THE EFFECT OF MOISTURE ON AC BREAKDOWN VOLTAGE OF SYNTHETIC ESTER OIL UNDERGONE DIFFERENT MOISTURE REMOVAL METHODS

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I hereby declare that I have read through this report entitle “The effect of moisture on ac breakdown voltage of synthetic ester oil undergone different moisture removal methods “and found that is comply the partial fulfillment for awarding the degree of Bachelor of Electrical Engineering (Industrial Power)

Signature : ……..

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Date : ……..

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A project report submitted in partial fulfillment of the requirement for the award of Bachelor of Electrical Engineering (Industrial Power)

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I declare that the project report entitled “The effect of moisture on ac breakdown voltage of synthetic ester oil undergone different moisture removal methods” is the results from my own research except as cited in the references.

Signature : ……..

Name : SYAHARIL BIN MAT ISA

Date :

To my beloved mother and father

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Firstly, I want to express my gratitude to Allah S.W.T for giving strength and ability in enduring this Final Year Project report. I also want to express my special thanks to my project supervisor that is Dr. Hidayat Bin Zainuddin whose give me a lot of advice and guidance in making this project and also in complete this report.

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ABSTRACT

Transformer is one of the valuable assets which used to deliver the electricity power to the whole nations. Inside the transformer is containing oil which its function is to cool down transformer from overheating and act as insulation for the windings. Generally, the mineral oil is used as the liquid insulator for the insulation purpose to prevent the transformer from breakdown. But unfortunately there are several weaknesses for the mineral oil. The weakness is not biodegradable, low moisture tolerance and also flammable. The ester oil has become one of the alternative ways to overcome the weakness of the mineral oil. The advantage of the ester oil is more biodegradable, excellent fire resistance and high dielectric strength. However, the occurrence of the moisture inside the transformer will affect the breakdown voltage of the insulation liquid to protect the transformer. This project will measure the effect of different moisture level on the ester oil in terms of its breakdown voltage by using breakdown tester set (OTS60PB) and also study on necessary method of the moisture removal technique in order to decrease the moisture contents inside the ester oil. The breakdown measurement comply with ASTM D1816 standard is used. For the moisture removal method, there are three techniques that been used which are by using vacuum, air ventilation and nitrogen gas treatment. Karl Fischer titration device is used to determine the water contents for those different techniques. From the analysis that been done, it is clearly shown that the breakdown strength decreases as the moisture contents increases. The breakdown voltage is the highest when nitrogen treatment is used compared to vacuum and air ventilation method. By doing this research, it is obvious that removing the moisture from the insulation oil will make the oil have great potential in overcoming electrical stress.

ABSTRAK

Transformer adalah salah satu aset dimana ia digunakan untuk menghantar tenaga elektrik kepada seluruh pengguna. Di dalam transformer mengandungi minyak dimana fungsinya adalah untuk menyejukkan transformer daripada berlaku pemanasan yang melampau serta bertindak sebagai penebatan bagi belitan transformer. Secara umumnya, minyak transformer digunakan sebagai cecair penebat bagi tujuan penebatan untuk mengelakkan transformer dari rosak. Akan tetapi terdapat beberapa kelemahan pada minyak mineral. Antara kelemahan yang terdapat pada minyak mineral ialah tidak mesra alam, toleransi terhadap kelembapan adalah rendah dan juga mudah terbakar. Minyak ester menjadi satu daripada alternatif untuk mengatasi kelemahan minyak mineral. Antara kelebihan minyak ester ialah lebih mesra alam, tidak mudah terbakar dan tahap kekuatan dielektrik yang tinggi. Akan tetapi kehadiran lembapan pada transformer boleh memberi kesan pada tahap kerosakkan dan tahap ketelusan bagi minyak mineral dan ester. projek ini akan mengukur kesan tahap kelembapan pada minyak ester dari segi tahap kerosakkan voltan dengan menggunakan set pengukur (OTS60PB) dan mengkaji teknik untuk membuang lembapan untuk mengurangkan kandungan air dalam minyak ester. Pengukuran kerosakan akan menggunakan standard ASTM D1816 dan menggunakan isipadau air yang berbeza. Bagi kaedah untuk menghilangkan lembapan, terdapat tiga cara yang digunakan iaitu dengan menggunakan vakum, pengudaraan dan gas nitrogen. Alat Karl Fischer digunakan untuk menganggar kandungan air untuk kesemua teknik yang digunakan. ia akan mengukur dalam unit parts per million (ppm). Daripada analisis yang dijalankan ia dengan jelas menunjukkan bahawa tahap pecah tebat akan berkurang apabila kandungan kelembapan bertambah. Daripada kajian ini, ia amat jelas menunjukkan dengan membuang lembapan dari minyak penebatan akan menyebabkan minyak tersebut mempunyai potensi yang lebih baik untuk menghadapi tekanan elektrik.

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CHAPTER 1

INTRODUCTION

1.1 Project Background

Power transformer and distribution transformer are widely used in public and private sector which involve consumption of electricity, distribution and generation [1]. For the power utilities in Malaysia, the oil immersed type is generally used for the transmission and distribution system [2]. The oil works as electrical insulation and it also act as a medium for heat transfer to make sure that transformer is not overheated when operate in high voltage for a long time. In Malaysia mineral oil is used inside the transformer for many years. The characteristic of the mineral oil which have relatively flammable and can cause hazard for environment make the researcher studies the alternative insulation oil to replace the mineral oil. One of the alternative oil that has comparable performance characteristic such in mineral oil is ester oil.

This project investigates the effect of moisture level in ester oil by using breakdown measurement and also determines its water content by using Karl Fisher Coulometric. In this study, the synthetic ester oil is tested based on different levels of moisture contents inside the oil. That synthetic ester oil (MIDEL 7131) will undergo 3 different types of treatment in order to remove the moisture inside it before doing testing for its breakdown. The types of treatment that been used are air ventilation, vacuum and nitrogen gas treatment methods. The efficiency of each treatment method is analyzed on the basis of water content level and breakdown voltages.

1.2 Problem Statement

Transformer is very important in electrical system because it is used to transfer electrical energy from one circuit to another. Inside the transformer there is oil that is used as insulation and also to keep the transformer cool from the heat. The oil is important to preserve the core and winding and also to prevent cellulose paper from direct contact with the atmospheric oxygen. Generally, the type of oil that widely used inside the transformer is mineral oil. But the mineral oil is not biodegradable, low moisture tolerance which tends to cause sulphur corrosion and also flammable which can risk the living environment. Therefore, alternative oil is needed to overcome the weakness of the mineral oil. One of the oils that can be used to replace the function of mineral oil in the power transformer which is more biodegradable, excellent fire resistance and low dielectric losses when the frequency is more than 1 kHz is ester oil. However the occurrence of the moisture inside the transformer oil will affect the potential of the mineral oil and ester oil inside the transformer in terms of breakdown voltage. This project is conducted to study the effect of moisture level in ester oils in terms of their breakdown durability. In addition, this ester oil will be having three types of treatment method to remove the moisture inside it before undergo the testing by using vacuum, ventilated and nitrogen. This method will be compared its efficiency in removing the moisture by using Karl Fisher and also testing its breakdown for each technique that applied on that oil.

1.3 Objectives of Research

1. To compare the effectiveness of different moisture removal treatment methods on synthetic ester insulation oil by using Karl Fisher moisture measurement and breakdown voltages measurement.
2. To investigate the level of breakdown voltage for synthetic ester oil in different moisture levels.

1.4 Scope of Project

In this project, the new oil is been used for analyzing the ester oil. This ester oil is taken from the drum but in this experiment, the ester oil must undergo moisture removal treatment. This oil undergoes with three methods of treatment that is by using vacuum, air ventilation and also nitrogen gas methods. All these methods is referring the technique that been used by previous study. Karl Fisher is been used to determine the water content inside the oil to see the effect of those treatment towards the quantity of moisture inside the oil and the measurement is in unit part per million (ppm). The study will involve addition of moisture levels of 0.1 ml, 0.2 ml and 0.3 ml in the ester oil. The type of ester oil that been used is MIDEL 7131 which known as synthetic ester. The ASTM D1816 standard is been used in analyzing the effect of moisture level in ester oil for breakdown measurement.

1.5 Significance of the Study

This study is about to observe the capability of the ester oil towards the effect of moisture and also to test the method that can remove the moisture effectively from the oil. The reason of this study is because ester oil has much advantage compare to the mineral oil. The disadvantage of mineral oil compared to ester oil is flammable for certain fire point, not environment friendly and will be depleted someday because it is produce from the refinery from the crude oil. Whereas the ester oil comes from the renewable source such as plants and it is produced from the esterification process to become ester oil. It is very important for researcher to study more on the effectiveness of using the ester oil for insulation in distribution transformer. The moisture removal treatment is used because ester has more moisture contents compared with the mineral oil. This oil easily absorbs the moisture when exposed to the humidity. When higher the humidity, then the higher moisture will be absorb inside the oil molecule. The free water molecule inside the oil can cause the breakdown occur faster than the actual of that insulation oil strength. Hence, in order to get maximum capability of the ester oil, it needs to remove the moisture first before testing the breakdown. This experiment will use vacuum, air ventilation and nitrogen gas methods in removing the moisture and to see which method is more reliable to be used. This study will give impact towards the use of mineral oil as common insulation

oil inside power transformer which can be replaced by ester oil that have more environment friendly characteristic and cheaper in cost compared to mineral oils.

1.6 Thesis Outline

This report consists of five chapters. This first chapter explains on the function of insulation oil in distribution transformer. This chapter also highlights the objectives, problem statement, project scope and significant of the study.

The second chapter is literature review. The literature reviews address the researches that have been carried out by other researcher that related to this project. By referring the previous research, it can be easier to find the right method and also the standard which can be used for this study to make sure that the experiment and data gathering for the analysis is correct and doing in proper way. For example, the uses of ASTM D 1816 in breakdown measurement for insulation oil is one of the standard that been review by previous research and the same method can be used in this study for analyzing the breakdown measurement.

The third chapter is methodology. This chapter explains the process of the experiment that will be conducted from the beginning until to the end of the research. The experimental setup and all the tools and device that will be used in this project are discussed.

Chapter 4 discusses the results of this project. The data from the research and experiment that been carried out is tabulated and shown clearly in the graph. The comparison on the moisture contents by using different method of oil treatment and also the effect of moisture towards the breakdown measurement on synthetic ester oil are discussed.

Lastly, chapter 5 concludes all about this project based on the observation during the experiment and the data collected in the result section. From the result that been gathered, a good conclusion can be made and also by referring from the previous researcher at the literature review section, the comparison can be made to see significant and also the contribution of this study.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this chapter, the literature review focuses on the principle and also the theory of the effect moisture level in synthetic ester oil on breakdown measurement and also the different methods that been used in ester oil treatment to remove the moisture inside the oil.

2.2 Dielectric Liquid

Dielectric liquid is used to prevent electric discharge. It is used in high voltage application which it served as electrical insulator. The common application that always been used is in high voltage application such as in power transformer. For the function of dielectric transformer, it is used to cool the winding and it is also used to provide the optimal performance to make sure the transformer is in good condition. Generally, the type of dielectric liquid which commonly used for the transformer insulation is mineral oil. Although the mineral oil is widely used inside the power transformer, but nowadays researchers are trying to find the alternative oil that is comparable with mineral oil. One of the oil that has the good characteristic to become insulation oil inside the power transformer is ester oil. Below is few of the characteristic for the mineral and ester oils to be discussed.

2.2.1 Mineral Oil

Mineral oils are obtained from the crude oil which undergoes the process of fractionation and ulterior treatment. The function of this mineral oil is to preserve the core and winding where these two components are absolutely immersed inside the oil. For the structure of mineral oil, it is a mixture which is combination of three basic molecules. The molecules that consist inside the mineral oil are naphthenic, aromatic and paraffinic. The characteristic of the mineral oil is based on these three chemical compositions [3]. For the paraffinic molecule, the formula is ($C_{2n}H_{2n+2}$), naphthenic molecule is ($C_{2n}H_{2n}$) and aromatic molecule is (C_nH_n). These hydrocarbons are combination of hydrogen and carbon which linked together with mono and double bonds depending on hydrocarbon types [4]. The structures of the molecule are shown in Figure 2.1 and the characteristics of mineral oil are shown in Table 2.1.

The Paraffinic oil has a lower performance as a coolant in power transformer although the oxidation rate is lower than Naphthenic oil. For the Naphthenic oil, it has a great performance as coolant in cooling system of power transformer. This is because the sludge is insoluble compared to Paraffinic oil [1]. The Aromatic oil has higher conductivities compared to the Paraffinic and Naphthenic oils and also has very low value of dielectric loss. Even though these three have different of the characteristic, but all of them are relatively flammable and can cause hazard for environment.

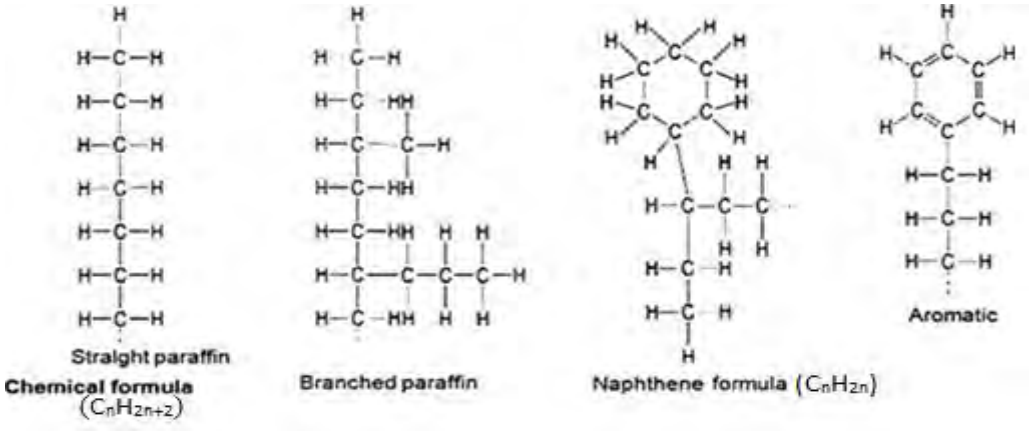

Figure 2.1: Molecular structure of mineral oil