PARTIAL DISCHARGE CHARACTERISTICS ON PALM-BASED OIL FOR TRANSFORMER OIL APPLICATION

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Dedicated to my family

Thank you for your perseverance

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“Praise is to Allah S.W.T, the Most Merciful and the Most Compassionate. Peace is upon him, Muhammad, the messenger of God”.

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ABSTRACT

Historically, Most of the transformer used liquid insulating material where its function is to provide electrical insulation and also act as a coolant to prevent overheating of the transformer. Since years ago, petroleum-based mineral oil has been used. This reason push for search of environmental friendly insulating oils. Conventional transformer insulating materials are usually non-biodegradable. It can contaminate soil and water when serious spill take place. This may disturb the plantation and other lives. In future, this petroleum will be come to an end because it is a non-renewable source. Therefore, this project has been carried out to seek alternatives of vegetables oil that is more environmental friendly. Palm Fatty Acid Ester Oil PFAE) has been recognized to be the potential replacement for petroleum-based mineral oil. The main objective of this project is to execute experimental study effect of ageing time and electrical characteristic of (PFAE) oil by using partial discharge method. Another objective of this project is to make a comparison on electrical properties between (PFAE) oil with petroleum-based (mineral oil). The result indicates that (PFAE) oil has better dielectric properties and meet all requirements to be used as liquid insulating material.

ABSTRAK

Menurut sejarah, kebanyakan pengubah menggunakan bahan penebat cecair yang berfungsi untuk menyediakan penebatan elektrik dan juga bertindak sebagai bahan pendingin untuk mengelakkan daripada pemanasan melampau terhadap pengubah. Sejak bertahun lalu, minyak mineral berasaskan petroleum telah digunakan. Alasan ini mendorong kepada usaha mendapatkan minyak penebatan yang mesra alam. Bahan penebatan pengubah konvensional biasanya tidak terbiodegradasi. Ia boleh mencemarkan tanah dan air apabila tumpahan serius berlaku. Ini mungkin mengganggu perladangan dan kehidupan lain. Pada masa akan datang, petroleum ini bakal berakhir kerana ia adalah sumber yang tidak boleh diperbaharui. Oleh itu, projek ini telah dijalankan untuk mencari alternatif minyak sayur-sayuran yang lebih mesra alam sekitar. Minyak Ester Asid Lemak Sawit (PFAE) telah diiktiraf sebagai pengganti berpotensi untuk minyak mineral berasaskan petroleum. Objektif utama projek ini adalah untuk menjalankan kajian eksperimen kesan masa penuaan dan ciri-ciri elektrik minyak PFAE dengan menggunakan kaedah pelepasan separa. Objektif seterusnya adalah untuk membuat perbandingan di antara sifat-sifat elektrik minyak PFAE dengan minyak mineral berasaskan petroleum. Keputusan menunjukkan bahawa minyak PFAE mempunyai sifat dielektrik yang lebih baik dan memenuhi semua keperluan yang sesuai untuk digunakan sebagai bahan penebatan cecair

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LIST OF ABBREVIATIONS

BDV	-	Breakdown voltages
BS	-	British Standar
FTIR	-	Fourier Transform Infrared Spectrometry
PFAE	-	Palm Fatty Acid Ester Oil
Kv	-	kilovolt
kA	-	Kilo Amperes
pCs	-	Pico Coulomb
m	-	Meter
mm	-	Millimeter

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CHAPTER 1

INTRODUCTION

1.1 Research Background

Insulators are devices that are used on electricity supply networks to support, separate or contain conductors at high voltage. Insulation is one of the most important parts in a high voltage apparatus. The insulator intended to support or separate electrical conductors without passing current through themselves. There are three basics types of electrical insulating, which is solid, liquid and gas. These materials are widely employed in electrical network components such as circuit breakers, transformers, cables, and capacitors [1].

Liquid insulation is used for filling transformers, circuit breakers and as impregnates in high voltage cables and capacitors. Insulation plays important parts in electrical system to insulate the potential charge materials with the earthed object (including human). Failure in insulation could cause electrical breakdown or short circuit in which may introduced the risk of faulty/damage to the equipment as well as causing potential danger to the human. In general, insulation can be formed of solid (e.g. glass, porcelain, or composite polymer

materials and etc.), gases (i.e. nitrogen and sulphur hexafluoride) and liquid such as mineral oils (e.g. naphthenic oil and paraffinic oil) [2].

There are several requirements for transformer insulating oil, which includes:

- To act as a coolant with the main task of absorbing the heat from the core and winding, then transmitting it to the outer surface of the transformer. At higher temperatures the viscosity of the oil decreases, thus facilitating the circulation of the oil. It is important to keep the pour point low so the oil is capable at any observable flow.

- To insulate different parts at different electrical potential. Oil makes a good contribution to transformer insulation by penetrating into and filling the spaces between wound insulation layers.

- In order to minimize the evaporation losses, the oil volatility should remain low. Oil temperature in service should be maintained below its flash point

The three most important properties of liquid are dielectric strength, dielectric constant and the electrical conductivity. Other important properties include the viscosity, thermal stability, specific gravity and flash point. The important factors that affect the dielectric strength of oil are the presence of fine water and the fibrous impurities. Therefore, when oils are used for providing electrical insulation, the oil should be free from moisture, products of oxidation and other contaminants [3].

Recently, several liquid insulating material has been introduced which are generally organics type and obtained from nature that are biodegradable and friendly to environmental. For instance, the new liquid insulating material includes vegetables oil such as Soya-bean oil, Sunflower oil, Coconut oil, Olive oil and Palm Oil.

Malaysia is one of the countries that have indigenous resource of palm oil. The sample of palm oil produced includes Crude Palm Kernel (CPKO), Crude Palm Oil (CPO), Crude Palm (CP8), Crude Palm (CP10), Refined Bleached and Deodorized Palm Oil (RBDPO) and Palm Fatty Acid Ester Oil (PFAE). This type of oils is safe and environmentally friendly renewable resources. These oils are widely used and have extensive of resources, hence there is then the assurance of sustainability [4, 5].

1.2 Problem Statement

Petroleum-based mineral oils have been used as liquid insulating materials in power transformer and other high voltage apparatus because of its excellent dielectric properties. Now, the existence of mineral oil in the world has been reduced as the time goes by and probably it will not occupy our needs for the next generation.

Due to environmental consideration, recently researches have been put in attempt to search the alternatives of liquid insulating materials. There are some reasons that push the search of environmental friendly insulating oils. Conventional transformer insulating materials are usually non-biodegradable. It can contaminate soil and water when serious spill take place.

This may disturb the plantation and other lives. It is important to find alternative oil sources that have similar dielectric characteristics with the existing one and probably can increase the performance of related equipment. Therefore, this oil needs to be replaced with a new type of oil that is friendlier towards the environment.

1.3 Research Objective

The main objective of this project is to execute experimental study effect of ageing time and electrical characteristic of Palm Fatty Acid Ester (PFAE) by using partial discharge method. Another objective of this project is to make a comparison on electrical properties between new insulating oil, Palm Fatty Acid Ester (PFAE) with commercial transformer oil (Hyrax mineral oil).

1.4 Scope of the Research

The scopes of the research are as the following:

i. Literature Review

Find and understand regarding literature review that covers all study of insulating oil, recent development research, past researcher work and method, characteristics of the liquid insulation, partial discharge method and etc.

ii. Material Sample

Sample used in the experiment is Palm Fatty Acid Ester (PFAE) as a Potential palm-based oil and industrial Hyrax transformer oil as a commercial power transformer oil.

iii. Electrical Properties that will be investigated are:

The partial discharge (PD) characteristic, which includes PD magnitude and PD numbers. And Breakdown Voltage (BDV).

iv. Analysis that will be carried out are:

a) Analyze the electrical properties of potential palm-based oil (PFAE) compared to other commercial power transformer oil (Hyrax).

b) Analyze the effect of ageing on electrical properties (BDV and partial discharge) of potential palm-based oil (PFAE) and other commercial power transformer oil (Hyrax).

v. Data Collected

The data is collected by using partial discharge meter and Fourier transformer spectrum (FTIR)

1.5 Thesis Outline

This thesis is divided into 5 chapters which discuss various aspects in the investigation of electrical and physical properties of palm-based oil as alternative power transformer oil. Chapter 1 is the introduction of the project that includes the background of the project, problem statement, objectives, and the scope of project. Chapter 2 summarizes literature reviews on power transformer oil, palm-based oil (PFAE) and electrical properties (breakdown voltage, and partial discharge). Chapter 3 explains the methodologies which are the experimental procedure of measuring breakdown voltage, partial discharge and the method of ageing process. Then the results from experiments and analysis done are discussed in Chapter 4. Last but not least, In Chapter 5, conclusions and recommendations are presented based on all work that has been done throughout this project.

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