I hereby declare that I have read through this report entitle “Surface Tracking and Erosion Performance Insulation Material Under Different Frequency Behaviour” and found that it has comply the partial fulfilment for awarding the degree of Bachelor of Electrical Engineering (Industrial Power)

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SURFACE TRACKING AND EROSION PERFORMANCE INSULATION MATERIAL UNDER DIFFERENT FREQUENCY BEHAVIOUR

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A reported submitted in fulfilment of the requirement for the degree of Bachelor of Electrical Engineering (Industrial Power)

Faculty of Electrical Engineering

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I declare that this report entitle “Surface Tracking and Erosion Performance Insulation Material under Different Frequency Behaviour” is the result of my own search except as cited in the references. This report has not been accepted for any degree and is not concurrently submitted in candidate of any other degree.

Signature :

Name : MUHD FAIRUS NIZAM BIN MUHAMAD

Date :

To my beloved family especially my father and mother Mr Muhamad Bin Yaacob and Norhawati Binti Haji Harun. Also to my siblings for their supports and also goes to everyone that directly or indirectly in this project.

May Allah bless all of us.

Wassalam.

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ABSTRACT

This project is conducted to investigate the effect of surface tracking and erosion performance of polymeric insulation material under different frequency behaviour in term of their ageing factor by using an inclined plane test. Although this polymeric insulation has been used for many years, the limitation of this type of insulation material is ageing where their lifetime performance is the main problems. The aim of this study is to investigate the effect of different frequency behaviour on the polymeric insulation material by complying BS EN60587 which the international standard for tracking and erosion. Polymeric material is hydrophobic type where it is water repellent compare than glass ceramic which is a type of hydrophilic. This project has been conducted by constructing the inclined plane test (IPT) to evaluate the resistance of surface tracking and erosion performance under different frequency. Some of IPT advantages is IPT is fast, good educational tool, require close attention and the cheapest among the other test procedure. The method including of development the LabVIEW software circuit, inject the fixed power supply which is 3.5 kV and the varying the frequency where the frequency is changed from 50 Hz to 1 kHz. Data were recorded and analyse between all the specimens to study the effect of surface tracking and erosion performance of polymeric insulation under different frequency.

ABSTRAK

Projek ini dijalankan untuk mengkaji kesan ke atas pengesanan di permukaan dan prestasi penghakisan terhadap bahan penebat pada julat frekuensi yang berbeza dalam terma faktor usia dengan menggunakan IPT dengan mematuhi piawaian kebangsaan BS EN60587. Walaupun bahan penebat polimerik telah digunakan sejak 50 tahun yang lalu, tetapi masalah pada bahan penebat polimerik ini adalah penuaan bahan tersebut dimana prestasi untuk kegunaan jangka masa yang lama menjadi punca utama masalah ini. Bahan polimerik ini adalah jenis hydrophobic dimana ia air tidak melekat padanya berbanding dengan kaca seramik yang bersikap hydrophilic. Projek ini telah dilakukan dengan membina IPT untuk menilai nilai rintangan pada prestasi permukaan dan penghakisan pada frekuensi berbeza. Di antara kelebihan penggunaan IPT ialah IPT lebih cepat, kaedah pembelajaran yang bagus, memerlukan pemerhatian yang mendalam dan kaedah ujian yang murah berbanding dengan prosedur ujian yang lain. Kaedah yang dijalankan semasa projek ini adalah membuat litar pada perisian LabVIEW, memberikan nilai voltan yang tetap iaitu 3.5 kV tetapi nilai pemboleh ubah di mana frekuensi diubah dari 50 Hz hingga 1 kHz. Data direkod dan spesimen dikaji dan dianalisis dari segi kesan ke atas pengesanan di permukaan dan prestasi penghakisan.

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SYMBOL	TITLE
HV	High Voltage
HDPE	High Density Polyethylene
PP	Polypropylene
IPT	Inclined Plane Test
BS	British Standard
AC	Alternating Current
DC	Direct Current
Hz	Heartz
KV	Kilovolts
PVC	Polyvinyl Chloride
mm	Milimeter
ρ	Density
TFD	Time Frequency Domain
LC	Leakage Current

CHAPTER 1

INTRODUCTION

1.1 Research Background

As to prevent the current flow to undesired paths, the insulation play an important role to keep the high voltage (HV) applications running well. Although the type of insulation had been used since 1900's, it is still under study and improvement. It involves the development of designing the insulator, material of insulation, development of practical monitoring and measurement [1]. Material for the insulation on outdoor and indoor is still under study and recent development of an insulation that are used ceramic and non-ceramic type. Material can be classified into 3 type of measuring ageing from diagnostic properties which are mechanical properties, chemical properties and electrical properties.

For electrical properties, the material can be test by the dielectric strength, resistivity and tracking and erosion. Tracking and erosion mostly test for outdoor used. Polymeric type of material was selected to be tested in this study because of its advantages compared to non-ceramic insulation. Among them are low surface energy and hydrophobicity surface properties [2]. Polymeric insulation is good resistance against vandalism damage, less cost and lighter in weight. Although this polymeric insulation had been used over 50 years, the questions still exist regarding to their lifetime performance. Therefore, the focus of this research is to study the life performance on surface tracking and erosion performance of polymeric insulation material with different frequency behaviour according to BS EN60587.

1.2 Project Motivation

This project has been motivated by the several previous studies and experimental. On the previous research, this test has been conducted under non material test. To complete the project, this polymer insulation has been test on surface and erosion tracking using different frequency behaviour.

Because of its advantages, the polymeric material seems become the imperative material proportionate from porcelain and glass fibre. Thus, this polymeric material now replacing the porcelain and glass usage in the transmission line and distribution industry.

1.3 Problem Statement

On previous study, the IPT test were conducted comply with the standard BS EN60587-1 which is using AC supply of 3.5 kV and 50 Hz of frequency. In the real world application, the AC supply and the frequency might be different. Hence, the aim of this project is to study the ageing by surface tracking and erosion performance on different frequency behaviour. What is the effect if different frequency is used on the polymeric insulation?

1.4 Objectives

In this study, the main objective to be achieved is:

1. To conduct different frequency and standard tracking and erosion test for polymeric insulation material.
2. To observe and compare the physical result of different frequency and standard test on surface tracking and erosion performance of polymeric material.

1.5 Scope of Works

The scope of work will be focused on:

1. International standard on tracking and erosion test according to BS EN60587-1 is complied.
2. The range of frequency to be tested are between 50 Hz to 1 kHz.
3. Material to be studied is polypropylene (PP)
4. Method 1 is the selected method for this test.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this segment, a few studies have been directed in regards to following and disintegration of the polymeric protection material test. The stream of studies begins from the sort of polymeric protection, caught up with the element influenced in polymeric protection, which is focused on surface tracking and erosion due ageing factor. Numerous studies have been led to comprehend the instruments of ageing, build up benchmarks for the testing of quickened ageing in research. Furthermore investigation strategies to demonstrate the debasement and the components of ageing of polymer materials utilized as a part of protection. From the past examination, the testing for surface tracking and erosion has been set up by utilizing a few test which one of that is IPT (inclined plane test). In general of the study has utilizing the standard BS EN 60587 in light of the fact that this standard has meet the specification and the aftereffect of the test is demonstrated as a substantial result.

2.2 Insulation Materials

Electrical insulator must be utilized as a part of electrical framework to avert undesirable stream of current to the earth from its supporting focuses. It is the most important material in the high voltage industry. The separator assumes an imperative part in electrical system. Insulator is a high resistive way through which for all intents and purposes to ensure the current disable to flow through it and also along these lines make it almost difficult to direct an electric current affected by an electric field. There are 3 sorts of insulating material which comprise of gas, fluid and solid or composites. This insulator appears differently in relation to different materials, semiconductors and conduits, which transmit electric current all the more effortlessly. The property that distinguishes of this insulator is its resistivity.

Based on the study for this project, a large amount of organic and inorganic materials had been used. Thus, high voltage insulation material can be classified into 3 groups which is organic materials, inorganic materials and synthetics polymers. There are numerous good insulating material can be used for protective coating on electrical wire and cables such as glass, rubber, PVC, asbestos and paper [3][4]. Therefore, the electrical insulation is stressed by several factors that is:

i. Dielectric
ii. Thermal
iii. Mechanical
iv. Chemical
v. Radiations

Ecological conditions, for example, temperature, dampness, weight can modify the dielectric properties of an electrical system prompting its disappointment because of not sufficient properties or corruption under that particular ecological condition. Hence, polymeric insulation material are picked as a result of its particular favourable circumstances, contrasted with the ceramic insulators.

2.3 Polymeric Insulation

Polymeric insulation is a hydrophobic type of insulation which means it is water repellent. Compared to ceramic material that is hydrophilic. But the limitations of the polymeric material is life performance. There are several ways to decide their life performance. Previous studies shows that, surface tracking and erosion on polymeric insulator can be displayed by utilizing leakage current [5]. Surface tracking and erosion had been test by using inclined plane test (IPT) method according to BS EN60587-2007 is directed on polymeric insulation.

Polymeric composite insulations were introduced in service for outdoor distribution and transmission for more than four decades. In high voltage insulation, there are three classes of polymeric material which are epoxy resins, hydrocarbon elastomers and silicone elastomers [6]. Polymeric material can be divided into two groups consists of thermoplastic and thermosetting. For this study, thermoplastic is selected for its low melting temperatures property. Thermoplastic consists of Polypropylene (PP) and High Density Polyethylene (HDPE).

Many research had been done on this polymeric insulation to improve its lifespan and performances. This is because of its physical and economic especially. Due to the advantages of the polymeric insulation compared to the ceramic insulation, it has replaced the use of ceramic insulation in the high voltage industry. Some of the advantages are [7]:

i. Low surface energy
ii. Better contamination performance
iii. Light in weight
iv. Easy to handle
v. Easy transportation and installation

For this study, PP is selected as a material under study because its properties that fulfil the requirements.

2.4 Polypropylene

There were two type of this thermoplastic polymers which is polyethylene (PE) and polypropylene (PP). Both of this properties had different in term characteristics of resistivity on temperature, moisture and chemical. Polypropylene (PP) has a good resistance to organic solvents, degreasing agents and electrolytic attack. Compare to polyethylene (PE), PP has lower impact strength. Despite the fact that polypropylene not good at receiving an impact, the reaction on temperature and tensile strength is better than PE. In addition, Polypropylene (PP) is one of flexible polymers and does not retain water. It is more hydrophobic which is unequipped for dissolving in water. The advantages of the polypropylene as below [8] [9]:

i. Lightweight
ii. High tensile strength, high heat resistance and impact resistance
iii. Non-toxic and non-staining
iv. Good dielectric properties
v. Resist chemical and stress cracking
vi. Easily fabricated

2.5 Factors Affected In Polymeric Insulation

All material that had been used for insulation in high voltage industry will had their factor to lead to problems on the transmission line or distribution. Therefore, in this research the factors that affect the performance of the polymeric insulation are ageing, water treeing, electrical trees and contaminant factor. For this study, ageing factor is the main factor that affected the life performance of the polymeric insulation.

2.6 Ageing

The major problems that lead to failure of an insulator is ageing. Ageing which can cause either surface tracking or erosion. Both of this defect can affected the life performance of the polymeric insulator. Ageing is a factor when the life performance of the insulator is reduce or failure due to any changes in the chemical, mechanical and electrical properties of the polymeric materials [10]. It consists in the degradation with time of one or several properties. Ageing is one of the factors that affect life performances of insulation material and will meet failure when the polymer encounter several type of stress which are electrical, environment, mechanical, heat, and weather pollution [11]. Surface tracking and erosion are the method to test the life performance of the polymeric insulation.

2.7 Surface Tracking and Erosion

Surface tracking and erosion one of the failure factor of the type insulation. It will decrease the long term performance for the insulation. Based on the study, surface tracking execution and erosion could be monitored by a leakage current behaviour. Surface tracking is where the physical state of the polymer insulation had some problems where when the thermal and electrical energy change from dry band arcing. This happen when the energy changes had limit the durability of the insulator which can lead to decomposition. Meanwhile, erosion happened when the insulator encounter loss of material because of leakage current and electrical discharge happened [12] [1]. According to BS EN60587, surface tracking and erosion is apply to study the effect of this ageing performance.

2.8 Surface Tracking and Erosion Performance Test

The best ways to investigate about the ageing of polymeric insulation is by examined the insulation material that is polypropylene under the actual area situation. Unfortunately, the time taken for the effects of this aging will take a long period of time. Therefore, surface tracking and erosion test consenting to BS EN 60587-2007 are led, at that point leakage current recurrence parts is utilized as an analytic apparatus for their surface condition checking and degradation seriousness. Basically, there are also other test can be conducted to test this surface tracking and erosion that is tracking wheel dust, fog test and salt fog test. All of the test are based on standard and each test have their own objective and purpose on getting the results [13]. For this study, IPT was chosen because of its advantages and it fulfil the requirement needed. The advantage of performing this test are because it is economical and all the material is provided. Furthermore, the results found within a short term period. Unfortunately, by using this procedure will make the researcher experienced in difficulty to determining the initial tracking voltage. Based on the study, a test to carry out performance of insulating material has been made. Table 2.1 has shown the important properties of material and minimum requirement of polymeric insulation.

Table 2.1: Important properties and minimum requirement of polymeric insulation [14]

Property	Minimum Requirement	Test Standard
Resistance to tracking and erosion	1A3,5b	IEC 60587*
Tear strength	>6N/mm	ISO 34-1*
Volume resistivity	>10MΩ	IEC 60093*
Breakdown field strength	10kV/mm	IEC 60243-1*
Water diffusion test	Voltage test -12kV-1min or tan δ<0.2	IEC 62217* IEC 60250*
Arc resistance	>180 s	IEC 61621*

2.9 Inclined Plane Test (IPT)

The inclined plane test on surface tracking and erosion is one of popular testing procedure to evaluating the surface tracking and erosion on polymeric insulation material. Based on standard BS EN60587:2007, the sample of polymeric insulator must be in rectangular shape with the size of 120 x 50 x 6 mm. The sample are place at 45 degrees angle according to the standard stated. Conductive solution (ρ = 3.95Ω.m) is dripping on a filter paper and streaming down the specimen towards the ground electrode where dry band arcing for the most parts happens [15]. Base on previous study, this test is conducted in the lab where the variable transformer has been used where on the other hand, the secondary voltage can be adjusted according to standard values (0-6kV) with a rated current not less than 0.1 A for each specimen. Then, the transformer will be through to the fixed resistor and connected to upper electrode that been tide with the specimen. The lower electrode is connected to ground. The peristaltic pump acts as a medium to flow the contaminant flow rate at the upper electrode. Figure 2.1 has shown the IPT test experimental setup.

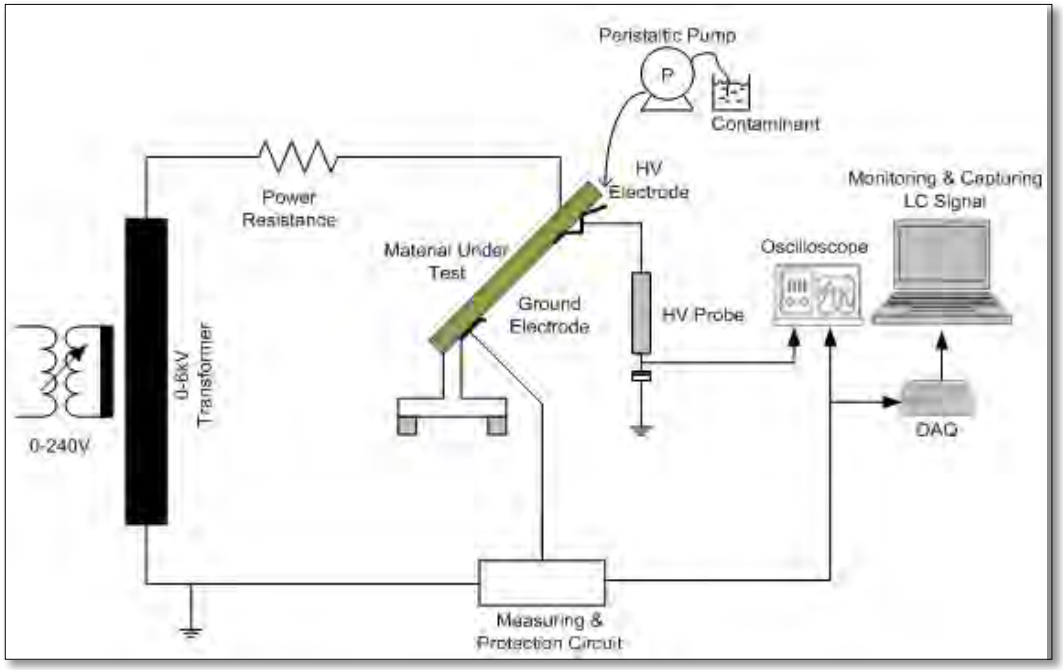

Figure 2.1: Inclined Plane Test Setup based on BS EN60587:2007 (IPT)