RECLAMATION OF WASTE COOKING OIL METHYL ESTER

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DECLARATION

I declare that this thesis entitled "RECLAMATION OF WASTE COOKING OIL METHYL ESTER is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : .....

Name : .....

Date : .....

APPROVAL

I hereby declare that I have checked this report entitled "Reclamation Of Waste Cooking Oil Methyl Ester" and in my opinion, this thesis it complies the partial fulfillment for awarding the award of the degree of Bachelor of Electrical Engineering with Honours

Signature : .....

Supervisor Name : .....

Date : .....

DEDICATIONS

To my beloved mother and father

ACKNOWLEDGEMENTS

In the name of Allah SWT the Most Beneficent and Merciful, all praises and glory be upon Him. Blessing and Greeting upon our beloved prophet Muhammad SAW, his family and companions.

First and foremost, I would like to say Alhamdulillah to Allah S.W.T. for giving strength, ideas and healthy body during the completing my progress report final year project. With the blessing from our creator Allah S.W.T., the progress report had completed as the way it is.

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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, liquid insulation in the transformer degrades and begins to lose its function as an insulation medium, which affects the transformer's life and efficiency. The problem occurs when the waste oil is converted into new mineral oil. Mineral oil in transformers can affect the environment if accidents occur during working hours. The decision of replacing, refurbishing or repairing a service aged power transformer requires considering several factors, especially the cost and time to execute the work. 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. Catalyst which is sodium hydroxide (NaOH) content is analyzed for WCO methyl ester transesterification. In addition to analyzing the differences in the sequence between recycling and transesterification in an opportunity to impact the oil quality improvement process. The study are carried out to verify the results using the optimum reclamation process parameters, it is found that there is significant improvement in the AC breakdown voltage, total acid number (TAN), moisture and Ultraviolet-Visible (uv-vis) for the reclaimed transformer oil. This method is believed to be an independent tool for determining the optimal parameters for the recovery process for methyl ester waste oil.

ABSTRAK

Penebat cecair adalah medium penting dalam sistem kuasa terutama transformer yang berfungsi sebagai penebat serta penyejuk. Apabila tahun berlalu, penebat cecair dalam pengubah merendahkan dan mula kehilangan fungsinya sebagai medium penebat, yang mempengaruhi kehidupan dan kecekapan pengubah. Masalahnya berlaku ketika minyak buangan diubah menjadi minyak mineral baru. Minyak mineral dalam transformer boleh menjejaskan alam sekitar sekiranya berlaku kemalangan semasa waktu bekerja. Keputusan penggantian, pembaikian atau pembaikan perkhidmatan pengubah kuasa yang berusia memerlukan mengambil kira beberapa faktor, terutama kos dan masa untuk melaksanakan kerja. Untuk mengelakkannya daripada berlaku, minyak sayuran digunakan sebagai cecair penebat alternatif untuk minyak pengubah kerana ia lebih mesra alam sekitar. Kandungan pemangkin yang natrium hidroksida (NaOH) dianalisa untuk transesterifikasi metil ester WCO. Di samping menganalisis perbezaan dalam urutan antara kitar semula dan transesterifikasi dalam peluang untuk memberi kesan kepada proses peningkatan kualiti minyak. Kajian ini dijalankan untuk mengesahkan keputusan menggunakan parameter proses penambakan optimum, didapati terdapat peningkatan yang signifikan dalam ketahanan voltan AC, jumlah asid (TAN), kelembapan dan Ultraviolet-Visible (uv-vis) untuk ditarik balik minyak pengubah. Kaedah ini dipercayai sebagai alat bebas untuk menentukan parameter optimum untuk proses pemulihan untuk minyak buangan metil ester.

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LIST OF SYMBOLS AND ABBREVIATIONS

UTeM	-	Universiti Teknikal Malaysia Melaka
FYP	-	Final Year Project
WCO	-	Waste Cooking Oil
WCOME	-	Waste Cooking Oil Metyl Ester
BdV	-	Breakdown Voltage
TAN	-	Total Acidity Number
IEEE	-	Institute of Electrical and Electronic Engineer
ASTM	-	American Society for Testing and Materials
uv-vis	-	Ultraviolet–visible
FTIR	-	Fourier-Transform Infrared
IR	-	Infrared
NaOH	-	Sodium Hydroxide
g	-	Gram

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CHAPTER 1

INTRODUCTION

1.1 Background

Power transformers are the backbone of the world's electricity and distribution systems. The price of power transformers is exorbitant and therefore, frequent maintenance is necessary to ensure that these systems are highly reliable during their operation. The service life of mineral insulating oils is typically 30 to 40 years for power transformer applications [1].

Insulating liquids are generally preferable because these liquids serve a dual purpose are insulator and coolant. It is expected that mineral oils will continue to be in use for at least a decade and it is known that the dielectric properties of the oils will be altered as a consequence of aging, which will degrade the efficiency of the transformers. In addition, it is common knowledge that the insulating systems of transformers will deteriorate gradually due to their high operating temperatures as well as high levels of moisture and oxidation of the transformer oils. The insulating systems performance will decrease due to changes in the chemical structures of the dielectric media as a result of high thermal stresses which adversely affect the transformer operation and if left unchecked, will lead to catastrophic failure of the transformers [7]. There are three ways to treat insulation oils through re-refining, reconditioning, and reclamation [2], [7].

1.2 Problem Statement

Petroleum based mineral oil has long been used as insulation for the transformer. Mineral oil acts as a cooling and insulating medium in transformer. Transformer mineral oil has been replaced by alternative oils such as vegetable oil. Oil is chosen based on its biodegradability and environmentally friendly nature. Due to the environmental consideration, mineral oil is the poor biodegradability and future scarcity. It can cause pollution and contaminate the soil if there is a heavy leakage.

The mineral oil was extracted from the oil that will run out in the future, and the oil is non - renewable energy [19].

The identification that is satisfied with their nature in different circumstances is the main reason for their application as an insulating liquid in the energy industry. Enhancing the production process and treatment of mineral oil has contributed to a significant price effect, which is one of the key criteria that potential potential transformers consider. Where transformer oil can't be used for a long time. However, the price is still reasonable to make mineral oil still the preferred liquefaction fluid for consumers, although alternative liquids have significantly improved environmental and fire properties. [13].

In addition, the use of waste cooking oil circumvents the problem of oil vs food, which has become a hotly debated issue in recent years. Cooking oil consumption increases and its consistent supply makes waste cooking oils commercially viable. Approximately 3 billion liters of cooking oil are used in Malaysia every year. However, only 30 % of waste oil food is available for biodiesel production which translates to about 10 % of diesel demand in Malaysia. Things look like waste, where demand increases every day. [28]-[29]. In this study, waste cooking oil methyl ester (WCOME) is chooses to be new insulating oil.

1.3 Objectives

The objectives of this project are:

a) To investigate the influences of catalyst for transesterification process of waste cooking oil methyl ester.

b) To investigate the reclamation process to improvement in the mean the breakdown voltage, total acid number, moisture, and ultraviolet-visible.

c) To analyze the sequence of process to improvement waste cooking oil methyl ester.

1.4 Scope of research

The scopes of the research are listed as follow:

a) To analysis the effect of different ratio of alcohol and catalyst for transesterification of waste cooking oil methyl ester.

b) Types of parameters which is weight of the Fuller's Earth adsorbent, stirring speed, and oil temperature for reclamation of waste cooking oil methyl ester.

c) The results for reclamation process of AC breakdown voltage, total acidity number, moisture and ultraviolet-visible.

d) Analysis the sequence of process to improvement waste cooking oil methyl ester.

1.5 Project Outline

This thesis consists of five chapters which are introduction, literature review, methodology, result and conclusion. The first chapter had reviewed the objective and scope of this project with background of study. Next, in chapter two is more focused on the literature review and theory from the research for this project.

In chapter three, the methodology of the project such as reclamation process, transesterification process and procedure for breakdown voltage has been summarized in this chapter. The result and discussion are presented in chapter four. Lastly, conclusion, recommendation and future work are outlined in chapter five.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Transformer oil is a type of fluid which may be a type of mineral which is an insulating oil. This oil needs to be through the breakdown of refining and treatment of crude petroleum at the petroleum refineries. The transformer oil works mainly for two purposes, namely liquid insulator in the electric power transformer and two heat release transformers, such as coolant. [19].

In today's uncertain economic climate, it is important to know the situation through the appropriate diagnostic test that fluid paper can be used as the main insulator in the transformer to be harmless and can be used for long periods of time. Today, the development of new laboratory test procedures for liquid insulators in recent years has been a satisfactory result of a cooperative research project designed to improve the life- long conversion of aging power[14]. Some references have been modified to discover alternative methods to maximize the present oil. However, the results are unsatisfactory because the study relates only to the nature of the insulating oil from the suitability of oil as an insulating oil without taking any other relevant factors.

2.2 Transformer Oil

Power transformer is one of the most important parts of transmission power and distribution network in the industry. Meanwhile, the main role of transformer oils provides a thermal insulation. The life and efficiency of the power transformer depends entirely on the quality of the insulating oil that needs to be monitored on an ongoing basis. [14]. There are three types of transformer oil that are mainly used such as mineral oil, ester oil and silicone oil.

2.2.1 Mineral Oil

Mineral oil is one of the most commonly used insulating liquids today. It is used in many electrical devices. Undoubtedly the application of mineral oil produces many positive properties and excellent recognition over the years [13]. Transformer oil based on mineral oil can be produced either from naphtha or paraffin. The Figure 2-1 below shows the elements of mineral oil based transformer oil production.

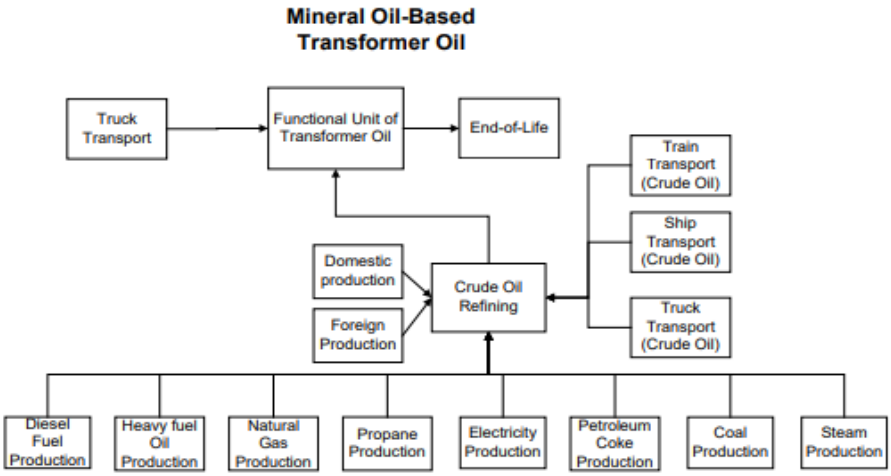


Figure 2-1 : Mineral Oil Based Transformer Oil System Boundaries

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 liquids from natural esters have several characteristics that are recognized in a variety of uses, compared to mineral oils. These characteristics are primarily ecological properties such as biodegradability and non-toxicity, and the operational safety properties of operations that include lightning and high fuels. For this reason, where fire safety and environmental protection play an important role as it is used in the industry. The use of esters filled with transformers is a reasonable solution for today [13].

2.2.3 Palm Fatty Acid Ester (PFAE)

In acknowledgment of increasing global environmental concerns and the need to switch from dependence on fossil fuels to energy needs, the development of transformers with ester- type oils is in progress. This type of oil, palm fatty acid ester (PFAE) is rich in biodegradability and used to replace conventional mineral insulation. Today, the industry leads to an ecosystem-friendly transformer using PFAE as a vegetable-based insect oil. PFAE is a very green and strong high performance oil. Compared with mineral oil, its kinetic viscosity is low and the dielectric constant is high. When used in oil transformers, there is therefore the possibility that we can realize a best design. When it is used as insulating oil, it offers outstanding features in terms of stable supply and oxidation stability [15].

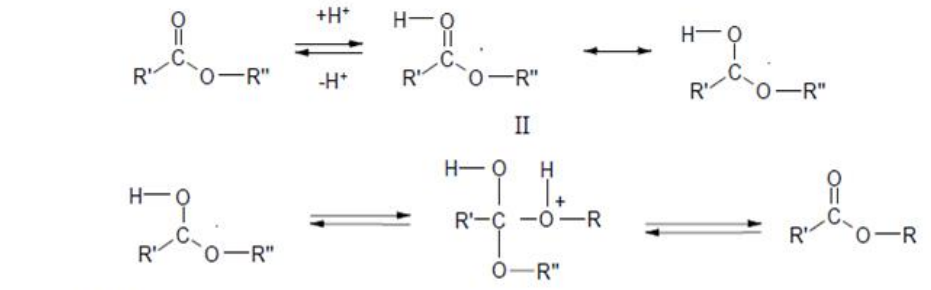
Table 2-1 shows the comparison of physical properties of PFAE, and mineral oil.

Table 2-1 The comparison of physical properties of PFAE, and mineral oil [15].

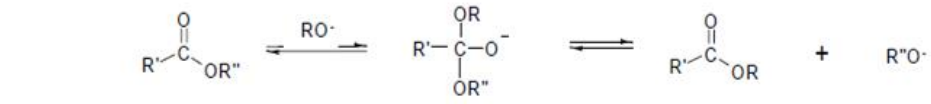
Item	PFAE	Mineral oil	Remark (condition)
Density (g/cm3)	0.86	0.88	15ºC
Kinetec viscosity (mm2/s)	5.06	8.13	40ºC
Flash point (ºC)	186	152	COC
Pour point (ºC)	-32.5	-45	
Acid Number (mgKOH/g)	0.005	<0.01	
Dielectric constant	2.95	2.2	80ºC
Volume resistivity (Ω. Cm)	7.1 x 1012	7.6 x 1015	80ºC
Dielectric breakdown voltage (kV)	81	70~75	2.5mm

2.3 Transesterification Process

Transesterification is a term used to demonstrate direct conversion of lipid triacylglycerol's by alcohol to an alkyl ester without separating free fatty acids (FFA). In particular, in the presence of an acidic or alkaline catalyst to produce fatty acid esters and glycerol, a triglyceride such as vegetable oil reacts with an alcohol, usually methanol. The catalyst may be acidic or alkaline. Alkaline metal alkoxides such as sodium methoxide and hydroxides are more effective than acid catalysts. The well-known mechanisms of acid and alkaline alcoholysis are depicted in Figure 2-2 [11], [12].



Scheme 1. Mechanism of acid alcoholysis.



Scheme 2. Mechanism of alkali alcoholysis.

Figure 2-2 ; Mechanism of Alcoholysis

2.4 Reclamation Process

The oil used can be claimed in many ways to restore its original characteristics. Oil reclamation effectively reduces the level of unwanted molecular species found in service transformer oils, such as sludge, acid, ketones, other polar species and water produced by the aging process. Therefore, reclamation brings substantial benefits not only to utility companies but also to communities in general, thereby reducing combustion of oil and environmental impacts on gas effluents generated by combustion of petroleum derivative. Another important benefit is the demand for lower mineral oil and therefore less use of non-renewable petroleum derivatives. For

the final consumer, the economic advantage of this process is considerable, as the cost of regenerated oils is about 30% lower than that of the new product, while the quality is similar [2], [3]. Reclamation of insulating oils by means of adsorbent beds has been widely implemented for almost 30 years. In practice, there are two types of operation modes for the reclamation process, as shown in Figure 2-3 [1].

Figure 2-3 : Online Mobile Insulating Oil Reclamation Plant: (left) Mobile Truck; (right) Column Tanks Filled with Adsorbent [1]

Some techniques have been carried out by some researchers and some oil regeneration companies. It consists of reclamation through adsorption and filtration type. The explanation below show two types of reclamation process.

2.4.1 Reclamation By Percolation

The oil used is filtered by a layer of granulated sorbent material loaded in vertical cylindrical vessels [20]. The insulating oil is collected from the bottom of the electrical equipment, and heated to a specific temperature. The insulating oil is circulated through a filter in order to eliminate solids and suspended particles, and the oil is delivered back to the top of the electrical equipment. The insulating oil is then circulated through one or more cartridges containing adsorbents such as Fuller's Earth in order to remove soluble polar contaminants. Lastly, the insulating oil is circulated through a reconditioning device in order to remove moisture and gasses [1].