COMPARATIVE STUDY OF MOISTURE REDUCTION TECHNIQUE IN MINERAL OIL

ALARY BENEDO ANAK AH CHUN

BACHELOR OF ELECTRICAL ENGINEERING
(INDUSTRIAL POWER)
UNIVERSITI TEKNIKAL MALAYSIA MELAKA

This report is submitted to the Faculty of Electrical Engineering of UTeM as a partial fulfilment of the requirement for the degree of Bachelor of Electrical Engineering with Honours. The member of the supervisory is as follow:

…………………………………………..

(Project Supervisor)

(Puan Nur Hakimah Binti Ab. Aziz)

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A report submitted

In fulfilment of the requirement for the Bachelor of Electrical Engineering with honour

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I hereby, declared this report entitled "*Comparative Study of Moisture Reduction Technique in Mineral Oil*" is the result of my own research except as cited in references.

Signature: ………………………………..

Author‟s Name: Alary Benedo Anak Ah Chun

Date: ………………………………

For my beloved parents and family whom without failed to give their full support till the completion of this project. Their love, passion and support help me to do weekly progression and complete the experiment and project report.

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ABSTRACT

The uses of the transformer are important for generation, distribution and transmission of the electrical system network. High dielectric strength and cooling performance of its insulating oil are properties that the transformer depends on in order to maintain normal operation. Several factors affected the dielectric insulation problem is moisture, acidity, pressure and suspended particle. 0.01% presence of moisture in the transformer oil can decrease 20% of the breakdown voltage of the oil. Thus, this project is focusing on reducing the moisture content in the mineral oil which results in improvement of the breakdown voltage. Three techniques of moisture reduction have been used which are Vacuum Oven (VO) technique, Nitrogen Saturated (NS) technique, and Molecular Sieves (MS) technique. The performance of breakdown voltage (BDV) and amount of moisture reduce are measured to determine the most effective technique. Karl Fischer Coulometric (KFC) complies with ASTM D1533 standard is used meanwhile for breakdown voltage (BDV) Megger OTA60PB follows the standard ASTM D1816. The analysis of experimental data shows among VO, NS, and MS techniques, the MS no filer techniques has 82.33% reduction of moisture content but BDV has not been tested due to MS particle will effect the BDV test. But, NS has 80.79% moisture reduction which has increased the BDV of mineral oil with enhancement 150%. The low moisture content value by the NS because theoretically when nitrogen gas saturated in mineral oil, the nitrogen gas replaced the dissolved oxygen in the oil. The result is an enhancement of the performance of the mineral oil. MS with a smaller pore size (0.22μm) has a better result than VO and (MS) bigger pore size (1μm) because the smaller pore size has filtered the moisture from re-dissolving with the good oil. Overall, NS technique has proven the most effective technique throughout the experiment and the best solution to reduce moisture from the mineral oil.

ABSTRAK

Penggunaan pengubah adalah penting untuk penjanaan, pengedaran dan penghantaran rangkaian sistem elektrik. Pengubah bergantung kepada kekuatan dielektrik yang tinggi dan prestasi penyejukan minyak penebat untuk mengekalkan operasi normal. Beberapa faktor yang mempengaruhi masalah penebat dielektrik ialah kelembapan, keasidan, tekanan dan zarah yang digantung. Kehadiran kelembapan 0.01% dalam minyak pengubah dapat mengurangkan 20% daripada volum kerosakan minyak. Oleh itu, projek ini memberi tumpuan kepada pengurangan kandungan kelembapan dalam minyak mineral yang menghasilkan peningkatan voltan kerosakan. Tiga teknik pengurangan kelembapan telah digunakan iaitu teknik Ketuhar Vakum (VO), teknik Nitrogen tepu (NS), dan teknik Molecular Sieves (MS). Prestasi volum kerosakan (BDV) dan jumlah kelembapan yang rendah diukur untuk menentukan teknik yang paling berkesan. Karl Fischer Coulometric (KFC) mematuhi piawaian ASTM D1533 digunakan sementara untuk voltan kerosakan (BDV) Megger OTA60PB mengikut standard ASTM D1816. Analisis data percubaan menunjukkan antara teknik VO, NS, dan MS, teknik MS tidak mempunyai pengurangan 82.33% kandungan kelembapan tetapi BDV belum diuji kerana MS zarah akan mempengaruhi ujian BDV. Tetapi, NS mempunyai pengurangan kelembapan 80.79% yang telah meningkatkan BDV minyak mineral dengan peningkatan 150%. Nilai kandungan lembapan yang rendah oleh NS kerana secara teorinya apabila gas nitrogen tepu dalam minyak mineral, gas nitrogen menggantikan oksigen terlarut dalam minyak. Hasilnya adalah peningkatan prestasi minyak mineral. MS dengan saiz liang yang lebih kecil (0.22μm) mempunyai hasil yang lebih baik daripada saiz lubang VO dan (MS) yang lebih besar (1μm) kerana saiz liang yang lebih kecil telah menyaring kelembapan daripada larut semula dengan minyak yang baik. Secara keseluruhan, teknik NS telah membuktikan teknik yang paling berkesan sepanjang percubaan dan penyelesaian terbaik untuk mengurangkan kelembapan dari minyak mineral

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ASTM	-	American Society for Testing and Material
DDF	-	Dielectric Dissipation Factor
DGA	-	Dissolved Gas Analysis
DORMS	-	Dissolved Oxygen and Moisture Removal System
FR3	-	Vegetable Oil Envirotemp
KP	-	Kraft Paper
RBPO	-	Refined Bleached Palm Oil
PFAE	-	Palm Fatty Acid Ester
VDE	-	Verband Deutscher Elektrochiniker
FTIR	-	Fourier-Transform Infrared Spectroscopy
FO	-	Fresh Oil
VO	-	Vacuum Oven
NS	-	Nitrogen Saturated
MS	-	Molecular Sieve
ppm	-	Part per million
CCL_2F_2	-	Freon
CO_2	-	Carbon Dioxide
OTS60PB		Oil Test Set 60 Portable

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CHAPTER 1

INTRODUCTION

1.1 Overview

This chapter describes the research background, motivation, problem statement, objectives and scope research. In the research background of the project will explain the purpose and significance of projects. While a short brief of issues that need to avoid and solved is explained in the problem statement. In objective, the goal of the project is been explained in the scope of research.

1.2 Research Background

Power transformers are valuable assets in electrical power network. The performance of a power transformer mostly depends on its insulation system. Hence, it is vital for the insulation system to have the ability to withstand all the various service conditions. As it say the better the insulation condition, the longer the life span of transformer.

Oil immersed transformer is the most widely used to date. The oil immersed transformer is still based on mineral oil. Due to generalization and standardization, the production of the transformer is a worldwide hit. Now the industry is going toward plant-based insulating oil but technology and knowledge are still lacking. The oil immersed transformer uses liquid insulation material as a heat transfer agent [1].

The lifespan of the insulating oil used in power transformer suffers from thermal, electrical and environmental stresses during operation services. Deteriorating and aging process of the insulation may be accelerated and can be a direct potential threat to the equipment safety. Slow and irreversible changes in material properties will result in a process called aging. Hence, oil become decomposed and oxidized which result in transformer losses and reduce its reliability [2].

The heat that comes from the transformer winding may cause acceleration of the reaction between unstable hydrocarbon molecular oil and oxygen, by product degradation cellulose paper and excess dielectric loss at high temperature [3]–[5]. Therefore, improving the mineral oil dielectric strength properties is important for improving the lifespan of the transformer.

1.3 Motivation

Mineral oil is widely use insulating oil for transformers but there is still a room for improving its performance or properties. This is due to the low cost, oil oxidation stability, cooling performance and good dielectric strength. However, the process of aging produces a by–product contributes to increment of moisture content. The existences of this harmful moisture is a well know threat to all liquid insulation that potentially decrease the breakdown voltage, increases paper degradation rate, decrease inception voltage in partial discharge and increase risk of bubbling with moisture content in paper. The dielectric strength and performance of transformer will decrease when there are existences moisture in transformer[6], [7]. Hence, this study has proposed a lot of research method for reducing moisture in the oil.

1.4 Problem Statement

There are many techniques proposed in the literature to reduce the moisture content in the insulating liquid but most of the techniques are costly and time consuming. But, there is still proper guideline available even there are many practices has been done in the industry without identifying the most effective to reduce moisture

Hence, this research work aims to finds the effectiveness of the proposed methods focusing only on three methods, molecular sieves and filter, bubble and heating. These three methods have different working principle. Therefore, the most convenient method with an effective moisture reduction is proposed in this work based on experimental results. Even so, the presence or existence of moisture can be put into three parts that are chemically bound water, physically dissolved water and free water [7]. These methods are chosen due to the availability of equipment available in the lab. The three methods in theory able reduce moisture content in the insulating oil and which is easy to conduct due to its simple concept.

1.5 Objective

Based on the title, "Comparative Study of Moisture Reduction Technique in Mineral Oil", the following objectives below are pursued:

- To compare the effectiveness of different techniques in reducing moisture from mineral oil
- To determine effect of molecular sieve on mineral oil
- To analyse the effect of moisture on Breakdown Voltage (BDV) on mineral oil.

1.6 Scope of Research

In this research the mineral-based insulating oil used is Nytro Libra. The dielectric strength and its moisture content are measured. Three methods of moisture reduction are used in example molecular sieves and filter, bubble and heating. Filter paper with a smaller pore size (0.22µm) and bigger pore size (1µm) are used in this experiment. The method used to measure the moisture content in the mineral oil is using Karl-Fisher method. Breakdown voltages are tested at MeggerOTS60PB Portable oil Tester

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter gather theory regarding transformer, including the insulating materials of a transformer and their properties of the insulating material. Methods or techniques reducing moisture for commercial users and for the previous work also provided.

2.2 Transformer

Transformer operates by the principles of electromagnetic induction from one circuit to another, either stepping up or stepping down the voltage. The construction of transformer consists of the iron core, windings, insulating material and bushings.

Transformers in electric power delivery systems around the world are mostly oil-filled. The oil transformers are as an electrical insulation and as a heat transfer fluid. Most of the transformer is petroleum-based which is refined specifically to meet the requirements. In electric power distribution and transmission systems, the transformers are to expected function reliably and efficiently for many years. The quality of the oil plays an important role in a transformer performance[1]

2.3 Insulating Material of Transformer

The insulating material is essential in making the transformer to work properly. One insulator alone is not enough to ensure the safety due fault can occur in any type of form for the transformer. There are three categories that use the transformer that is solid, liquid and gas[9].

2.3.1 Solid Insulation

A good mechanical and bonding strength is the specification of a good solid insulation. Materials used for solid insulation are organic and inorganic material. If a solid insulator is perfectly homogeneous and doesn"t have any imperfection the breakdown voltage can be high.

The largest insulation inside transformer is the solid insulation. The forms of this solid insulation are electro-technical (Kraft) paper and pressboard. The functions of this solid insulation are mechanical stability, the direction of oil flow, electrical insulation and creation of space. Hence, every material has its limit same goes to this solid insulation where the aging will affect the properties of the mechanical and electrical part. Where aging of the solid insulation depending on the water and temperature [9].

Figure 2.1: Structure of a transformer.

The figure 2.1 above and figure 2.2 below shows the component inside the transformer. The insulating paper is used to separate each winding and cover the conductor. The paper comes in numerous forms like different in structure, density and thickness depending on the type of application of transformer. As so, the pressboard for insulation of high-voltage is soaking with liquid insulation[10].

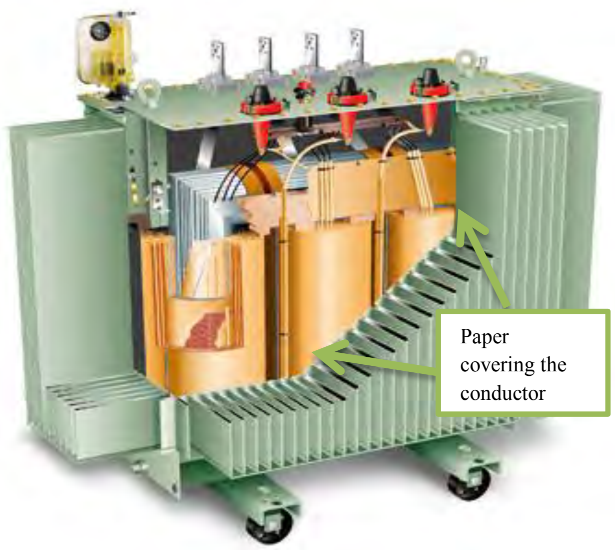

Figure 2.2: More detail location of insulating paper

2.3.2 Liquid Insulation

From figure 2.3 below show that‟s liquid insulation in transformer does not only act as an insulator but also as heat dissipation agent which help to cool the transformer system. Losses in the transformer can be categorized as "no-load losses" and "load losses" which is caused by the existing of the magnetic and electrical field. Types of losses are converted into the copper winding, steel sheet core and other conductor parts. The losses in this transformer will lead to increase of temperature in transformer if the transformer system is not cooled, hence overheating the equipment will lead to fatal damage to the transformer and increased the rate of aging[6], [10].

Thus, it is vital for a transformer to have the transformer oil as it acts as a cooling medium by extracting the heat to the coolant. The low viscosity of oil also allows it to penetrate the solid insulation setting up convection current for conveying heat from core material to the radiators. Hence, to operate for a long period and at high voltage the liquid insulation oxidation has to be stable.

The liquid portion of an insulating system plays an important role and able to withstand the designed and calculated stress. It is due to the transformer can increase in temperature during operation. Furthermore, to prevent and protect the transformer from overheating is by using liquid insulation. The normal factor of BDV for both and liquid insulation are temperature, humidity and water content. The temperature will determine the interactions between two insulations. Hence, all normal and abnormal transformers operating condition the transformer oil should serve as a solvent that can tolerate with the transformer [10].

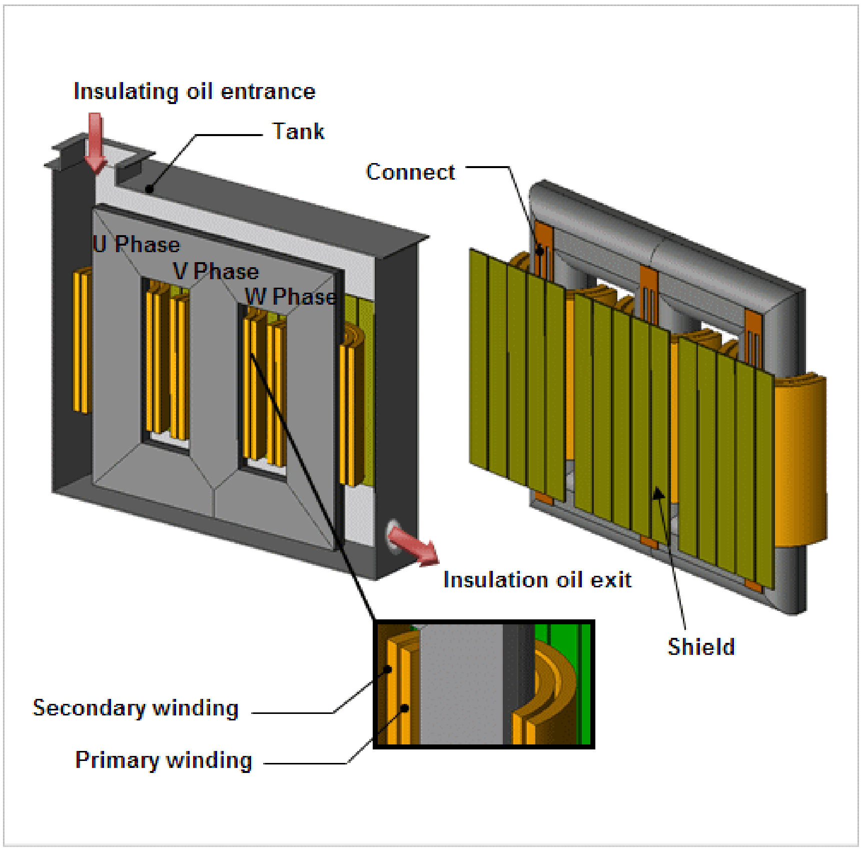

Figure 2.3: Cooling System of a Transformer

2.3.3 Gas Insulation

Air at atmospheric pressure is the most common gasses insulation. The breakdown of gasses occurs when collision ionization between free electron and gas molecule. Chemical inertness and stability are properties that normally chose as an insulating gas. Nitrogen (NS), carbon dioxide (CO_2), Freon (CCL_2F_2) and sulfur hexafluoride (SF_6) are some of the common insulating gasses. An ideal condition for gas insulation is the vacuum, where the absence of gas molecule prevents the collision between molecules. Hence, for the ideal condition will result in a large breakdown voltage.

2.4 Properties of Insulating Material

There are 2 types of oil to be compared, palm fatty acid or vegetable oil and mineral oil. Mineral oil always has been a go-to product for the transformer oil