" I hereby declared that I have read through this report entitled *"The Effect of High Voltage Stress on Different Types of Engine Oils"* and found that it has comply the partial fulfillment for awarding the degree of Bachelor in Electrical Engineering (Industrial Power)"

Signature : ……

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Date : …….

THE EFFECT OF HIGH VOLTAGE STRESS ON DIFFERENT TYPES OF ENGINE OILS

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

Faculty of Electrical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

MAY 2010

I declare that this report entitle *"The Effect of High Voltage Stress on Different Types of Engine Oils"* 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.

Signature: .....

Name : MOHD FAQRUL REDZA BIN TAHIRUDDIN

Date : 22 April 2010

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ABSTRACT

There are 4 types of insulator which are solid, liquid, gas and high vacuum. This project was focusing on liquid insulator. The project was carried out to determine the breakdown voltage of 3 different types of PETRONAS engine oil which are MACH 5, SYNTIUM 800 and SYNTIUM 5000. Generally, the data from this project were an indicator for the suitability of the engine oil to replace the transformer oil as an insulator. The expensive price of the transformer oil is the main reasons to replace it. In this project, each type of engine oil were tested with the nature of high voltage that consists of high voltage alternate current HVAC and high voltage direct current HVDC generated by the HAEFELY High Voltage Construction KIT. Each oil was divided by three conditions such as new oil from bottle, heated oil and contaminated oil. Test results show the different breakdown voltage of each type and condition of the oil. The analysis from the breakdown voltage of each type of the engine oil determined the most optimum engine oil performance according to high voltage.

ABSTRAK

Terdapat 4 jenis penebat iaitu pepejal, cecair, gas dan vacuum tinggi. Projek ini memfokuskan kepada penebatan cecair. Projek ini dilaksanakan untuk mendapatkan voltan pecah tebat terhadap 3 jenis minyak enjin PETRONAS iaitu minyak MACH 5, SYNTIUM 800 dan SYNTIUM 5000. Secara umumnya data yang diperolehi daripada projek ini akan dapat menentukan kesesuaian minyak enjin untuk menggantikan minyak pengubah sebagai penebat. Penggantian minyak pengubah ini adalah kerana harga nya yang mahal. Di dalam projek ini, setiap jenis minyak enjin diuji dengan voltan tinggi arus ulang alik HVAC dan voltan tinggi arus terus HVDC yang telah dijana menggunakan kelengkapan Voltan Tinggi HAEFELY. Setiap jenis minyak dibahagikan kepada tiga keadaan seperti minyak yang baru keluar dari botol, minyak yang dipanaskan dan minyak yang tercemar. Keputusan ujian menunjukkan perbezaan voltan pecah tebat mengikut setiap jenis minyak dan keadaan minyak tersebut. Analisa daripada voltan pecah tebat setiap jenis minyak enjin menghasilkan prestasi minyak enjin yang paling optimum terhadap voltan tinggi.

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CHAPTER 1

INTRODUCTION

1.1 Project Background

The title of this project is *"The Effect of High Voltage Stress on Different Types of Engine Oils".* This is a study case project base on experimental work approach that studied and analyzed the effect of high voltage stress on different types of engine oil. The main reason of the study was to replace the transformer oil in the transformer. The transformer needs oil for the insulation of its winding. The oil must have high breakdown strength to rely on the rating of the transformer. By studying the effect of high voltage stress on the engine oil will gain the knowledge of the electrical characteristic of the engine oil. High voltage has a range of exceeding 1000v for HVAC and exceeding 1200v for HVDC were been used in huge applications such as in the power systems, industry and research laboratories. Both HVAC and HVDC need to have a good medium of insulation during the operational for safety precaution.

This project was developed to focus on the PETRONAS engine oil as the medium of liquid insulation. Three types of oil that involve in this project were PETRONAS MACH5 (mineral oil), PETRONAS SYNTIUM 800 (half synthetic oil) and PETRONAS SYNTIUM 5000 (full synthetic oil). Each type of oil was divided by three conditions which are new oil from bottle, heated oil and contaminated oil. The experiment was focusing to determine the electrical characteristic which is the breakdown voltage of each type of engine oil.

The different types of engine oil will be tested with two types of nature high voltage which are the high voltage alternating current (HVAC) and the high voltage direct current

(HVDC). Both types of nature high voltage were generated using the HAEFELY High Voltage Construction KIT.

The analysis from the breakdown voltage of each type of the engine oil stress on the different kind of nature high voltage will determined the most optimum engine oil performance.

1.2 Problem Statement

Transformer oil was usually applied in the transformers for the purpose of electrical protection. It plays an important role to protect and prevent the explosion in electrical circuits. The fluctuations of the world economy have influenced the cost of transformer oils and became more expensive. Hence, this project was implemented to replace the transformer oils with the engine oil that are cheaper than the cost of transformer oil. The quality of transformer oils, as the insulated liquid, is one of the most important factors to be focused. Regarding to that reason, this project analyzed the quality of the engine oil within 3 different conditions test which are new oil, heated oil and contaminated oil. Besides that, most of the transformer oils were imported from overseas, causing a long purchase period and affected the plan of projects construct and change oil during overhaul. The research of PETRONAS engine oil will be a platform to rid of the foreign oil supplier's monopolization and saving money to reduce operation costs.

1.3 Objective

The objectives of this research are:

i. To replace the imported transformer oil which have high cost.
ii. To identify the electrical characteristics focusing in breakdown voltage of the engine oil.

iii. To analyze the result among each type of engine oil and their condition from the breakdown voltage.

1.4 Scopes of the research

This project has a limitation in term of tools, method and approach. The project focuses on:

i. Using three types of PETRONAS lubrication oil product only. Which are MACH 5, SYNTIUM 800 and SYNTIUM 5000
ii. Each type of oil was divided in three conditions which are the new oil from bottle, heated oil and contaminated oil.
iii. Generating the nature high voltage using the HAEFELY high voltage test kit.
iv. Doing the high voltage test of HVAC and HVDC test on each type of engine oil.
v. Analyzing the suitability of engine oil to replace the transformer oil in the step down transformer rating of 33kV to 11kV

1.5 Report Outline

This report was divided into 5 chapters where is consisting:

Chapter 1 : Introduction

Chapter 1 is about introduction of the project that has been conducted, problem statements, objective and scope of the project. The project was done according to the objective and scope of this project that state at earlier.

Chapter 2 : Literature Review

Show the overview of this project based on literature review and theory background. In this chapter the explanation was about the liquid insulation and the standard to test and how to generate High voltage using several methods such as AC and DC using the HAEFELY High Voltage Construction KIT. Studies on literature review helps in understanding about methods and their circuit diagram of the high voltage circuit.

Chapter 3 : Methodology

Shows the flow chart of the methodology in the entire project that being conduct for this testing and with some brief explanation about the flow chart.

Chapter 4 : Result and Discussion

Show the table of the results, and the discussion including the analysis from the result.

Chapter 5 : Conclusion and recommendation

Conclude all the experimental work and testing that conducted in this project. Some suggestion was given to help another student for their project reference.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Transformer is the most important device in electrical field. It is like a heart of electricity. The price of a transformer can be from RM40, 000 to RM1, 000,000 according to the rating and the application of the transformer. The transformer rating of 33kV/11kV worth up to RM 70 000 and above while the transformer rating of 11kV/3.3kV worth above RM40 000. Transformer is a component used in AC circuit to convert the incoming voltage to another voltage either higher or lower. The function of transformer is to transfer the electrical energy which involving the changes in magnitudes of voltage and current. It usually used in consumer electronic products to step down the supply voltage to a suitable level. Within the operation of the transformer, the cooling and insulating system is the most important factor to ensure the efficiency performance of the transformer. Because of that reason, the use of oil in the transformer fulfills the both insulation and cooling system of the transformer. Figure 2.1 shows the cross section of the transformer, where the oil filled in the whole area.

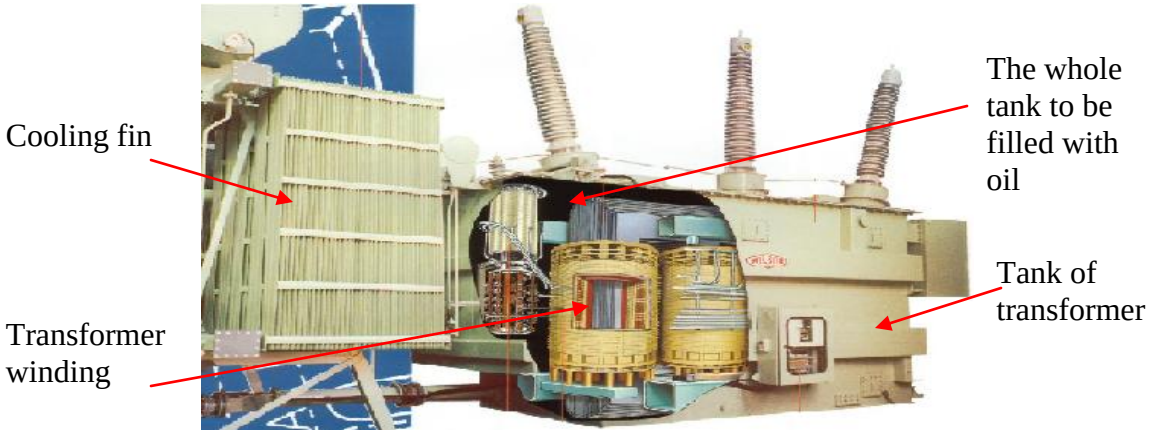

Figure 2.1: The cross section of the transformer.

2.2 Liquid Insulation

Transformer oil is categories as liquid insulator acts as heat transfer agent [1]. The transformer oil must have a high breakdown voltage to avoid a transformer failure. The failure of the transformer will cause an expensive cost to replace the new transformer. Hence the quality of oil needs to be as higher as possible. The breakdown strength of the oil can reduce due to the presence of impurities [1]. The important electrical properties of the liquid are dielectric strength, conductivity, flash point, gas content, viscosity, dielectric constant, dissipation factor, stability, etc [1]. The factor that affects the electrical strength of insulating oil is the presence of water in the form of fine droplets suspended in the oil. Dielectric strength of oil reduces more sharply if it contains fibrous impurities in addition to water [1]. The breakdown voltage also depends on the liquid viscosity, liquid temperature, the density and the molecular structure of liquid [1]. The effort to obtain the highest quality of transformer oil is still going for better performance of transformer in the future. The decision to use better quality transformer oils is also justified by the costs and reliability influence of a transformer failure [2].

2.3 Previous Research

From the previous efforts, the research to replace the imported SHELL Diala oil with the new oil of Kelamayi Oil has been done in Guangzhou China 2009 [2]. The research was done because the high cost of the imported oil [2]. The result shows that the domestic Kelamayi Oil is superior to SHELL Diala oil in general properties [2]. The research has improved the significant independent technology innovation in their country and Domestic production of transformer oils [2]. Base on others previous research, the engine oil have been studied to determine the dielectric strength. Three type of engine oil from the manufacturer of SHELL such as synthetic based oil, mineral oil and motorcycle oil were tested [3]. The research was focus to determine the breakdown voltage of each type of upon the HVAC, HVDC and Impulse Voltage [3]. The result shows that the sample of synthetic oil has the highest breakdown voltage during the testing [3].

2.4 Current Research

After evaluating the previous research, this research is focusing to determine the breakdown voltage of domestic PETRONAS Engine Oil. The oil is cheaper because it was not imported from other country. The test is design in two types of nature high voltage such as High Voltage Alternating Current (HVAC) and High Voltage Direct Current (HVDC). Figure 2.2 below shows the circuit diagram of HVAC and HVDC construction with the point of test object.

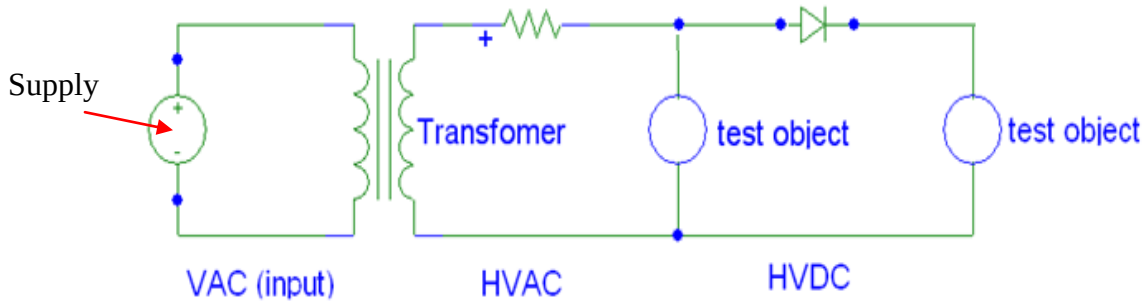

Figure 2.2: The circuit Diagram to generate the nature high voltage of HVAC and HVDC with the point of test object [4].

From the figure 2.2 above, the circuit was the most suitable design to generate HVAC and HVDC applied by UTeM High Voltage Laboratory. The AC voltage was the input from the supply. The AC input will increased by the step up transformer. The secondary winding of the transformer will increased the voltage output to above 1000V for HVAC. The test object which is the engine oil was connected from the transformer to the ground. Probe was used to connect the oil with the circuit connection. For HVAC generation, the components involved in completing the test were the transformer and probe connected with the test object.

To generate the HVDC natural high voltage, the component of HV Diode plays an important role. By plugging in the additional component of HV Diode, the circuit was ready to generate the HVDC output. HV Diode act like switch to filter the negative output waveform, producing the pure DC output waveform. The DC voltage was increase before it was filtered by the diode. The test object was clipped by the probe between the end of the connection of HV diode and the ground point.

2.4.1 Main Component of HVAC

The HVAC circuit is consisting of a step up transformer and the test object. The construction of the HAEFELY High Voltage Construction KIT to generate HVAC as shown in Figure 2.3 below:

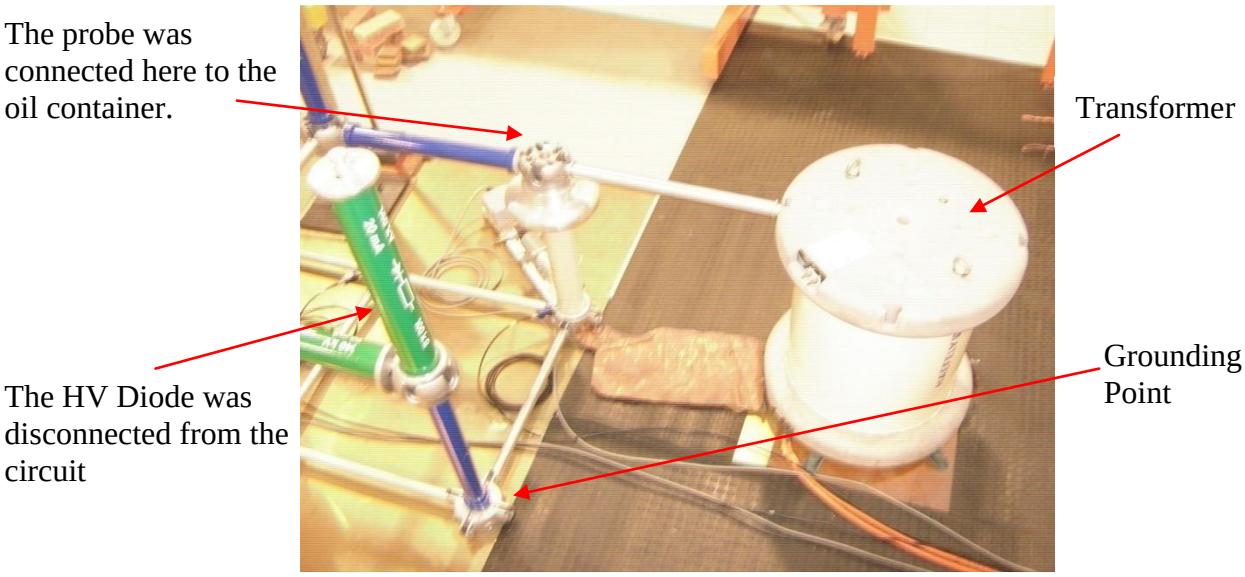

Figure 2.3: The Construction of HAEFELY High Voltage Construction KIT to Generate HVAC in UTeM's High Voltage Laboratory.

2.4.1.1 Transformer

The transformer that been used is Single Phase Ac Voltage Test Transformer (PZT 100-0.1). Test transformer was used for AC and DC generation [4]. The rated as shows below:[4]

Rated voltage : 220V / 100kV
Rated power : 5kVA, continuous
10kVA, 1 hour
Rated current : 0.075 mA

2.4.2 Main Component of HVDC

The HVDC circuit is consisting of a step up transformer and high voltage diode. The construction of the HAEFELY High Voltage Construction KIT to generate HVAC as shown in Figure 2.3 below:

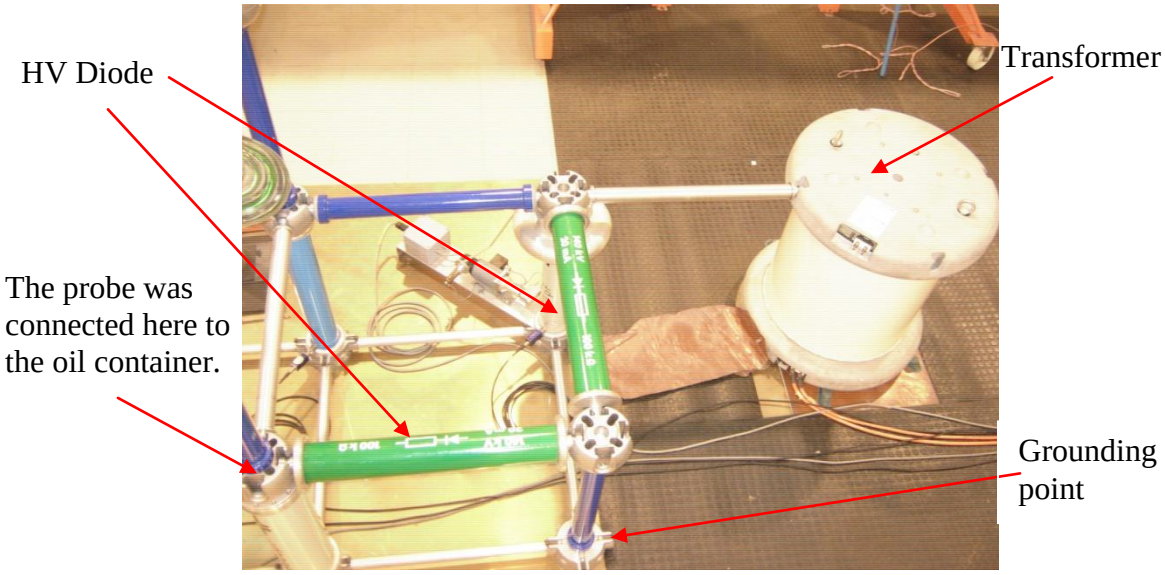

Figure 2.4: The Construction of HAEFELY High Voltage Construction KIT to Generate HVDC in UTeM's High Voltage Laboratory.

2.4.2.1 Transformer

Use the same transformer rating as to generate the HVAC.

2.4.2.2 HV Diode

Two diodes are used in generation of HVDC. The specification of the diode is shown as below [4].

Protective resistor	: 100 kΩ
Inverse peak voltage	: 140 kV
Rated current	: 20mA

The frequency for the 2 types of nature high voltage affected the dielectric strength of the oil. The HVAC tested results obtain lower breakdown voltage comparing with the breakdown voltage of the HVDC. This is because the heat from the alternating current and frequency of the waveform in HVAC will lead to the formation of vapour bubbles and followed by the breakdown [1]. Furthermore the HVDC did not have a frequency of the current.

2.4.3 Type of Engine Oil

The oils uses in this project are PETRONAS MACH5, PETRONAS SYNTIUM 800 and PETRONAS SYNTIUM 5000. Each type of oils has their own performance to the engine. The specification of the oil was briefly explained as shows in Table 2.1 below [5]:

Table 2.1: The Product typical of the engine oil.

Types of Oil	**PETRONAS MACH5**	**PETRONAS SYNTIUM 800**	**PETRONAS SYNTIUM 5000**
Parameter	Mineral Oil	Half Synthetic	Full Synthetic
Viscosity Index	139	146	176
Density @ 15°c	0.8810	0.8655	0.8450
Pour Point, °c	-30	-32	-51
Flash Point, °c	212	230	220
Sulphated Ash, %wt	1.06	1.03	0.72
Kinematic Viscosity, cSt **@ 40°c** **@100°c**	 67.9 10.4	 128.6 17.2	 51.0 9.6

2.4.4 Typical of the Engine Oil

This explains the typical or the term used in the characteristic of engine oil.

2.4.4.1 Viscosity

Viscosity is the measurement of liquid resistance to flow [6]. The different viscosities indicate different power variation of engine [6]. It must be high enough to provide lubrication for the engine [6]. Low viscosity will produce problem to restart the engine in hot temperature, rough idle and white exhaust smoke [6].

2.4.4.2 Density

Density is a relative mass of material [6]. The higher the density of the oil will produce more power to the engine than the low density because the thermal energy content is high [6]. 10 degree of decreasing density will decrease 3% - 5% thermal energy in the oil [6].

2.4.4.3 Pour Point

The better quality of engine oil is the lower the cloud point [6]. As ambient temperature continues to drop the oil reach it pour point, where it solidifies and no longer flow [7].

2.4.4.4 Flash Point

Flash point is a temperature at which the vapors on the surface of oil will ignite and exposed to an open flame [6]. A lower than normal flash point will indicate contamination of engine oil [6].

2.4.4.5 Sulphated Ash

Sulphur content is important for the live of engine [6]. Sulphur creates sulphuric acid during combustion process which can damage engine component [6]

2.4.4.6 Kinematic Viscosity

Automotive oil is needed at both high and low temperature. SI unit for kinematic viscosity is centistokes, cSt which is equivalent to mm^2/s [6]

2.4.5 Transformer Oil

Transformer oil also has their own typical product as an indicator to the quality of the oil. This typical product of transformer oil is different from the engine oil because of the different usage of the oil. Table 2.2 below shows the typical product of transformer oil [7].

Table 2.2: The product typical of transformer oil.

Types of Oil	**SHELL DIALA A**
Density @ 15°c kg/l	0.885
Pour Point, °c	-50
Flash Point, °c	148
Breakdown Voltage kV	37
Kinematic Viscosity, cSt @ 40°c	2.3

2.4.6 The price Transformer Oil and Engine Oil

The research is focus to compare each type of oil in concern of the price of the product. The price of the product is depending on the global economy. Table 2.3 shows the price of engine oil and the transformer [5][8][9].