon yang boleh memberikan tafsiran yang lebih tepat mengenai hasil ujian DGA. Kajian komparatif ini berdasarkan kepada data sebenar yang diperolehi daripada syarikat utiliti Malaysia. Analisis menggunakan kaedah Duval Pentagon telah memberikan analisis kerosakan yang tepat dan sama seperti analisis yang diberikan oleh garis panduan IEC 60599. Analisis yang tepat oleh kaedah Duval Pentagon membolehkan anggaran masa hayat, jenis kemungkinan kerosakan dan cadangan yang lebih baik untuk tindakan penyelenggaraan pada masa hadapan.

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LIST OF ABBREVIATIONS

HI	-	Health Index
DGA	-	Dissolved Gas Analysis
DTM	-	Duval Triangle Method
IEEE	-	Institute of Electrical and Electronics Engineers
DPM	-	Duval Pentagon Method
IEC	-	International Electrotechnical Commission
PD	-	Partial Discharge
TNB	-	Tenaga Nasional Berhad
ppm	-	part per million
H2	-	Hydrogen
C2H2	-	Acetylene
CH4	-	Methane
C2H4	-	Ethane
C2H6	-	Ethylene
SPSS	-	Statistical Package for Service Solutions
PASW	-	Predictive Analytics Software
B-ph	-	Blue phase
UHF	-	Ultra High Frequency
SFRA	-	Sweep Frequency Response Analysis

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CHAPTER 1

INTRODUCTION

1.1 Problem Background

Power transformers are most important equipment that has been installed in both the transmission and distribution of electrical power. It is important to detect and forecast incipient faults in a transformer to prevent failures since a fault in a transformer can have a huge repercussion when failures occur [1-5]. Transformer are subject to electrical and thermal stresses, which can cause the degradation of the insulating materials during the operation time. Generally, the degradation products are gases, which will get dissolve in the oil entirely or partially. These gases are easily detected at the ppm level by dissolved gas analysis.

Dissolved gas analysis (DGA) is a widely used and most powerful method to detect incipient faults on oil filled electrical equipment [6-9]. DGA of transformer oil is the best indicator of a transformer's overall condition. Hence this widely accepted method is used in routine maintenance of power transformers [10,11]. Transformer oil provides insulation, provides cooling, and helps extinguish arcs. Oil also dissolves the gases which are generated due to degradation of oil, moisture and gas from insulation, deterioration of cellulose, and gases and moisture from the surrounding the oil is exposed to [12-15]. Any deterioration in the oil can lead to premature failure of the equipment. The most common type of oil used in transformers is of a mineral oil origin [16]. When the mineral oil is subjected to high thermal and electrical stresses, it decomposes and, as a result, gases are generated. Different types of faults will generate different gases, and the chemical analysis of these gases, performed through a procedure called DGA, will provide useful information about the condition of the oil, and help to identify the type of fault in the transformer [17]. There are different types of faults which can be detected by DGA. The details about the faults are explained below. This project aims to study on the comparative between two methods of DGA analysis of an oil immersed transformer which are Duval Triangle & Duval Pentagon methods.

1.2 Problem Statement

Interpretation of DGA using Duval Triangle method is quite complicated because of more than one triangle need to be use in analysing faults and easily can lead to misinterpretation of faults. Later in 2014, Duval Pentagon method has been introduced to overcome the mention problem. Duval Pentagon method is not the replacement method of the Duval Triangle method but to bring complementary information for instance for the case of mixtures of faults.

DGA diagnosis using Duval Pentagon method used 5 gases at a time instead of just 3 gases used by Duval Triangle method. The differences between consideration of these gases will also lead to a different DGA diagnostic result and accuracy of fault interpretation. To date, comparison analysis between these two methods for DGA in Malaysia which uses a real data provided by the utility has never been conducted. Therefore, the investigation and analysis on the accuracy between Duval Triangle & Duval Pentagon method ought to be done throughout this study.

1.3 Research Objective

The specific objectives of this study include:

1) to compare and identify between Duval Triangle and Duval Pentagon methods which may provide more accurate interpretation of DGA test result.
2) to statistical analyse the difference between both method (Triangle & Pentagon)

1.4 Scope of Study

The scopes of this comparative study are to make sure development of the study is heading to the direction in fulfilling the objectives. There are several scopes to be followed.

1) To analyse real data using different methods of DGA
2) Statistical analysis tools such as histogram, linear regression, correlation coefficient etc. for classification of fault occurrence and gassing rate will be utilized.
3) This study deals only with those insulating fluids of mineral oil origin.
4) This comparative study is based on real data provided by Malaysia utility company.

The analysis using Duval Pentagon method supposed to give a better output of types of possible faults and recommendations for future maintenance action.

1.5 Thesis Outline

This thesis is dividing into five main chapters. Firstly, Chapter 1 is the introduction of the whole project including problem statement, objectives, scope of project and methodology. Besides, includes the overview of DGA, type of gases analyses and incipient fault condition in oil immersed power transformer.

Chapter 2 will cover about dissolved gas analysis method such as Duval Triangle method and Duval Pentagon method, correlation between dissolved gas and fault occurrence and other related topics.

Data collection and analysis techniques will be discussed in Chapter 3. The analysis includes the comparison between both Duval Triangle & Duval Pentagon method. The suitable analysis technique such as histogram, linear regression and correlation coefficient will be employed in analysing the data.

Chapter 4 will cover data analysis results. The results obtained will be discussed to compare which method can give better interpretation of fault occurrence which also can be used to indicate the condition of a transformer as well as an early warning sign in avoidance catastrophic situation.

Finally, Chapter 5 will explain the conclusion and recommendations of this project. The conclusion is a summary of this project and the recommendations are other alternative or suggestion to improve the lacks that might occur through this project.

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