CURRENT MEASUREMENT OF ENGINE OIL WITH VARIOUS GAP LENGTH ELECTRODE

BENEDICK CONOLIUS AK GABRIEL ADDRIS

UNIVERSITI MALAYSIA PAHANG

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This thesis is submitted as partial fulfilment of the requirements for the award of the Bachelor of Electrical Engineering (Hons.) (Power Systems)

Faculty of Electrical & Electronics Engineering
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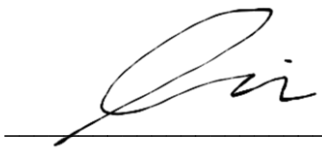

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DEDICATION

Dedicated especially to my parents;

Mrs. Lanen ak Sitin

Dearest family members and friends

My Supervisor Dr. Amir Izzani bin Mohamed

Without their support, inspiration and kindness for me, I might not be the person I am today.

Thank you so much.

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ABSTRACT

This thesis present about the conductivity of engine oil that exist when there is conductive particle involve in the viscosity of lubricant oil. Its also known as hydrocarbon particles. Experiment for voltage-current characteristic normally done by using electrode to detect the current or conductivity of lubricant oil. For this experiment, the gap length of electrode has been design from 1mm until 10mm. The electrode has been printed to PCB board so that easy to be conducted during experiment. Different kilometre of the sample lubricant oil has been collected after their utilization in transport system. There are two types of lubricant oil that being tested that are motorcycle's and car's lubricant oil. The high voltage DC supply will be connected to electrode. All the data obtained for each gap length of electrode has been recorded.

ABSTRAK

Tesis ini adalah mengenai tentang kekonduksian minyak enjin yang wujud apabila terdapat zarah konduktif yang terlibat dalam kelikatan minyak pelincir. Ia juga dikenali sebagai zarah hidrokarbon. Eksperimen untuk ciri voltan-arus electric biasanya dilakukan dengan menggunakan elektod untuk mengesan kekonduksian minyak pelincir. Untuk eksperimen ini, panjang jurang elektrod telah direka bentuk dari 1mm-10mm. Bentuk elektrod telah dicetak pada papan PCB supaya mudah untuk dikendalikan semasa melakukan eksperimen. Sampel minyak pelincir telah dikumpulakn mengikut perbezaan jarak penggunaan dalam system pengangkutan. Terdapat dua jenis minyak pelincir yang akan diuji iaitu minyak pelincir motosikal dan kereta. Bekalan voltan tinggi arus terus akan dihubungkan dengan elektrod. Semua data yang diperolehi untuk setiap panjang jurang elektrod telah direkodkan.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

Ω	Ohm
V	Volts
I	Current (amps)
ρ	Resistivity
σ	Conductivity
A	Area (cm^2)
d	Distance
$\varepsilon_{o,}\ \varepsilon$	Electric Constant
C_0	Capacitance in the absence of the dielectric
+	Positive
-	Negative

LIST OF ABBREVIATIONS

API	American Petroleum Institute
DC	Direct Current
HVDC	High Voltage Direct Current
kV	KiloVolts
Mg	Milligram
mL	MiliLitre
mm	Milimetre
PCB	Printed Circuit Board
RPM	Rotation Per Minute
RTD	Resistance Temperature Device

CHAPTER 1

INTRODUCTION

1.1 Overview

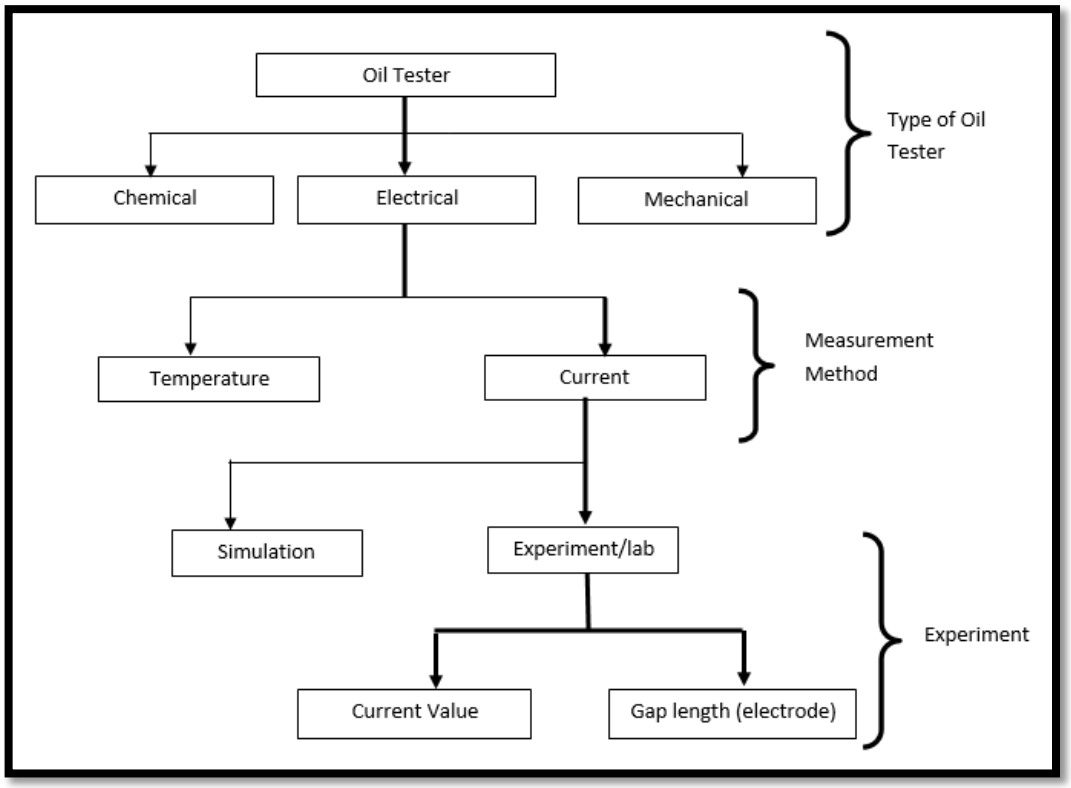

Figure 1.1 Focusing of the project

Figure 1.1 shows that this project will focus to do the analysis of the engine oil to get the current value or conductivity for each different of the gap length of the electrode based on the distance of lubricant oil has been used in transportation system.

Engine oil tester or engine oil analysis is one of most important way to know whether the engine oil is in good condition; that mean that it can be use further or need to be changed. Lubricating oil is a major requirement for most applications that involves moving parts. It used to reduce the friction between the moving parts hence this can make the engine or the moving parts to run smoothly. Lubricant degrades during the course of the operation and the degradation process is governed by many parameters such as temperature, contaminants, electrical properties and etc.

The changing of the engine oil need to be taken seriously since the lubricant deterioration leads to undesired problems such as system malfunction, damage and failure of the engine. To prevent this happen, appropriate maintenance strategy need to be taken by the owner since the exchange of the engine oil is depends on the mileage, driver's style and habit, driving routines etc. Nowadays, there are so many sensors or type of detecting the condition of the engine oil but people also cannot buy it due to the price and budgets.

Today, figure 1.2 is one oil tester that have been used widely that is Lubricheck. People nowadays just depend to the advice that been given by the oil companies or service station to changes oil every 3000 to 5000 miles. Normally by using this tester it is easier to know the condition of the oil since it's used to measure or test all variables in the chemistry of the oil. This because the tester will directly detect or react to the acidity, metal particulates, carbonized particulates and foreign liquids such as water leaks or coolant leaks that may present in the oil.

Figure 1.2: Lubricheck Tester [21]

This project or data analysis can help the people to check their engine oil condition since the increase of the living costly lately reducing the buying power of people. In this project, a simple design of gap length of the electrode has been designed by using PCB construction. This is to find the different current or conductivity of each distance lubricant oil has been used to be references in the future. That's mean to help people nowadays to know their own condition of engine oil.

1.2 Objectives

The objectives of this project or research are to:

- To identify the current/conductivity from original oil compares with used oil
- To suggest the data of electrical graph with the condition of the engine oil

1.3 Scope of Project

The motorcycles and automobile lubricant oil has been choose for this project since it more cheaply and because the engine normally run in higher rotation per minute (RPM) and it has very short time used compared to car's engine.

The scopes of project are:

- Electrical graph is limited to current value obtain
- Engine oil tested is motorcycle's and automobile lubricant oil

1.4 Problem Statement

Nowadays, most of people do not know whether they buy the genuine engine oil or maybe the oil has been recycled that mean it has already been used by other user. Besides that the price of the oil that seller offer or sell is much cheaper by the reason that it is promotion since we know that the engine oil is not cheaper but how the seller put the promotion for long time period. This is suspicious enough to show that the oil that they put promotion maybe recycled oil that has been use before by the others user. The hypothesis of this experiment was the value of current will increase depends on their utilization in transport system.

1.5 Thesis Organization

This thesis consists of five chapters that are introduction, literature review and methodology, result and conclusion.

Chapter 1, overview of project, objective research, project scope, problem statement and thesis organization are discussed.

Chapter 2, Literature review contains a detailed description from others journal about engine oil analysis. All the ideas and results from the journal are summarized and conclude into the review to be references during this project progress.

Chapter 3, Methodology contains detailed explain about steps that need to follow during this project. In this chapter, all the design such as electrode design and full design of the hardware are presented. All method and hardware price also placed in this chapter.

Chapter 4, Results will discuss about the result of the project. All the result obtained will be provided by using Microsoft excel. There also some figures of experiment that has been conducted.

Conclusion chapter will discuss about the conclusion based on the result obtained from this project. Also include the recommendation for this project for future improvement.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter discuss about the literature review of engine oil analysis. This reviews based on the journals that have been summarize. This chapter has 4 parts, condition monitoring, oil properties based on electrical analysis, method of electrical property measurement and experiment by using electrode.

2.2 Condition Monitoring

Generally, condition monitoring increases the performance of a machine and its life-time, lowers the operating costs, reduces the downtime cost and prevents failures [4]. This play an important role in many machine based technologies and systems maximising machine reliability, availability and maintainability. It can be seen from three points of view: the condition of the lubricant, the presence of contaminants and machine wear [5].

Engine oil is very important since the function is to reduce the tear and wear of engine. Primary function of the oil is to lubricate the moving parts and also to clean, prevent to rust formation, improve the sealing and cooling the aggregate by transportation of heat from engine [1]. As we know that the engine part is moving against each other and this is resulting to the friction and power loss through conversion into heat.

Besides that, the process of degrading will continue and if we not take action to this, it will cause a system malfunctions, damage or something that really does not want to happen is failure. So, it needs to be changed regularly due to the moving part of the engine component [3].

Apart from that, as we know that there is so much analysis or study of degradation parameters in engine oil that have been done by so many researcher to ensure that the user can use their engine oil for maximum utilization to prevent that just follow the instruction given by the mechanics or someone that really understand about the engine oil. When the viscosity decrease it will cause the mobility charge carriers to increase (Walden's Law) [15]. The contamination during oil use is the chemical breakdown of additives and the subsequent interaction among the resultant components to produce corrosive acids and other undesired substances [7].

Engine condition monitoring techniques through lubricant oil analysis are widely used and are an effective way to diagnose abnormal wear and engine malfunctioning [5]. Therefore, the interest in developing a more sophisticated method in determining the condition of the lubricant (for oil changes) has grown amid automotive, industrial and lubricant companies. The changes in physical and chemical of lubricant oil proved that it's was the main caused of finite life time engine oil that will degrade according to time and usage [17].

The easy way to know the condition of oil was looking the change of viscosity of lubricant oil. But, it's not easy just by looking, so many research have been done by using spectroscopy technique [7] [17]. This is because its can give a better result for doing degradation monitoring.

2.3 Oil properties based on electrical

Lubricating oils have a large number of properties and they are classified into physical, chemical and electrical properties. The electrical properties has been summarized here since it related to this project. Fresh lubricants are poor electrical conductors. However, as oil degrades, its electrical conductivity increases due to the increase in concentration of carboxylic acid and other conductive. Therefore, electrical properties are often used to assess the quality of oils.

2.3.1 Electrical resistivity, impedance and conductivity

Resistance is a measure of how much a material opposes the flow of electric current. From Ohm's law, the electrical resistance "*R"* (ohm Ω) is defined as:

$$R=\frac{V}{I} \tag{3.1}$$

Where "*I"* (amps) is the current and "*V"* (volts) is the potential difference applied. Alternating current (AC) circuit also represents the ratio of the voltage to current.

Complex division of the voltage and current is the one type method to calculate the impedance. Besides that, the sweeping the frequencies of an applied signal are also can be used to measure the phase and magnitude of impedance. The darkness colour of the sample of the engine oil means that the contents of hydrocarbon is higher and that can showed the resistance of the engine oil is also higher [3].

Electrical conductivity is the quantity of electricity per unit transferred through a body at a given voltage gradient. The process of conduction in engine oil is complicated by temporal change of current after the application of constant electric field [2]. The conductivity of the oil can be calculated from the real part of the complex impedance (resistance) by refer to the area and distance between 2 electrodes. The equation below had shown how the calculation can be done:

$$R= \rho \frac{d}{A} = \sigma = \frac{1}{\rho} \quad (3.2)$$

Where R is oil resistance in ohm, ρ is the oil resistivity in ohm cm, σ is the oil conductivity in 1/ (ohm cm) or Siemens/ cm, A is the electrodes area in cm2 and d is the distance between the electrodes in cm. The greater mobility of the electron carrying such as acid will make the conductivity of the oil increase. Conductivity of the engine oil rises with amount of accumulated contamination [1]. This is because the engine oil electric conductivity has electron as well as ionic character that are leads to equilibrium by the formation and discharge of ions. The presence of acids that is produced by the aging of oils will make the higher conductivity so the resistance to oxidation is essential for electrical insulating oil [8].

2.3.2 Electrical Strength

This property expresses the maximum voltage that oil can withstand as an insulator before a discharge occurs [4]. This electric strength is normally defined by the kV per unit distance. Besides that, the electric strength can be measured by the determining the breakdown voltage that in homogeneous electric field between two electrodes in specific size at a predetermined distance between each other [8]. Electric strength is playing an important role for electrical insulating oil such as transformers and cables.

2.3.3 **Dielectric Loss**

Dielectric properties reflect the measure of the interaction of oscillating electric field in molecules [1]. It was a material which has no free charges that show the all electrons are bound and associated with the nearest atom. Dielectric constant of motor oil is normally strongly depends on used addictive and increase of the concentration of the contaminants mainly from oxidation.

The electric current observed in dielectric liquids are often determined by injection of charge carriers from electrode [6]. The engine oil is normally having an impurity when its run and this will produce the carbon. Carbon is a conductor that will make the current high and the voltage breakdown will decrease since the oil block the electron to attract to the electrode tester.

$$C=\frac{Q}{\Delta V}=\varepsilon.\varepsilon_{o}.\frac{A}{d} \qquad (3.3)$$

Where *"C_0"* is the capacitance in the absence of the dielectric and "ε_o" is the electric constant of air (or permittivity of free space: $\varepsilon_o \approx 8.854\times10\text{-}12$ Fm-1), *"A"* is the area and *"d"* is the distance between the two conductor plates [4]. The amount of charge stored is proportional to the magnitude of the applied potential across the conductors. In order to measure the electrical properties of the oil, the conventionally capacitor type electrodes are used. If the capacitor is filled with a dielectric, the capacitance increases by a factor of ε (relative permittivity or dielectric constant), that is:

$$C= \varepsilon.C_0 \qquad (3.4)$$

Lubricant oil have their own dielectric constant. It was around 2.1 to 2.8 (room temperature [1]. It can be related to boiling point since the viscosity of substances was depends how the engine functioning that produce heat. The heat will supplies the energy to overcome the forces between molecules. Besides that, the dielectric hydrocarbon lubrication oil also depends on the addictive that been produce during its used. Table 2.1 shows the example dielectric constant.

Table 2.1 Dielectric Constant of Common Materials [18]

Material	Dielectric Constant
Vacuum	1 (exactly)
Metals	Infinite
Gases	1.00xx (at one atmosphere)
Water	87.9 (0 C) to 55.5 (100 C)
Hexane	1.8865 (20 C)
Benzene	2.285 (20 C)
Lubrication oils	2.1 to 2.8 (room temperature)

2.4 Method of Electrical property measurement

The permittivity, impedance and conductivity of the oil will changes due of it degradation. As mention before, the fresh lubricants are poor conductors since there is no concentration of conductive species such as contaminants and etc.

2.4.1 Conductivity measurements

By developed the platinum screen-printed conductivity sensor with temperature sensor RTD (resistance temperature device) that is shown in the figure 2.1 [4]. The oil was collected from the vehicle by referring the parameters such as viscosity, oxidation and etc.

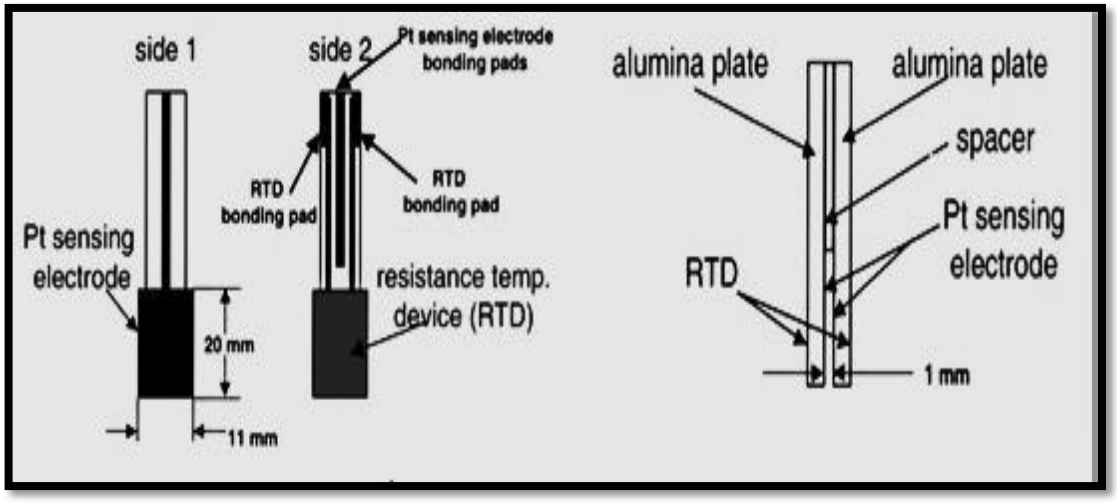

Figure 2.1: Schematic Diagram of Platinum screen-printed conductivity sensor with temperature sensor RTD

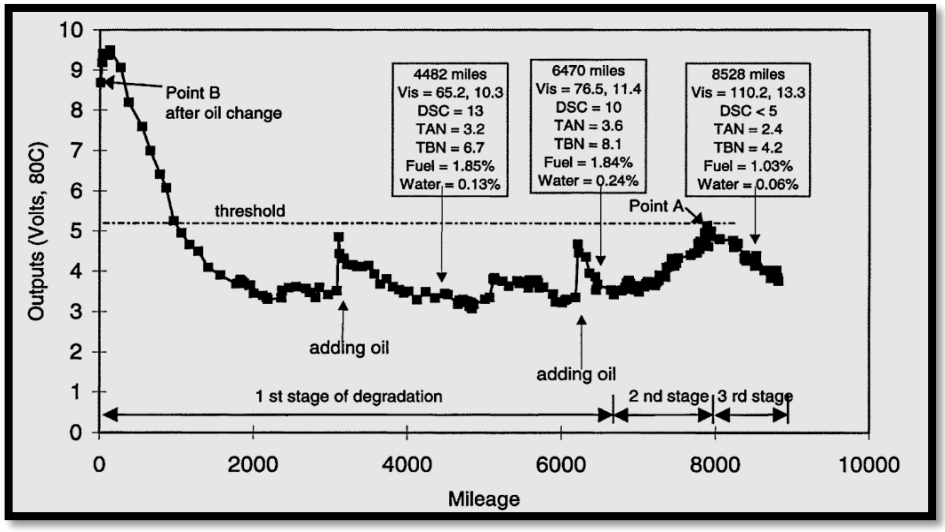

Figure 2.2: The plot of sensor outputs versus the mileage driven after the oil change [4]

Figure 2.2 show that oil conductivity initially drops as the detergents and antioxidants are depleted. There is rapid oxidation show once the anti-oxidant additives had been assumed.

Conductivity measurements have been carried out using polymeric bead matrix electrodes where changes in the resistance of a polymer depend on its oxidation products and free water [9]. Figure 2.3 illustrates the inter-digital electrodes structure

printed on a glass substrate with gold and other sensitive layer [4]. The results showed that the their sensors are highly sensitive to the added acid and output of the sensors increased approximately 3 micro Siemens for 50 mg/mL of added capric acid. Besides that, the decrease of conductivity that happen when doing the experiment can be explain by space-charge formation at the electrode [12].

The conductivity of the oil was measured from the resistance between the electrodes to examine the condition of the oil. The voltage-current characteristic was the complicated thing in dielectric liquid because the current can be changed on time at a fix voltage [14]. The longer lubricant oil being use in transportation system, the higher the viscosity. The viscosity was the one that shown the oil has higher hydrocarbon particles. The ion migration from the hydrocarbon will generally assumed to conduction of electricity to occur [16].

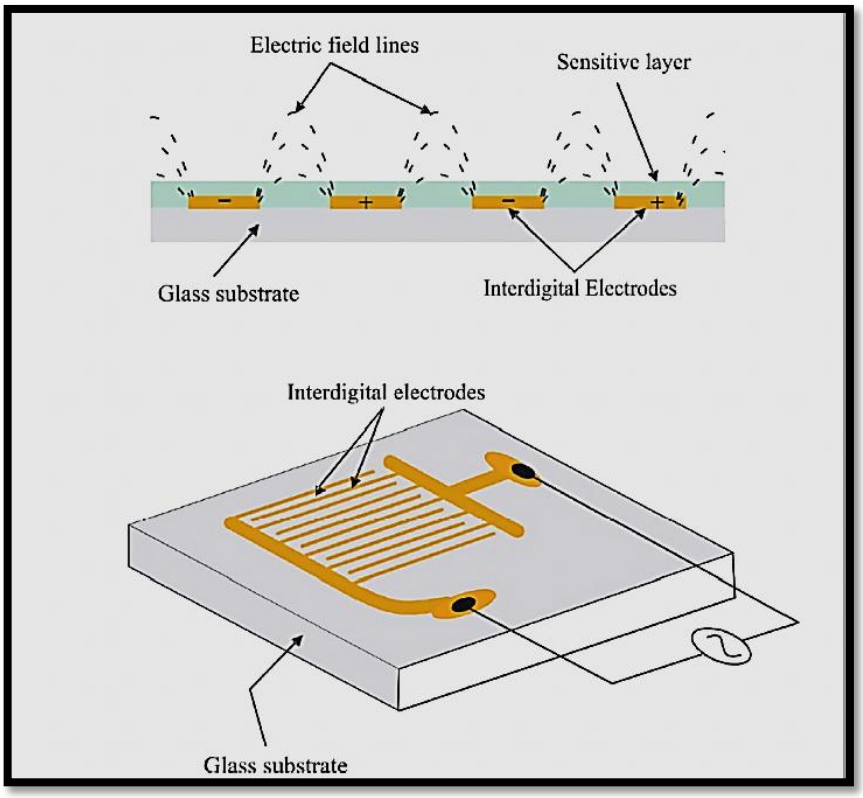

Figure 2.3: The conduct metric sensor; polymer covering the inter-digital electrode [10]

Mostly oil has their own uniqueness since the conductivity obtained by many research will never have the same value [11] [12] [14] [19]. This is due the sample collected was depends on the condition of the engine and individual driving habit.

2.4.2 Permittivity measurements

Tan-delta dielectric sensor is based on the permittivity of the oil and includes capacitive electrodes and an oscillator circuit which provides an output signal proportional to the oil Tan-delta [4]. Delta is the phase of angle of the permittivity. Permittivity sensors are thus divided into 2 main groups: the ones that detect changes in the real part of the permittivity and those based on the complex permittivity measurements. The oxidation of oil will caused the capacitance increase complying with the increase of permittivity [20]. Figure 2.4 shows the tan-delta dielectric sensor.

Figure 2.4: Tan-Delta dielectric sensor

2.5 Experiment by Using Electrode

Mostly the experiment for monitoring degradation of lubricant oil has been achieved and also have been produce for customer such as Lubricheck. But tis tester was normally not detect the conductivity of the lubricant oil. It’s just based on the acidity of lubricant oil and contaminants such as water and other metal involves [21].

The conductivity always been checked by doing experiment of using electrode for many researcher. But the result obtained very often does not agree with each other [6]. This is due to the engine type and condition and mostly related to individual driving habit. The Russian State Standard recommend to use the test cell with two parallel electrodes [2].

The Fluorocarbon cell arrangement has been develop to detect voltage-current characteristic [16]. The experiment design by using gold-plated electrodes in parallel condition by area of 10 cm^2 each. The electrode also adjustable by using micrometre to set the gap length of electrode. But the micrometres were insulated electrically to prevent any external sparking and corona effects. This experiment been conducted by using supply voltage from 0 until 6000V. The conductivity of lubricant oil was read just before the voltage was changes. The types of oil being tested are benzene and n-heptane. Figure 2.5 show the fluorocarbon cell arrangement.

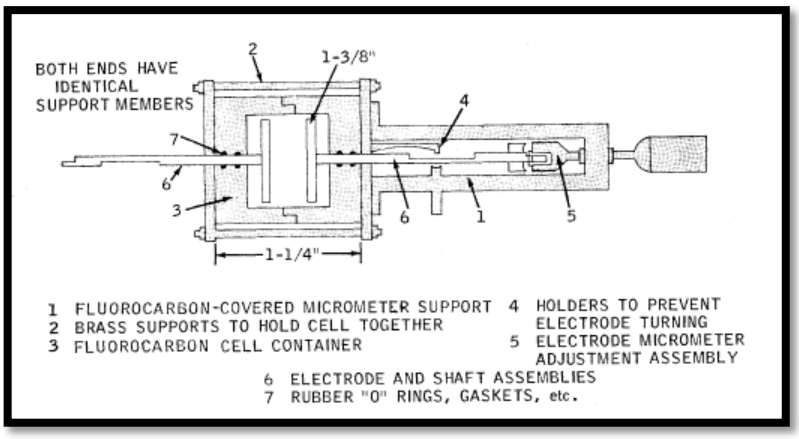

Figure 2.5 Fluorocarbon cell arrangement

This experiment was conducted to detect the voltage-current characteristic. The value obtained when decrease the voltage much lower when increase the voltage supply. Besides that, when the voltage supply was below 10 volts, the value for current will be in negative value. Besides that, when there is storage of charges happen between the gaps of electrode, it will affect the electrical strength and determines a decrease of the current with time [15]. Figure 2.6 and 2.7 shows the value of voltage-current characteristic between two types of liquid.

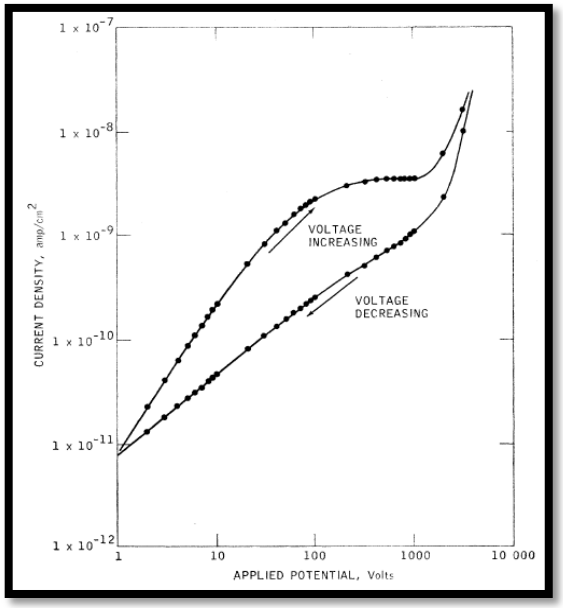

Figure 2.6 Voltage-current characteristics of benzene for increasing and decreasing voltages, 25°C, gold electrodes, separation 0.005 cm.

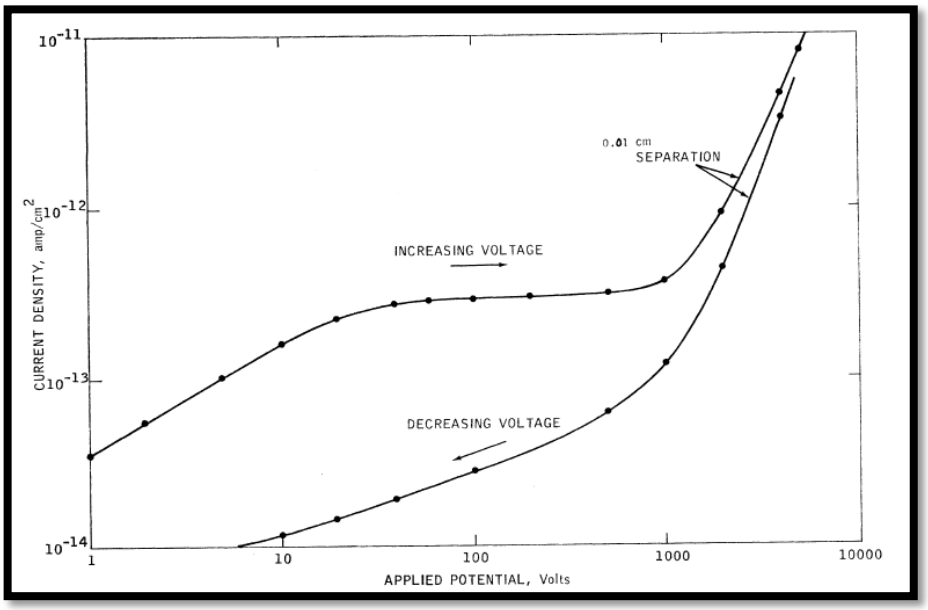

Figure 2.7 Voltage-current characteristics of n-heptane for increasing and decreasing voltages, 25°C, gold electrodes.

Although the conductivity has been studied for some decades, but this condition was not fully explained [14]. This is because the value obtained from the experiment was depends on the engine condition and others factors that has not been revealed.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter show the method of the project. This chapter consists of the flow chart that shows the step to take the data until one task is completed. In this chapter also, the full design of the project also been provided. Besides that, list of hardware that will be used in this project also included. The progress of this project also being presented in this chapter.

3.2 Flow Chart

Flow chart is a diagram that show the step that need to follow to be taken in this project. The flow chart is very important to make sure there is no step miss or the fault could happen during the project progress. Figure 3.1 shows the process that need to be follow during the experiment.

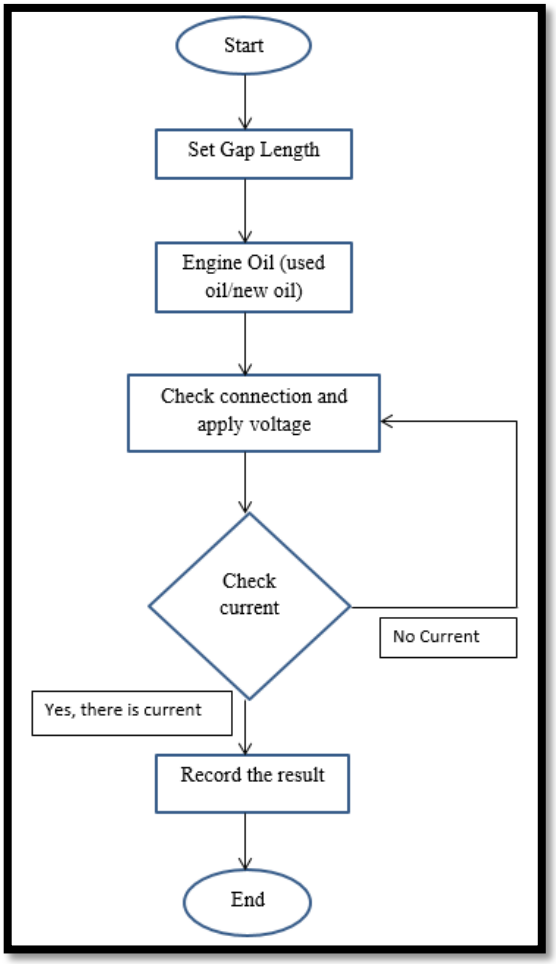

Figure 3.1 Process during experiment

Before start the project, the gap length of the electrode will be choose that is between 1mm-10mm so this we can save the result obtained due to the electrode gap length. After that, the engine oil will be tested either original oil or used oil since in this project the focus is to analyse the current value between used oil and new oil. Make sure before test the oil, check the connection of the circuit to prevent any short circuit happen. Apply the voltage. If there is no current value, check again the connection and continue the experiment again. If there is current value obtained, save the result and continue with different electrode gap length.

3.3 Progress of the project

This show the project progress until this project is successfully done. Figure 3.2 shows how this project been knowledge before been conducted. Before this experiment been conducted, the research need to be done first so that this project can run smoothly without any mistake. Besides that, this to make sure the project can be done successfully and know about the result obtained.

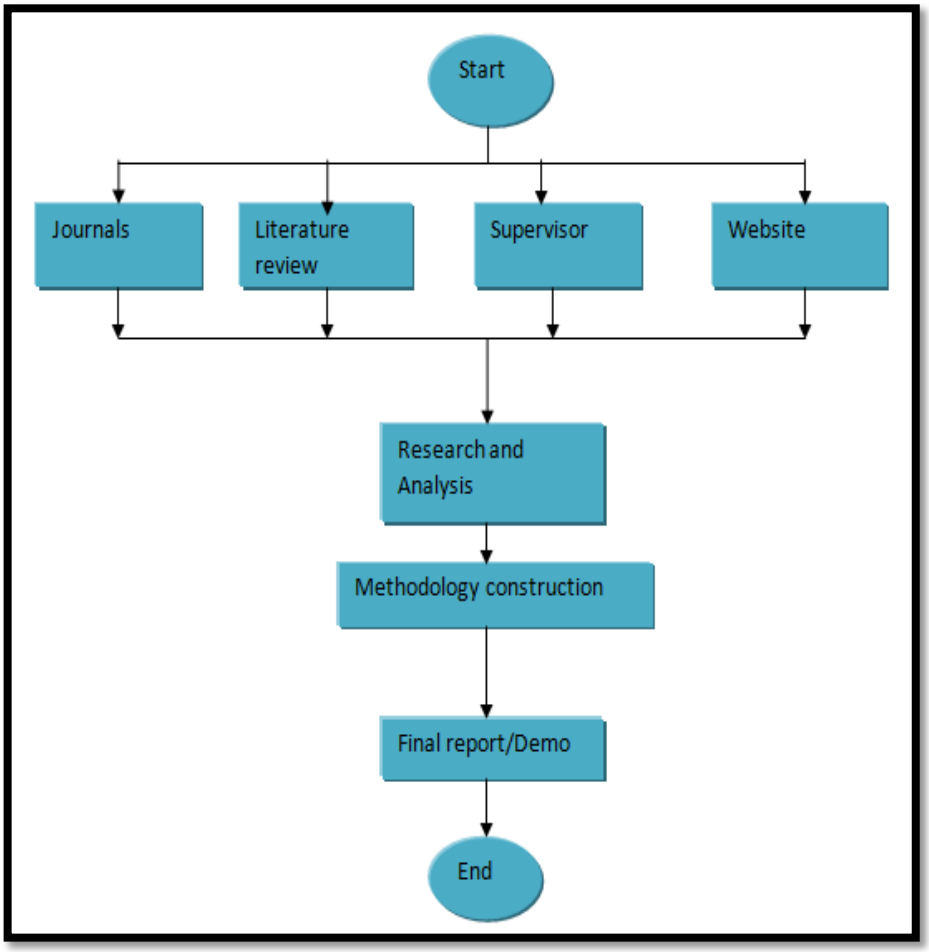

Figure 3.2 Progress of the project

3.4 Electrode Construction

In this project, various gap length of electrode has been designed. The entire electrode have diameter of 1 millimetre with the length of each electrode is 5 millimetre. The space to put the sample engine oil that being tested have a diameter of 5 millimetre for the electrode gap length between 1 millimetre to 5 millimetre. For electrode gap length 6 millimetre to 10 millimetre have a space radius of 15 millimetre since the electrode gap length position is not have enough space for diameter 5 millimetre. Figure 3.4 shows the design that been choosed for this experiment. The electrode development is being design by using software Microsoft word before being printed to PCB (Printed Circuit Board). Figure 3.5 shows the design that ready to be printed into PCB board.

A 1mm radius of hole was drill at the end of the copper from the PCB that represents the electrode. Then, a pin header is being solder through the holes between the PCB copper. The function of the pin header is to connect the electrode to the multimeter and HVDC supply. Figure 3.3 shows the pin header that been used.

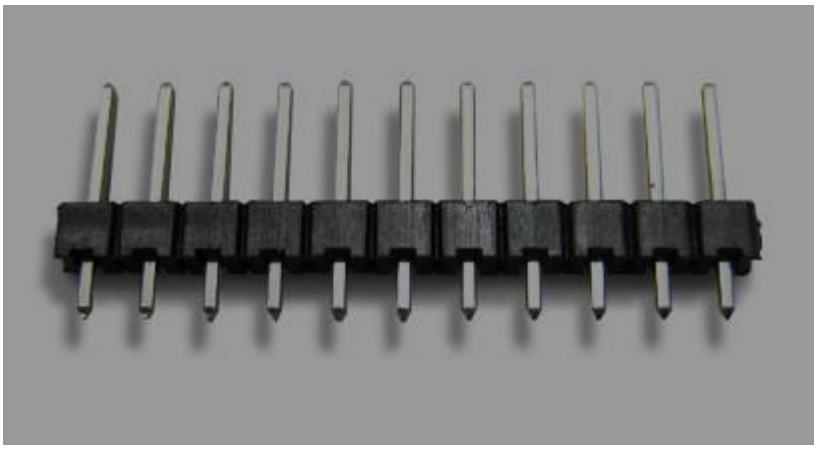

Figure 3.3 Pin Header

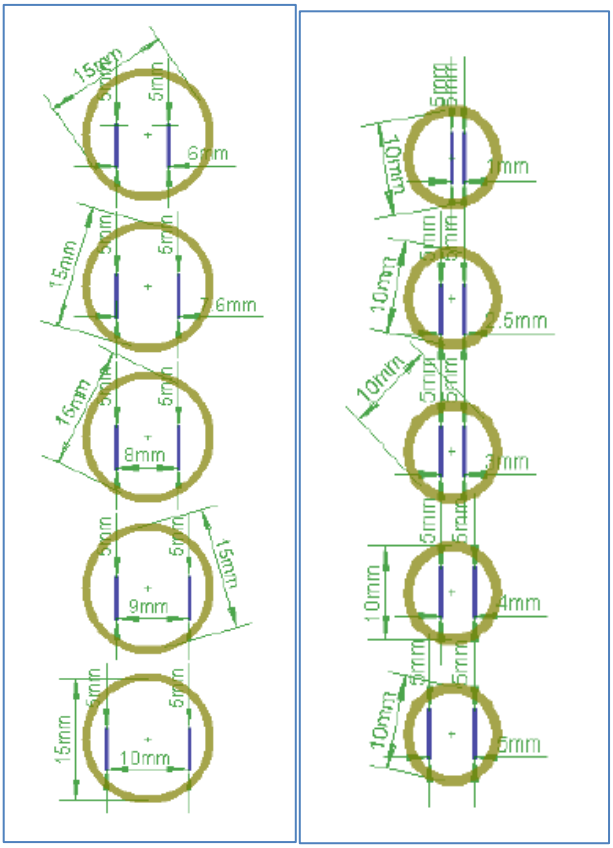

Figure 3.4 Designs for Electrode Gap Length

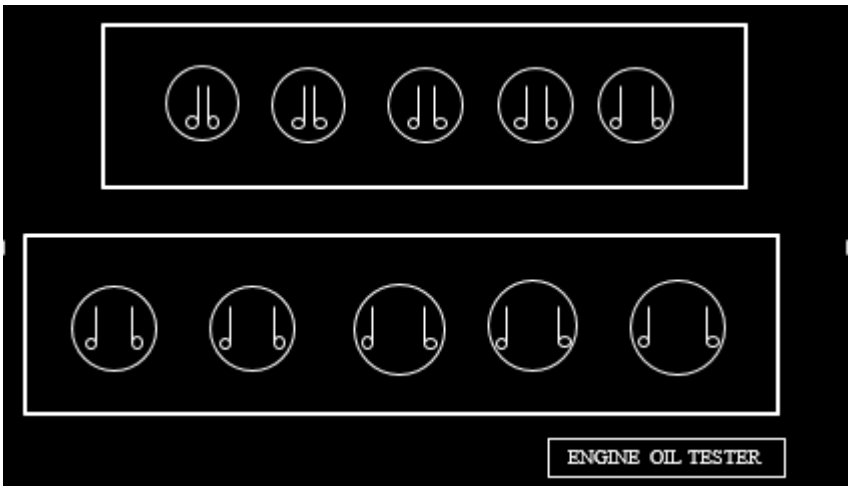

Figure 3.5 Schematic that being printed to PCB board

This electrode design had being printed to PCB board so it is easy to be conducted and tested. The gap length electrode need to be checked correctly after print so that there is no connection touch each other. This is to prevent any error of the result needed. The silicon being used around the electrode to hold the oil from leaking. The parallel copper electrode from PCB will be drill to make hole around 0.5mm diameter. The pin header being solder through the hole so that easy to make the connection. Figure 3.6 shows the design of electrode that has been printed.

Figure 3.6 Electrode printed PCB

3.5 Flow of Project

Figure 3.7 shows the full design of this project. For starting, the type of liquid will be selected as a sample that will be tested. The type of oil that being choose is motorcycle and car engine oil. The motorcycle's lubricant oil is normally run in higher rotation per minute (RPM) and it has very short time used compared to car's engine. The liquid will be poured into the space box that consists the electrode and will be

tested. The engine oil that being tested is between original engine oil and used engine oil. This is to investigate or to record the conductivity between those two conditions.

Manual design to collect the conductivity of the current also been design so that it can be shown how the data been recorded. Figure 3.8 shows how the data been collected. All this data will be recorded and the graph been built by using Microsoft excel.

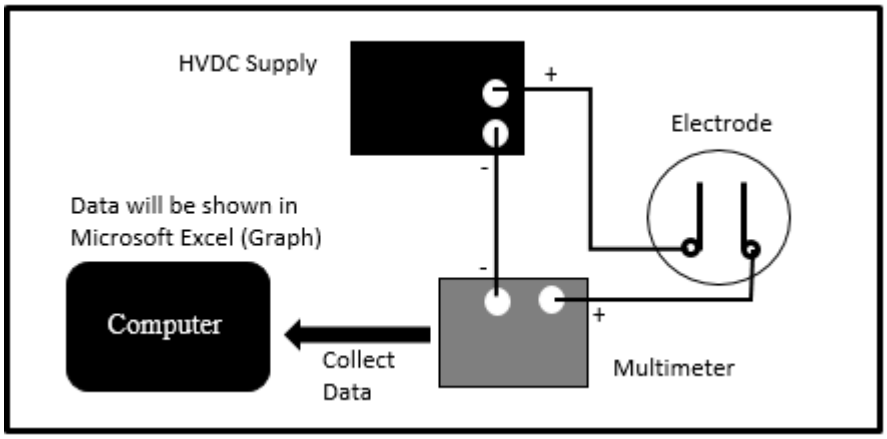

Figure 3.7 Full Design of Project

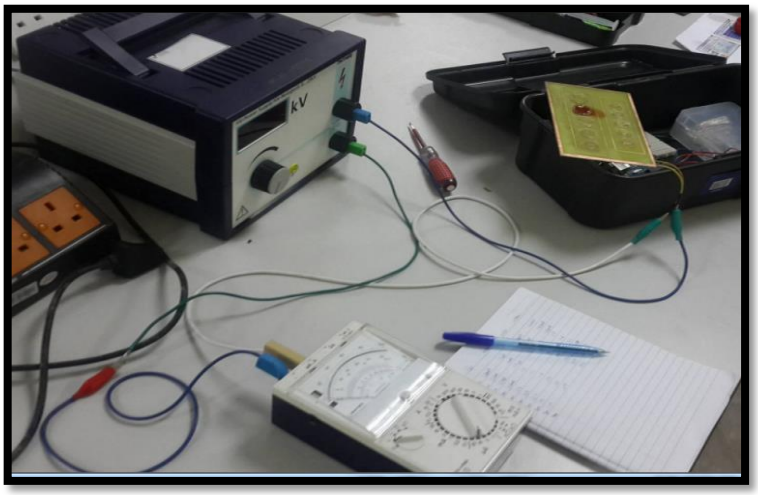

Figure 3.8 Collecting the Data

CHAPTER 4

RESULTS

4.1 Introduction

In this chapter, the result obtained from the experiment are discusses. The result obtained was about the emergence of the current in the lubricant oil. The lubricant tested is motorcycle and car engine oil. Result obtained are based on different gap length of the electrode. The lubricant oil was been tested with room temperature condition.

The high voltage direct current will be using as the source that will be connected to the multimeter and electrode. In this project, the adjustable HVDC supply being used since the value voltage used are 200V, 500V, 700V and 1000V. The electrode need completely submerged by the engine oil before tested. The value of current obtained was being recorded.

4.2 Result

Safety must to be priority since this project related to using HVDC and the voltage used exceed 1000V. Before conduct this experiment, the connection must be check carefully to make sure there is no mistake happen. The current was read just before changing the voltage supply.

4.2.1 Types of Oil

In this experiment, there are two type of oil that being tested, motorcycle and car lubricant oil. The condition of motorcycle lubricant oil that being tested was 0km, 300km, 500km, 700km, 1200km and 1500km while for car lubricant oil, its was taken for 0km,4000km,5000km and 9000km. All condition will be tested for every gap length of electrode.

Figure 4.1 Motorcycle's Lubricant Oil (1st Sample)

Figure 4.2 Motorcycle's Lubricant Oil (2nd Sample)

Figure 4.3 Car's Lubricant Oil

4.2.2 Experiment Result and Analysis

The oil has been collected from new oil that ever been use and after their utilization in the transport system. The gap length chosen was 1mm, 3mm, 6mm, 8mm, 10mm for motorcycle to build the graph since the value obtained has no big different. For car lubricant oil, 1mm, 4mm, 7mm and 10mm gap length.

Motorcycle's lubricant Oil

1st Sample:

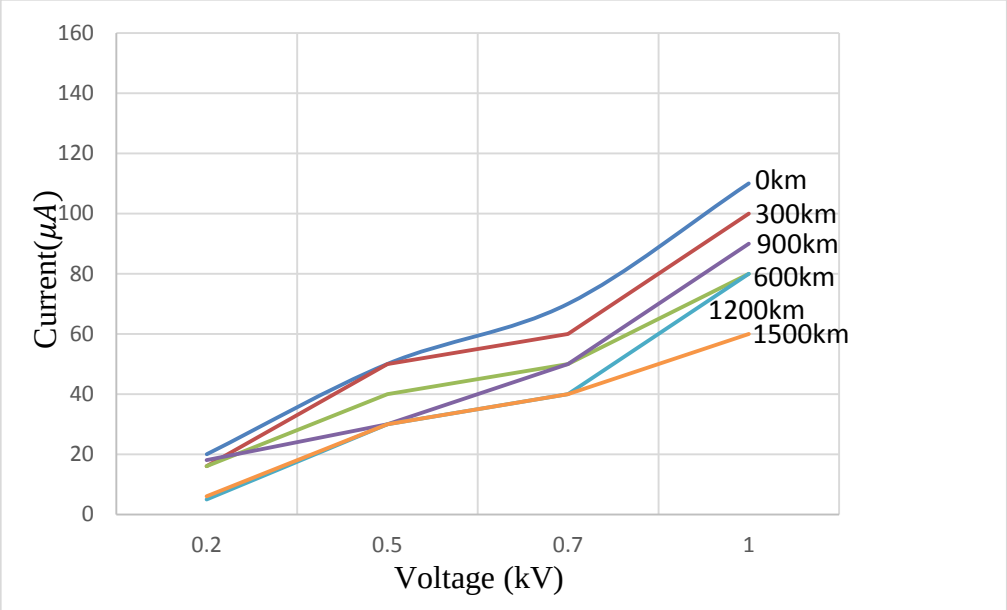

Figure 4.4 Voltage-current characteristic of 1mm gap length.

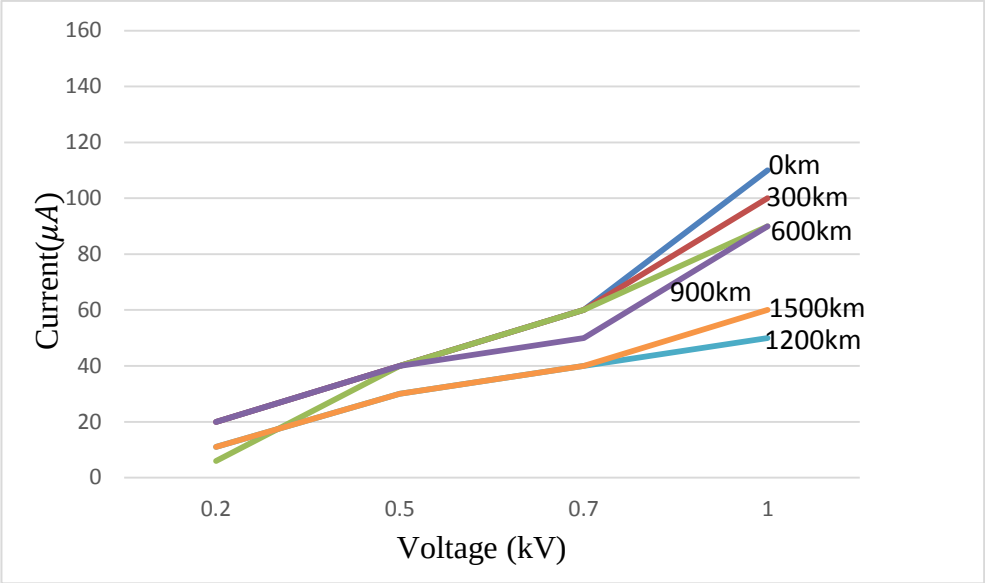

Figure 4.5 Voltage-current characteristic of 3mm gap length.

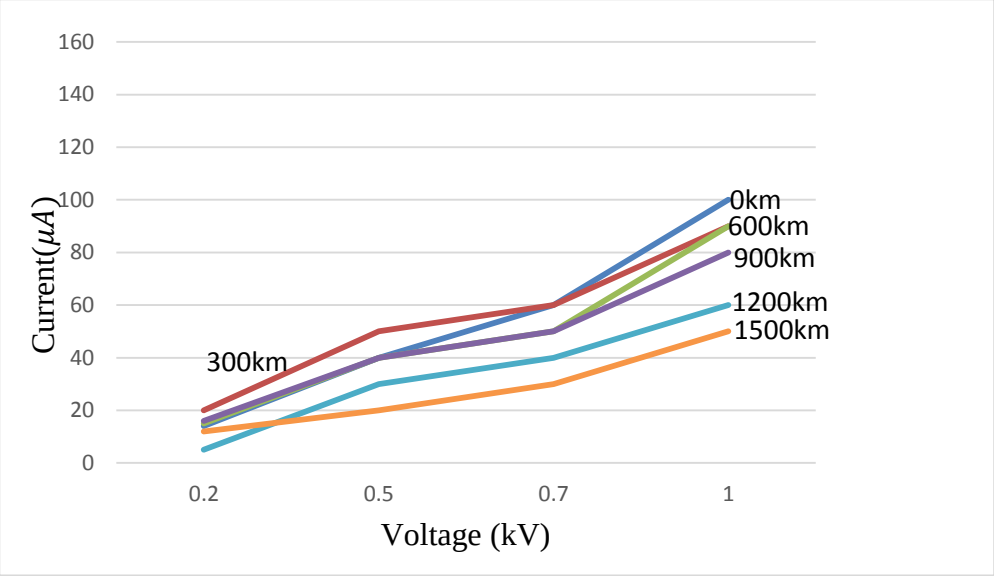

Figure 4.6 Voltage-current characteristic of 6mm gap length.

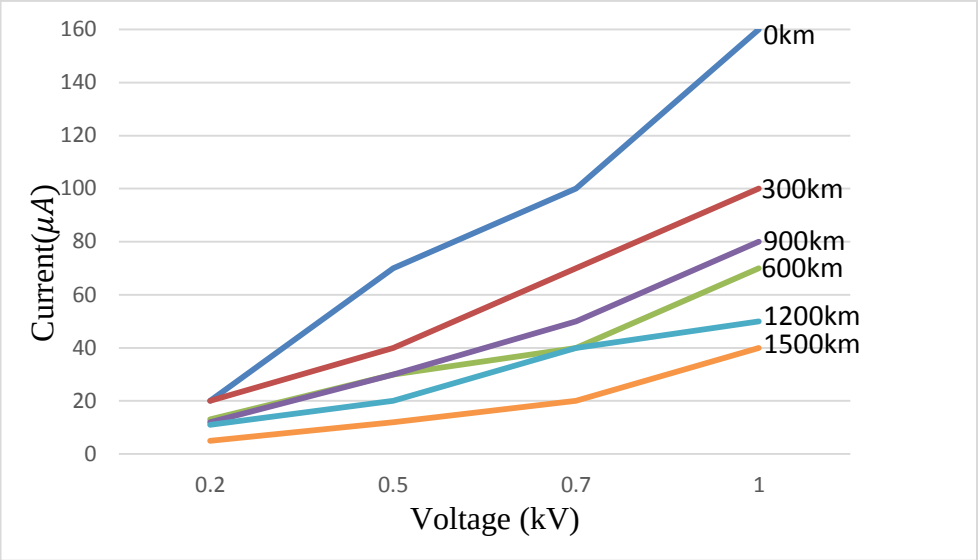

Figure 4.7 Voltage-current characteristic of 8mm gap length.

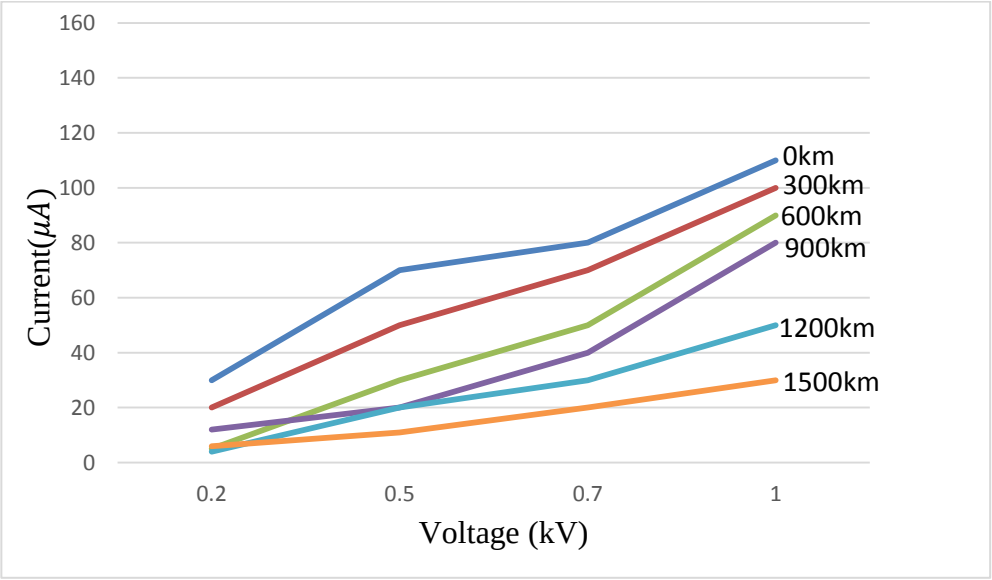

Figure 4.8 Voltage-current characteristic of 10mm gap length.

Figure 4.4 until 4.8 shows the result for first sample of motorcycle lubricant oil. This lubricant oil has been collected from a new condition engine motorcycle that has been running around 10 month but the lubricant oil start been collected after it been changed. From this figure, it show that the value of current obtained is lower than the second sample. This has been explained in chapter 2 of this thesis that's proved the conductivity of liquid is related to its condition of engine.

Since the first sample of lubricant oil been collected from a new motorcycle, so the probability of carbon or conductivity particles produce is much smaller. The different value of current can be seen from the second sample. Besides that, the value of current from the new oil is different since it was depend on the production of oil or base oil according to American Petroleum Institute(API).

2nd sample:

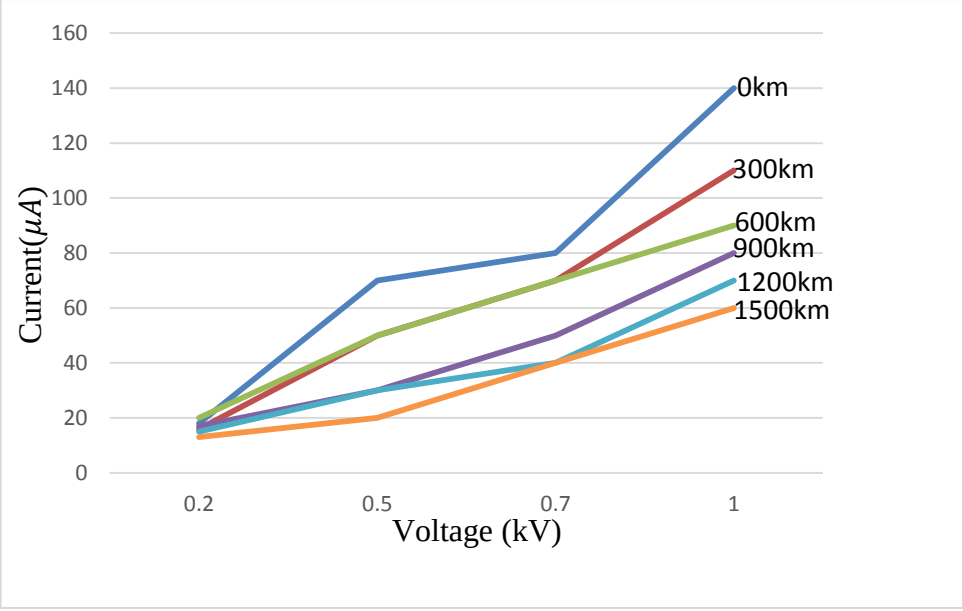

Figure 4.9 Voltage-current characteristic of 1mm gap length.

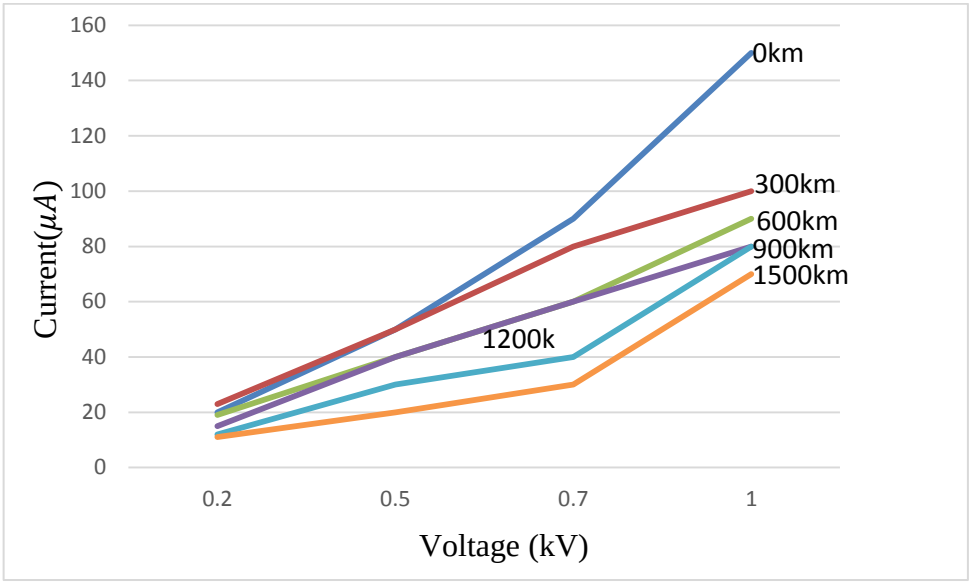

Figure 4.10 Voltage-current characteristic of 3mm gap length.

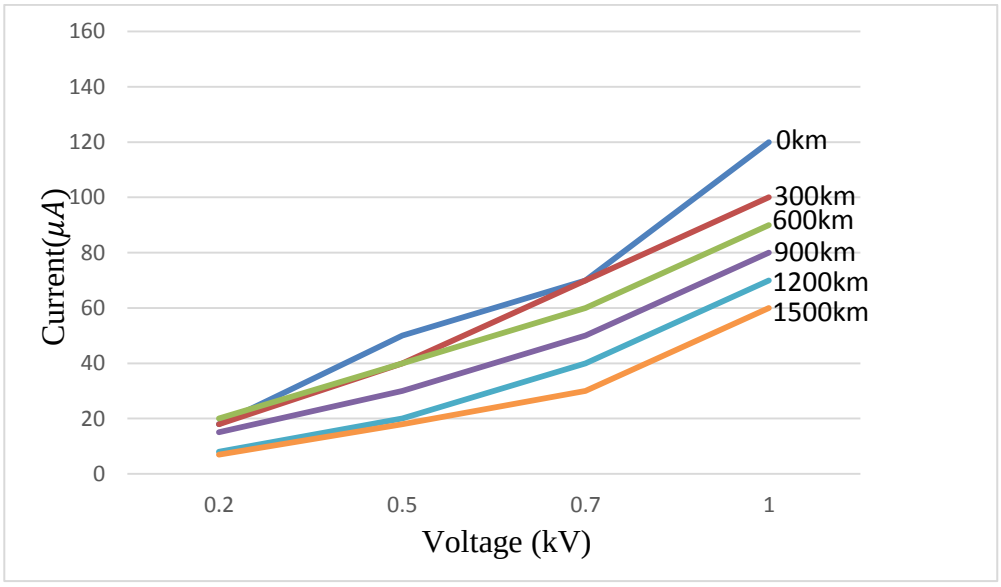

Figure 4.11 Voltage-current characteristic of 6mm gap length.

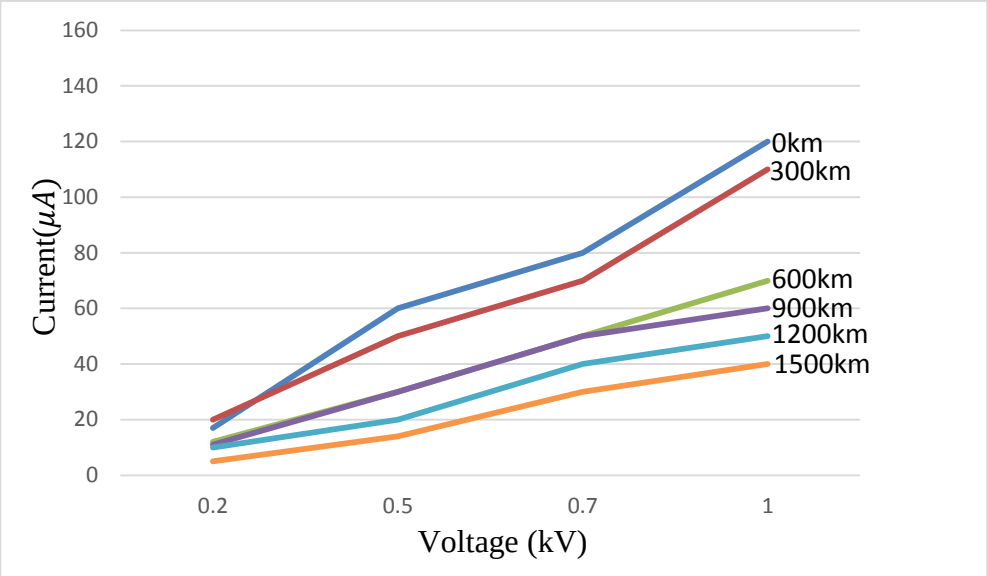

Figure 4.12 Voltage-current characteristic of 8mm gap length.

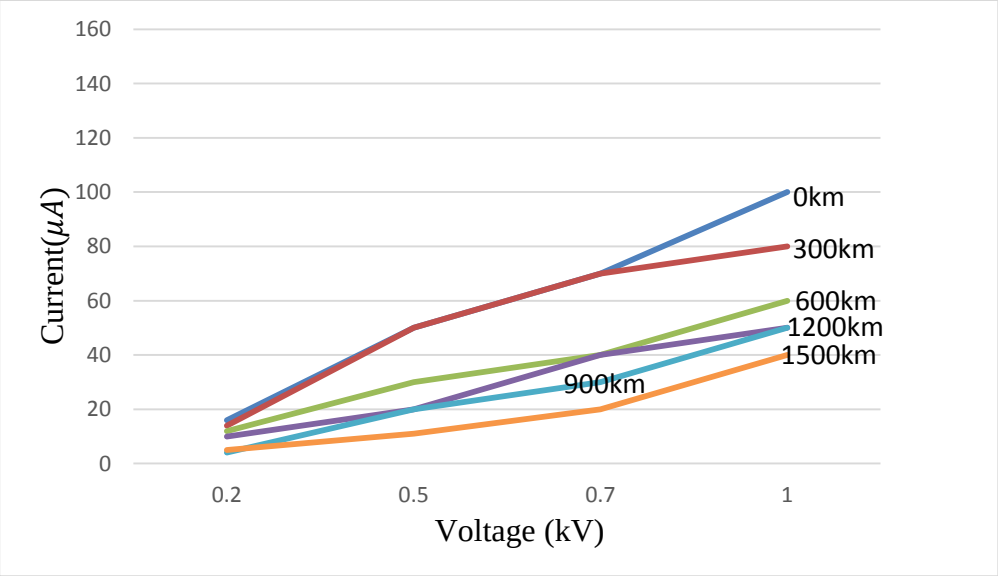

Figure 4.13 Voltage-current characteristic of 10mm gap length.

For figure 4.9 until 4.13, it shows the result of lubricant oil that has been collected from a four years of running engine motorcycle but the lubricant been collected after it been changed using new oil. From this figure, it is understood that the conductivity of liquid was completely depend on the criteria that has been mentioned in chapter 2 such

as condition of the engine since the value of current obtained from this second sample was higher than first sample.

Figure 4.9 and 4.13 shows the result obtained was different based on the gap length of electrode. This can be say that the decrease of voltage-current characteristic because of space charge near electrodes which depends on electrode gap length. The electric field cause the ions to move and produce the current.

Car's lubricant Oil

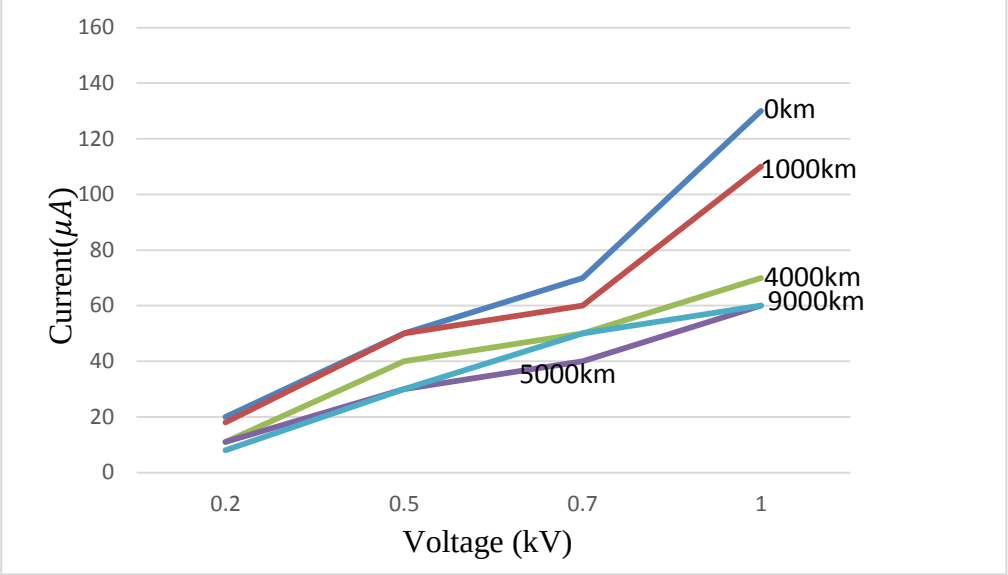

Figure 4.14 Voltage-current characteristic of 1mm gap length.

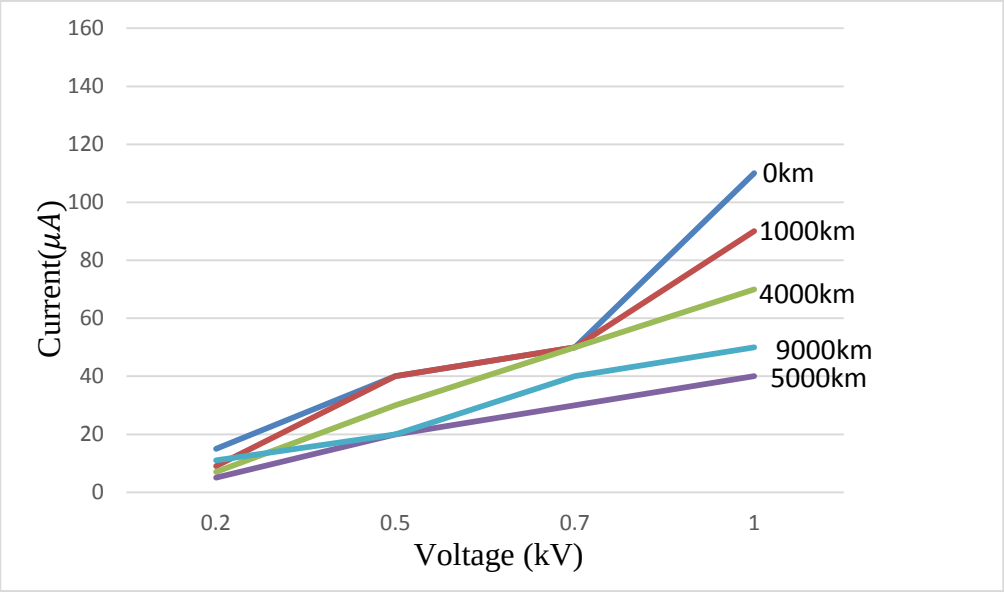

Figure 4.15 Voltage-current characteristic of 4mm gap length.

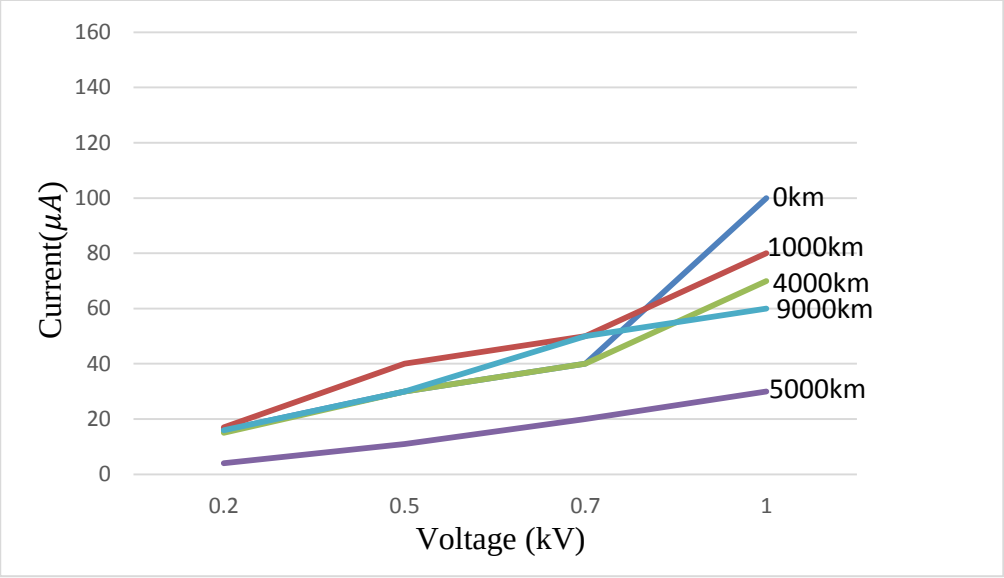

Figure 4.16 Voltage-current characteristic of 7mm gap length.

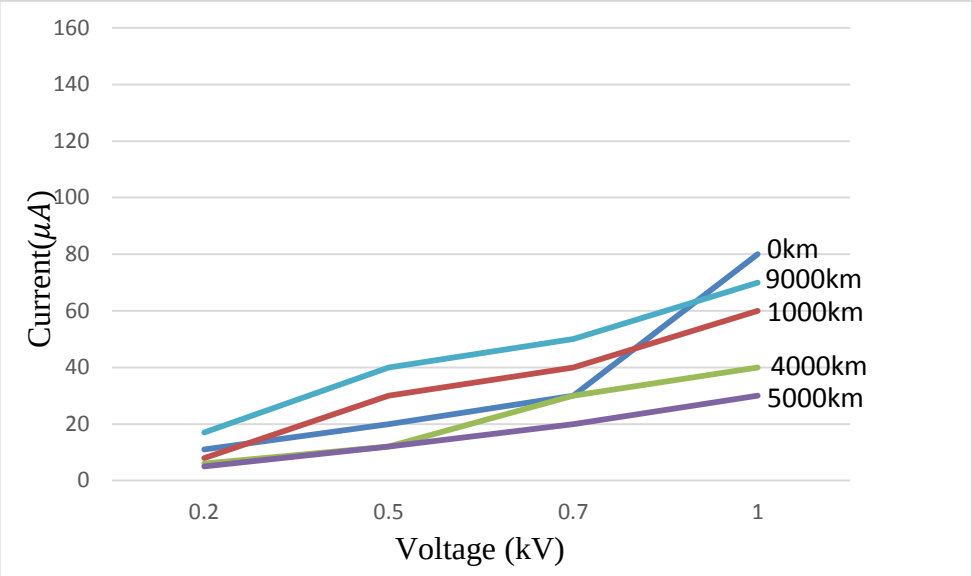

Figure 4.17 Voltage-current characteristic of 10mm gap length.

For figure 4.14 until 4.17, the result also shows the value of conductivity was decrease based on their utilization in transport system. But the value of current for 9000km was slightly increase. Besides that, this value was increase because this sample has been taken directly after their utilization and the temperature between other samples was different. This can be say that the conductivity of liquid will increase when it achieve their limitation used. The increase of temperature will cause the increasing of conductivity. From this figure, it is understood that the value conductivity of liquid will never be the same with each other's since the value obtained from this experiment was not the same with other researcher[12][14].

4.3 Analysis for all Result

From the result obtained for both motorcycle and car lubricant oil, it shown that there is existence of conducting particles in it as the traces of contamination. The value for current obtained was slightly decrease after their utilization in transport system.

This shown that the lubricant oil degradation will make the value of current decrease after their utilization in transport system based on voltage-current characteristic. The result showed that the value obtained was different than expected result from other research that the value of current was increase after their utilization in transport system [1] [14]. But it's showed that the value of current was increased depend on the value voltage supply and decreased based on the mileage.

The two sample of motorcycle lubricant oil showed a slightly different of current because it's depend on the purity of the liquid and the condition of engine. Besides that, it also depend on the production of engine oil based on their base oil (Appendix). The both type of lubricant oil showed much lower currents obtained after their utilization in transport system.

Besides that, according to Ohm's Law (V=IR) the resistance value can just be calculated by using that formulae directly. The value of resistance was directly depends on voltage and current obtained. Resistance value increase when the voltage supply increase and the value of current decrease.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

As the conclusion, this experiment showed that the current or conductivity of lubricant oil after their utilization in transport system was decreased. It's showed that the hypothesis of this experiment was inversely from the other research. This can be said that the longer the lubricant oil utilize in transport system, the lower the value of conductivity. Besides that, the value of current obtained for both sample of motorcycle oil was slightly different due to condition of the engine and the purity of engine oil. This is the biggest or the main problem for presentation of voltage-current characteristic because the result obtained very often do not agree with each other. Apart from that, each type of lubricant oil has their own base oil and this will affect the result obtained.

Even though the current value obtained was different from the other research [11] [12] [19] conclusion but this shows the current value influences by vehicle mileage. The value of current will increase depend on the voltage supply. The higher the voltage supply, the higher the value of current that can be obtain.

The gap length of electrode was the most important because it's can give impact for the result. The smaller the gap length, the higher the conductivity. The most realistic value that can be as a reference was 1mm gap length since the value obtained show a most accepted result because the different between each mileage of lubricant oil can be differentiate.

Result in chapter 4 show that the conductivity can be identify for each distance of oil used. But the value of current obtained was different since its depend on the factor that has been mentioned. Besides that, the data of electrical graph have been suggested with the condition of the engine oil. This can be a reference for customer or user to identify the lubricant oil condition. The objective of this project has been achieved.

5.2 Recommendation

In research, due to limitation of facilities, the result obtained was not satisfying. For future recommendation, the value of current can be detected by using a digital multimeter or different type of multimeter that can read the smallest value of current since the multimeter provided during this experiment was not in good condition and affect the result obtained. This experiment can be completely be achieved by doing or collect more result so it's can be differentiate and improved.

Besides that, by using high voltage supply its will increased the electric field produced by electrode and also make the value of current or conductivity also increase. But, since it related to high voltage its must be handling carefully to prevent any harm or bad thing happen.

The most important was time management since to collect the lubricant oil after their utilization in transportation was taking most of the time. Making up the schedule will improved the different type of data obtained. Besides that, this experiment also can be used to detect the conductivity of transformer oil since it has higher dielectric constant.

Besides by supply the high voltage, this experiment can completely being achieved by other method that was temperature-current characteristic since most of numerous authors have performed this method for the same dielectric liquids. Although this project cannot be achieved by using current sensor to detect the conductivity but for future it's can be design and be constructed if the current sensor obtained can detect smallest current. Apart from that, to improve this project by using current sensor, it can be done by using current multiplier method.

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APPENDIX

API Base Oil Groups

TABLE 1. API BASE OIL GROUPS

Group I – Lightly Refined Base Oils (Solvent Neutral or SN)
These are oils with an increased proportion of aromatics and less than 90 percent saturates. The viscosity index (VI) is between 80 and 120. Additives dissolve relatively easily.

Base for:	Simple gear and hydraulic oils
Conductivity:	High polarity, values less than 10 pS/m, very low conductivity

Group II – Hydrocracked Oils
Additional treatment with hydrogen reduces unsaturated compounds. More than 90 percent saturates. VI is between 80 and 120. Improved oxidation resistance and evaporation behavior.

Base for:	Simple engine oils
Conductivity:	Less polar, values less than 10 pS/m, very low conductivity

Group III – Highly Refined Hydrocracked Oils
These oils are labeled as partly synthetic and even as synthetic lubricants in some countries. However, they contain no chemically produced components. They have much more than 90 percent saturates. VI is more than 120. They contain very few aromatics and thus have poor additive solubility.

Base for:	Engine oils and modern industry lubricants
Conductivity:	As a base oil with no additives, virtually nonpolar; values less than 10 pS/m; very low conductivity

Group IV – Synthetically Manufactured Hydrocarbons (SHC)
Polyalphaolefins (PAO) are characteristic examples. Unverifiable proportion of unsaturated components. VI over 130.

Base for:	Fully synthetic modern engine oils and some industry lubricants (wind turbine gear oils)
Conductivity:	Values less than 10 pS/m, very low conductivity

Group V – Synthetically Manufactured Fluids, Esters or Polyolesters

Base for:	Flux oils or blend components for the production of additives. Usually not suitable as a base oil.
Conductivity:	They contain high proportions of polar components. Conductivity is usually more than 2,000 pS/m.