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**FINAL YEAR PROJECT REPORT II**

**STUDY ON THE DIELECTRIC STRENGTH OF RECLAIMED WASTE COOKING  
PALM OIL FOR POWER TRANSFORMER APPLICATIONS**

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Date : 1<sup>st</sup> June 2016.....

**STUDY ON THE DIELECTRIC STRENGTH OF RECLAIMED WASTE COOKING  
PALM OIL FOR POWER TRANSFORMER APPLICATIONS**

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**A report submitted in partial fulfillment of the requirement for the degree of Electrical  
Engineering (Industrial Power)**

**Faculty of Electrical Engineering  
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**JUNE 2016**

I declare that this report entitle “*Study on the Dielectric Strength of Reclaimed Waste Cooking Palm Oil for Power Transformer Applications*” is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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Date : 1<sup>st</sup> June 2016.....

## **DEDICATION**

Alhamdulillah Hirrabbi'lalamin, I am full of gratitude to Illahi with His grace, I have completed this Final Year Project II with great success for 14 weeks. During this period, it would not have been possible without the help from other people surrounding me.

Thank you for those who helped me a lot especially my supervisor and project teammate for giving me a guidance during this 14 weeks. A special thanks to my supervisor, Puan Nor Hidayah Bt Rahim for her guidance and monitoring. I would like to extend my sincere thanks to the most important person, Mr Sharin B Ab Ghani, head of project who always guide me to complete this project. All of them really inspired and motivate me to finish the project.

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## ABSTRACT

Liquid insulation is a vital medium in power system especially transformers which acts as insulation as well as coolant. As the year passed, the liquid insulation in transformer will degrade and start to lose its function as an insulation medium and this will affect the life and efficiency of transformer. The problem arises when the waste mineral oil is change to new mineral oil. Mineral oil in transformer can be potentially hazardous to the environment when occur accident during its working time. In order to prevent that from happen, vegetable oil is used as an alternative insulation liquid for transformer oil because it is more environmental friendly. In this work, waste cooking palm oil is reclaimed to replace mineral oil. Reclamation of oil is the process of removing contaminant using adsorbent and produce new oil that have almost same characteristic as new oil. This process is carried out by mixing and heating 1000 ml of waste cooking palm oil with 100 g of Fuller's earth as an adsorbent for 4 hours before filtration to remove the used adsorbent. In this work, investigation of various parameters such as breakdown voltage, total acid number (TAN) and moisture content of different samples of cooking oil like waste cooking palm oil, new cooking palm oil, reclaimed cooking oil and antioxidant-reclaimed cooking oil using the standard of ASTM. From this experiment, it prove that the reclamation of waste cooking oil helps to improve the performance of this liquid insulation as its breakdown voltage, moisture content , and total acid number is reduced.

## ABSTRAK

Penebat cecair adalah medium penting dalam sistem kuasa yang bertindak sebagai penebat dan juga penyejuk. Semakin masa berlalu, cecair penebat dalam pengubah akan merosot dan mula kehilangan fungsinya sebagai medium penebat dan ini akan memberi kesan kepada kehidupan dan kecekapan pengubah. Masalahnya timbul apabila minyak yang digunakan ditukar kepada minyak baru. Minyak mineral sangat bahaya kepada alam sekitar sekiranya berlaku kemalangan semasa waktu kerja. Dalam usaha untuk mengelakkan kejadian sebegini daripada berlaku, minyak sayuran digunakan sebagai cecair penebat alternatif kerana ia lebih mesra alam. Dalam kajian ini, sisa minyak sawit digunakan untuk menggantikan minyak mineral. Penambakan minyak adalah proses mengeluarkan bahan cemar menggunakan penjerap dan menghasilkan minyak baru yang mempunyai ciri-ciri hampir sama dengan minyak baru. Proses ini dilakukan dengan mencampurkan 1000 ml minyak yang dipanaskan dan dicampurkan digunakan dengan 100 g tanah Fuller selama 4 jam sebelum penapisan untuk membuang bahan penjerap digunakan. Dalam kajian ini, siasatan pelbagai parameter dilakukan seperti voltan pecahan, jumlah asid dan kandungan lembapan sampel dengan menggunakan standard ASTM. Dari kajian ini, penambakan sisa minyak masak membantu meningkatkan voltan kerosakan, kandungan kelembapan dan juga jumlah asid.

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**LIST OF ABBREVIATIONS**

BdV	-	Breakdown Voltage
TAN	-	Total Acid Number
DP	-	Degree of Polymerization
PFAE	-	Palm Fatty Acid Ester
TNB	-	Tenaga Nasional Berhad
DDP	-	Dissolve Decay Product
ASTM	-	American Society for Testing and Materials
IEC	-	International Electrotechnical Commission

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## CHAPTER 1

### INTRODUCTION

#### 1.1 Research Background

Power transformers are essential in the transmission of alternating current and are the most costly equipment in the substation. The transformer lives mostly rely on the insulating oil used which the function is for heat transfer medium. Basically, transformer oil work for two purposes which are for liquid insulation in power transformer and for dissipates heat of the transformer which is act as a coolant. Solid (kraft paper and press board) and liquid (mineral oil) are typically two dielectric mediums that are used in transformer [1]. Between these medium, liquid medium dominate in transformer because of its multifunction. However, the performance of transformer insulating oil starts to decrease with respect to time because of the chemical reaction. The change in insulation characteristics is most probably due to the effects of chemical, thermal, electrical and mechanical stresses, such as hot zones, voltage spikes and vibrations [2]. The interaction between solid and liquid create byproduct which then will deteriorate the oil and causing the insulating oil to lose its functionality as transformer insulation. In essence, the moisture content in transformer like in the cellulose-

based paper used as an insulation in the windings can result in electrical breakdown which resulting the increasing of dielectric dissipation. Other than that, aging of solid insulation is always in combination with aging of transformer oil. Oxidation is the predominant mechanism leading to formation of carboxylic acids in oil [3]. The increase of acid number happened due to the oxidation process that cause of excessive temperature and oxygen which can damage the insulation paper. An action need to be taken to protect the state of insulation system as the contaminants from the byproduct can harm the insulation system.

## **1.2 Problem statement**

Production of mineral oil came through the oil refinery which crude oil is process and refined into some useful product. This process produced gaseous which come from the combustion of the crude oil and will affect the environmental and give bad consequent to the community. Since the oil used at transformer will degrade after a long time, the oil need to change to a new oil for a better insulation. This will lead to more oil incineration in order to produce new oil. More oil incineration means more oil pollution will happen. In addition, mineral oil may harm the environment if any accident occurs during working time.

In order to prevent pollution and costing problem from happen, other step should be taken which is to reuse waste cooking palm oil by reclamation process. To restore the characteristics of used oil such as dielectric strength and dissipation factor, reclaim the used oil [2]. Oil reclamation helps to improve the performance of the oil by reducing the level of contamination found in the age transformer such as sludge, acids, ketones and also moisture produced from a degradation process [3]. There are a few adsorbents that can help used oil to

retain its features and could be used back as a new oil. The adsorbents mostly produce from clay material which also used in industries as a fertilizers, cleaning agent and pesticides.

### 1.3 Motivation

Therefore, it is motivate to do the project on the reclamation of waste cooking palm oil by improving the performance of the oil using reagent also known as adsorbent. The process of reclamation would help to reduce the production of new oil and also oil disposal since it reuse back the waste cooking oil. This process also can be applied to different usage of oil such as motor oil lubricants. With this step, energy provider could save more money rather than buying new oil which is costly. Figure 1.1 shows graphically the percentage of oil disposal at United States of America (USA) in 1991. From that figure, it shows that 67.2 percent of used oil was burned as fuel and this will increase air pollution and harm the environment.

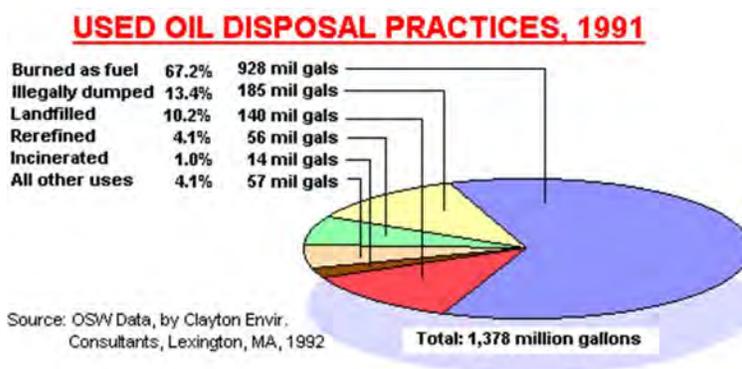


Figure 1.1: Used oil disposal practices in 1991 [1]

## 1.4 Objective

The objectives of this project are:

1. To reclaim waste cooking palm oil using Fuller's earth as an adsorbent.
2. To determine the breakdown voltage (BdV), total acid number (TAN) and moisture content on a reclaimed cooking palm oil.
3. To analyze the performance of reclaimed cooking palm oil in term of breakdown voltage, total acid number and moisture content.

## 1.5 Scope

This project focus on the

1. Study the breakdown voltage, total acid number and moisture content on the reclaimed cooking palm oil.
2. Waste cooking oil that has been used for frying process only.
3. Reclamation of waste cooking oil using Fuller's earth as an adsorbents.
4. Standard test used ASTM D1816-12, Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using VDE Electrodes, ASTM D974, Standard Test Method for Acid and Base Number by Color-indicator Titration, and ASTM D1533, Test Method for Water in Insulating Liquids by Coulometric Karl Fischer Titration.

## 1.6 Project outline

This report consist five chapters. This report starts with the introduction of the project and the following five chapters of this report are arranged as follows:

Chapter 1: Covers the short explanation of the background project, problem statement, objectives and scope of the project.

Chapter 2: Covers the theoretical background of this project including the detail about basic type of transformer oil, the general adsorbents used and the technique of oil reclamation.

Chapter 3: Covers about the project methodology. This chapter consists of the flowchart of the project, milestone, Gantt chart, simulation model, hardware design and the switching method used in this project.

Chapter 4: Gathered all the result of experimental setup.

Chapter 5: Summary of this project and the recommendation for the further research.

## CHAPTER 2

### LITERATURE REVIEW

#### 2.1 Introduction

Transformer oil is an oil that has great electrical insulating characteristics and very stable at high temperature. The function of the oil is to cool the transformer and also as insulator. During the early stage as an insulator, the oil is as clear as water since it has no particle or chemical reaction occur. During the operation in the transformer, the oil is facing several process which comes from heat, oxygen and electrical discharge that lead to its deterioration especially through oxidation process. Most of this time, the acidity of the oil is increase due to the result of by-product, and this will affect the cellulose insulating material since it may attack them. After a few years, this transformer oil will start to lose its primary functions of insulation and heat transfer as aging products will reduce the electrical characteristic and cooling efficiency.

Transformer oils perform at least four basic functions in an oil-immersed transformer. Oil provides insulation, cooling (heat distribution), and helps extinguish arcs (voltaic

discharge). Oil also dissolves gases generated by oil degradation, deterioration, and gases and moisture from whatever atmosphere the oil is exposed to [6].

## **2.2 Transformer Oil**

Oil that is used in industry such as hydraulic, transformer and engine oil are come from special grade petroleum oils, which had different level of specific gravity and viscosity [7]. Generally oil is spoiled by carbon, which can be extracted by filtration and by fractional distillation technique. The oil that is use in transformer has their specific boiling range and degree of refining process to get the characteristic of resulting oil. The different level of boiling range is used to make other products such as kerosene, gasoline and other chemical products.

### **2.2.1 Mineral Oil**

Alkanes in the range of C15 to C40 are mineral oil that contains various colorless and odorless taken from mineral source especially a distillate petroleum [8]. This mineral oil comes from the by-product of the distillation of petroleum in order to generate gasoline and other petroleum-based products from crude oil. Crude oil is produce from the extraction source called as crude petroleum comes beneath the Earth's surface. It is essentially a mixture of hydrocarbon and non-hydrocarbon features and mainly present as elements of complex molecules.

The majority of power transformers used in the world make use of mineral oil and cellulose insulation system to handle the dielectric stresses. The mineral oil production processes are generate from the distillation technique and the end product consists of a few bases known as paraffinic, naphthenic and aromatic which come from the long chain of hydrocarbon contain in crude oil. Conventional engine lubricating used paraffinic based oil because it have good oxidation stability, approximately contain higher wax, high pour point and also have great viscosity index [11]. It usually referred to as alkanes and the simplest paraffin molecule is methane,  $\text{CH}_4$ . Naphthenes or naphthenic base oil also referred as cycloalkanes are saturated hydrocarbon compounds. Main application of naphthenic based oils is in electrical industry as a transformer oil, lubricant industry, chemical and tire industry. It has low viscosity at high temperature and excellent solvency at low temperature. Aromatic is very different from paraffinic and naphthenic oil because it contain benzene ring which is unsaturated but very stable and commonly act as saturated compound. Because of its reactive nature, aromatic base oils are very useful as petrochemical building blocks and also capable to generate synthetic fluids and other petrochemical compound [11].

### **2.2.2 Natural Ester**

Natural esters are produce from vegetable oil which is manufactured from plant crops. It has good biodegradability but most of natural esters have problem in oxidation stability as other types of insulating liquids. Generally, natural esters for electrical utilization are most commonly come from soya, rapeseed and sunflower oil. The reason is because of its availability, cost and performance distinctive. In addition, they are biodegradable and have

greater flashpoint. Transformer with vegetable oil can be operated in large population areas. The characteristic of natural esters are not only give advantages to the surroundings, but also let the customer to think the cost advantage over other type of insulating liquids.

### **2.2.3 Palm Fatty Acid Ester**

In 2005, 36 million tons of palm oil and palm kernel oil had been produced and since then it has become the most abundant and consistently produced vegetable oil around the world including soybean and rapeseed oils [12]. Palm fatty acid ester (PFAE) has oxidative stability, biodegradability and intense toxicity to fish and have been concluded that this oil is better than mineral oil because it has 0.6 times lower in viscosity and 1.3 times more dielectric constant. This factor cause a transformer oil that contain PFAE as an insulation liquids has better cooling efficiency and better insulation performance, thus the size of conventional transformers immersed in mineral oil could be reduced. In addition to its biodegradability, the PFAE is said to be environmental-friendly insulating oil than mineral oil if it were spill onto soil or water. Table 2.1 shows the comparison properties of PFAE, vegetable oil and mineral oil.