"I hereby declare that I have read through this report entitle " Comparative Study of Leakage Current On Insulation Surface Condition" and found that it has complied the partial fulfillment for awarding the degree of Bachelor of Electrical Engineering (Industrial Power)"

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COMPARATIVE STUDY OF LEAKAGE CURRENT ON INSULATION SURFACE CONDITION

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

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2015

I declare this project entitled " Comparative Study of Leakage Current on Insulation Surface Condition" is the results 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 the candidature of any other degree.

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Specially dedicated to my late beloved father and mother, sisters and friends who always give me strength, guidance, and encouraged throughout my journey of education.

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In the name of Allah, Most Gracious, Most Merciful

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ABSTRACT

Electrical insulation is a significant component in all electrical systems. It is really important in parliamentary procedure to maintain the functioning and the refuge of the electrical appliances and creature. The demands for polymer insulator are much higher and have become a replacement for all traditional insulators such as porcelain, glass, and ceramics. Due to its advantage in the ratio of strength-to-weight is better than the other insulator, it has attracted lots of users to use polymer insulator as to reduce cost on insulator installations. Glass insulator has been widely used in high voltage engineering such as in distribution system. The utilization of glass/ ceramic insulators on the electrical energy transmission system which tend to accept higher voltage are no longer profitable because the glass/ceramics density is great, long, fragile and losses. However, pages still have the ability better than other polymer insulation because it is not eroded. The purpose of the study is to investigate the leakage current patterns for classification of Glass, Polypropylene and High Density Polyethylene surface degradation. The test follows the standard of BS EN 60587:2007 as a guideline to conduct the Incline Plane Tracking (IPT) test. The test is conducted to determine the pattern and value of leakage current of the Glass, Polypropylene and High Density Polyethylene. The patterns of leakage current can be classified into 4 phases which are capacitive, resistive, symmetrical and unsymmetrical. As a result, the pattern and value of leakage current for each of the insulation materials used can be seen. From the study, Glass is proven to be a good material for insulation compare to Polypropylene and High Density Polyethylene.

ABSTRAK

Penebat elektrik adalah satu komponen penting dalam semua sistem elektrik. Ia merupakan satu perkara penting dalam prosedur utama untuk mengekalkan fungsi dan perlindungan terhadap peralatan elektrik dan benda hidup yang lain. Permintaan untuk penebat polimer adalah lebih tinggi dan telah menjadi pengganti untuk semua penebat tradisional seperti tembikar, kaca dan seramik. Oleh kerana mempunyai kelebihan dalam nisbah kekuatan-kepada-berat adalah lebih baik berbanding dengan penebat yang lain, ia telah menarik banyak pengguna untuk menggunakan penebat polimer dalam usaha mengurangkan kos pada pemasangan penebat. Penebat kaca telah digunakan secara meluas dalam bidang kejuruteraan voltan tinggi seperti dalam sistem pengagihan. Penggunaan kaca / penebat seramik pada sistem penghantaran tenaga elektrik yang cenderung untuk menerima voltan yang lebih tinggi tidak lagi menguntungkan kerana ketumpatan kaca / seramik yang besar, panjang, rapuh dan kerugian. Akan tetapi, kaca masih lagi empunyai keupayaan yang lebih baik daripada penebat polimer yang lain oleh kerana sifatnya yang tidak terhakis. Tujuan kajian ini adalah untuk mengkaji corak arus bocor untuk pengelasan degradasi permukaan Kaca, Polipropilena (PP) dan Polietilena berketumpatan tinggi (HDPE).Ujian dijalankan mengikut standard BS EN 60587: 2007 sebagai garis panduan untuk mengendalikan ujian Incline Plane Tracking (IPT). Corak kebocoran arus boleh dikelaskan kepada 4 fasa iaitu kapasitif, rintangan, simetri dan tidak simetri. Hasilnya, corak dan nilai kebocoran arus bagi setiap satu daripada bahan penebat yang digunakan dapat dikenalpasti. Dari kajian ini, kaca terbukti sebagai bahan yang tebaik untuk penebat berbanding Polipropilena (PP) dan Polietilena berketumpatan tinggi (HDPE).

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LIST OF ABBREVIATIONS

PP	-	Polypropylene
HDPE	-	High Density Polyethylene
LC	-	Leakage Current
BS	-	British Standard
IEEE	-	Institute of Electrical and Electronic Engineering
IPT	-	Incline Plane Tracking
DAQ	-	Data Acquisition Card
AC	-	Alternating Current
DC	-	Direct Current
HV	-	High Voltage
SiO2	-	Silicate Oxide
A	-	Ampere
V	-	Voltage

CHAPTER 1

INTRODUCTION

1.1 Research Background

Electrical insulation is a significant component in all electrical systems. It is really important in the main procedure to maintain the functioning and the refuge of the electrical appliances and creature. Nowadays, the use of polymer as an insulator is widely used all over the world, despite using the glass or ceramic as an insulator in the electrical system. This is due to the polymer insulator have better ease of handling and installation, not causing pollution and resistance to vandalism rather than the glass or ceramic insulator.

Nowadays, the demands for polymer insulator are much higher and have become a replacement for all traditional insulators such as porcelain, glass, and ceramics. Due to its advantage in the ratio of strength-to-weight is better than the other insulator, it has attracted lots of users to use polymer insulator as to reduce cost on insulator installations.

The utilization of glass/ ceramic insulators on the electrical energy transmission system which tend to accept higher voltage are no longer profitable because the glass/ceramics density is great, long, fragile and losses. It has a higher cost of construction and maintenance of electric power network [1].

The degree of effectiveness of insulator actually depends on how much leakage current that flow through the insulator itself. Leakage current is any current that can flow either through the body or over the insulator when the idle current is zero. In electrical systems and

the use of home appliances, the leakage current is often associated with the user's safety and the public. To better understand the situation, taking the example of an electric motor that has a weak winding insulation. Insulation may wear at some point and mostly due to long time running, heating or some other factor. The voltages at that stage will be shifted to the core of the motor.

The core is linked to motor body so, a voltage will appear along the outer surface of the motor body. If the body is grounded, this potential difference will make a net current flow to ground. This current is passed directly from point of insulation failure. The magnitude of this current depends only on the resistance of ground [2].

1.2 Motivation

In high voltage engineering and distribution system, a lot of test need to be conducted in order to maintain the performance of insulator. By following the several standard to achieve the reliable result, a lot of tests can be conducted. In this project, the IPT test is conducted and the standard BS EN 60587:2007 is used as a guideline to obtain accurate and reliable results of leakage current on the surface of the insulation material. The specimen used as the materials which is glass, polypropylene and high density polyethylene are the most use material as an insulator nowadays. The result of this project explains more about the leakage current patterns, behaviour and value of the leakage current. Besides, the length of carbon tracking on the surface of the specimen at the end of the test conducted will determine whether the material is passed or failed, according to the specifications given in the standard BS EN 60587 : 2007.

1.3 Problem Statement

Insulator plays an important role in the electrical system. Most common problems in High Voltage (HV) application or system is the insulation failure. A lack or bad in insulation might cause problems for electrical application or might injure people who deal with electrical system itself. One of the causes that led to failure in insulation is the surface of the insulator have been deteriorated. Basically, this condition happened when there is a leakage current. There are two types of leakage current which is AC leakage current and DC leakage current. Therefore the leakage current should be handled seriously. In this project, the leakage current was analysed based on their leakage current pattern, whether it is a capacitive pattern, resistive pattern, symmetrical pattern or unsymmetrical pattern. Also from the project, the reliability of an insulator on handling HV can be identified.

1.4 Objective

The objectives of this project are:

1. To investigate the Leakage Current (LC) patterns for classification of glass, Polypropylene (PP) and High Density Polyethylene (HDPE) surface degradation.
2. To analyze using MATLAB to gain the information on AC leakage current for the glass, Polypropylene (PP) and High Density Polyethylene (HDPE).
3. To determine the tracking on the surface of the glass, Polypropylene (PP) and High Density Polyethylene (HDPE) in High Voltage (HV) application.

1.5 Scope of Work

This project focuses on the following scope:

1. Usage of the glass, Polypropylene (PP) and High Density Polyethylene (HDPE) as an insulation material according to electrical discharge behavior and the insulator surface condition.
2. The Inclined Plane Test (IPT) method has been used to evaluate the tracking and erosion resistance based on BS EN 60587:2007.
3. Usage of the „Method 1" as stated in BS EN 60587:2007 with constant tracking voltage and contaminant flow rates.
4. LabVIEW software used as an On Line monitoring leakage current system in order to study the leakage current waveform signal.
5. The contaminant use of the IPT test is ammonium chloride, NH4Cl, and also isooctylphenoxypolyethoxyethanol (a non-ionic wetting agent)

1.6 Thesis Outline

This report consist of five chapters. For Chapter 1, it consists of an introduction, problem statement, objectives, and scopes of the project. This chapter explained the overview of the research project and this research is done by based on the objectives and scope.

Meanwhile, Chapter 2 discussed about the type of materials used in the project and its properties. Besides, the properties of leakage current, patterns, and the The Incline Plane Tracking test and the previous project about the leakage current also being discussed. Chapter 3 begins with the explanation of the tracking and erosion test, and followed by the IPT set up. The On-Line monitoring system that used in measuring and analyse the leakgae current also being explained in this chapter.

In this thesis, Chapter 4 represents all the results and discussion gain from the experiment conducted. The leakage current model and the analysis of the leakage current

explains about the pattern and the behaviour of all the materials used in the project. Other than that, the tracking and erosion test result which leads to pass and fail of the specimen is also being showed in this chapter. Finally, Chapter 5 is the conclusion of the project and also recommendation that can be done in the future.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Polymeric and glass insulator nowadays has become one of the most wanted materials in developing or manufacturing of insulator. This section will discuss about the overview of polymeric and glass insulation material of its development, the important of leakage current and the causes of the leakage current.

2.2 Polymeric Insulator

Polymeric insulators were considered as a replacement for porcelain and glass for special applications such as areas with high incidences of vandalism, urban locations with limitations on the right of way and areas of severe contamination problems due to their superior properties such as light weight, superior in mechanical strength and high hydrophobicity. When silicon rubber is used as an outdoor insulator, different environmental factors such as ultraviolet light, rain and air pollutant deteriorate the material properties. Then, tracking and erosion are caused by electrical factors such as arc and corona partial discharges. It happens when the power system is in operation tracking and erosion of polymer sheds, chalking and crazing of sheds which lead to increased contamination, arcing and flashover,

bonding failures and electrical breakdowns along the rod-shed interface and corona splitting of sheds. This condition will lead to electrical breakdown. It is well realized that aging, which leads either to tracking or erosion or to flashover under defiled conditions at normal working voltage, is still the major problems of failures for non-ceramic insulators [3].

Nowadays, electrical appliances accept polymer as an insulator proportionate to traditional insulator. This kind of insulator is widely used due to its advantages such as light in weight, low surface energy, better performance in wet condition and also great mechanical strength to weight ratio which means it is sturdily although it was light in weight.

When subjected to a range of in-service electrical, mechanical and environmental stresses, polymeric materials are more likely to predispose against chemical changes. The electrical stress is important to polymeric insulator which is under both normal and transient overvoltage conditions which are imposed under lightning and switching operations. In the high field locales, the initiate corona and surface electrical discharges that can prompt premature degradation, and under extreme conditions, a complete protection flashover, especially close to the HV transmitter and the earth terminal. Electric field distribution on the insulator surface are one of the main factors that contributed to the development of discharges on insulating surfaces, which will then be, control the current density. The surface of the insulation will reach its maximum level when the dry pond surface is formed on it as well as the insulation is starting to erode and leave traces on the surface of the insulation material. To reduce the effects of surface discharges on polymer outdoor insulator, the field control is required by considering these undesirable consequences [4].

2.3 Properties of Glass

Nowadays, glass has been widely used as an insulator in transmission and distribution system. Glass is a thermoplastic inorganic material comprising a complex system of oxides (SiO2) [5]. The main reason glass is used as an is due to its ability to operate in a very long period of time. In addition, the glass also will not undergo a process of erosion of the surface which also been known as surface degradation.

The dielectric strength of a glass is around 3000 to 5000 kV/cm depends on temperature. If the temperature increases the value will decrease [5]. Besides, glass has very high resistivity if compared to porcelain and polymer. Glass also has very high dielectric strength compared to any other compound such as polymer and porcelain. Glass properties which are transparent to light, which does not get hot when under extremely hot conditions or exposed to direct sunlight [6]. Because of its nature, it is transparent to light so that the resulting air bubbles in it can be detected easily. The resulting air bubbles in the glass insulation will result in a partial discharge of which would cause it breakdown to occur [7].

However, glass also has disadvantages which is when moisture condensed on its surface it will provide a path of leakage current of the system. This is due to, when the moisture condensed, it might contain contaminant which can allow the leakage current to flow.

Figure 2.1**:** Glass Specimen

2.4 Properties of Polypropylene

The thermoplastic polypropylene (PP) is used as a specimen in this project. Polypropylene (PP) has good balance between electrical and mechanical properties. It also has high dielectric strength [8]. Polypropylene (PP) has the best balance of electrical and mechanical properties. Because of Polypropylene can be synthesized from a low-cost

petrochemical raw materials, it makes the PP become a very versatile resin that suitable for processing in the mold or extruded parts by using a Ziegler type catalyst [9]. PP also has good attractive properties such as good in heat resistance, good surface hardness and also protected from moisture. Other than that, PP is much easier to fabricate if compared to the other insulator such as ceramic or glass. Due to its advantages, PP has become a key element in the production of insulation.

Figure 2.2**:** Polypropylene (PP) Specimen

2.5 Properties of High Density Polyethylene

Polyethylene is a thermoplastic material which is also being used widely as an insulator in high voltage system. Due to its versatility, the percentage of it to break is very low. It can elongate more before its break. Despite being very good in strength, it is light in weight compared to glass and porcelain [10]. Due to its weight is light, it gives less load to the supporting structure compared to glass insulator which is much heavier.