UNIVERSITI TEKNIKAL MALAYSIA MELAKA

FREQUENCY ANALYSIS TECHNIQUE FOR DETERMINATION OF HIGH VOLTAGE INSULATION MATERIAL SURFACE CONDITION

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Engineering Technology (Industrial Power) (Hons.)

By

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APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfilment of the requirements for the degree of Bachelor of Electrical Engineering Technology (Industrial Power) with Honours. The member of the supervisory is as follow:

……………………………….

(Nurbahirah binti Norddin)

ABSTRACT

This is a project in purpose to study the pattern of the erosion on the insulation material cause by leakage current using high voltage and compare the leakage current pattern between insulation material with erosion and without erosion on its surface. Insulation plays an important role in order to determine the reliability and availability of an electrical power apparatus in delivery system. With a good insulation system, it will give a better design, performance and safety of the apparatus. In order to see the insulation is good, leakage current is used to see the system is good determine the tracking and erosion on the material used. A new approach of leakage current harmonics analysing will be applied. This method would indicate a correlation of high harmonics components of leakage current and the aging of the material, as well as good diagnostic tools for degradation of high voltage insulation material for outdoor application compare to low harmonics information that previously used.

ABSTRAK

Projek ini adalah bertujuan untuk mengkaji corak hakisan ke atas bahan penebat terhasil akibat daripada arus bocor dengan menggunakan voltan tinggi dan corak hakisan akan di bezakan di antara bahan penebat yang terhakis dan bahan penebat yang tidak terhakis di atas permukaan bahan tersebut. Penebat memainkan peranan yang penting dalam mengenal pasti kebolehan dan ketersediaan perkakas kuasa elektrikal dalam sistem pengaliran. Dengan sistem penebat yang baik, ia akan memberikan rekaan yang baik, pertunjukan dan keselamatan terhadap perkasas tersebut. Untuk mengenal pasti sesuatu sistem penebat itu adalah baik, arus bocor akan digunakan untuk mengenal pasti keadaan sistem tersebut menggunakan kaedah "tracking" atau jejak dan "erosion" atau hakisan terhadap permukaan bahan penebat yang akan di gunakan. Cara baharu mengenal kebocoran arus, "harmonic analyzing" akan di gunakan. Cara ini akan menunjukkan hubungan ketinggian keselarasan komponen terhadap arus bocor dan penuaan terhadap bahan penebat, sebaik alat diagnostik yg baik untuk merendahkan bahan penebat untuk voltan tinggi untuk kegunaan luaran di bandingkan terhadap keselarasan rendah maklumat yang telah di gunakan pada kajian dahulu.

DEDICATIONS

To my beloved mother, family and my fellow friends thank you for the support and help given to me in completing this thesis

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LIST OF SYMBOLS AND ABBREVIATIONS

FFT	=	Fast Fourier Transform
TFD	=	Time Frequency Distribution
μ	=	Dipole moment
PO	=	Polyphenylene oxide
PP	=	Polypropylene
PS	=	Polystyrene
°F	=	Fahrenheit
°C	=	Celsius
IEC	=	International Electrotechnical Commission
IPT	=	Incline Plane Test
V	=	Voltage
DFT	=	Discrete Fourier Transform
IDFT	=	Inverse Discrete Fourier Transform
PSD	=	Power Spectral Density
TFR	=	Time Frequency Representation
Hz	=	Hertz
RTV	=	Room Temperature Vulcanized
HTV	=	High Temperature Vulcanized
HV	=	High Voltage
GP	=	Ground Potential

CHAPTER 1

INTRODUCTION

1.0 Introduction

In this section basically explain the background of this project and explaining the objective, the scope, problem statement and project significant.

1.1 Background

According to (Loom,1990), an electrical insulator is a material whose internal electric charges do not flow freely, and therefore make it very hard to conduct and electric current under the influence of an electric field. The other words, insulators which are used on electricity supply networks to support, separate or contain conductors at high voltage. Based on (Loom, 1990) a special case, the insulating tools which are used in the maintenance of live apparatus, is included because of the many features in common with classical insulators. Insulator made an important role in electricity. Without insulator people cannot handle electric current and it will cause casualties.

In this project, insulator which is polymeric will be used to study the pattern of the erosion on the insulation material cause by leakage current using high voltage and compare the leakage current pattern between insulation material with erosion and without erosion on its surface.

In order to get the pattern, both simulation and on real insulation material will be done to get the measurement data. For simulation, MATLAB will be used. A few coding will be used to produce Fast Fourier Transform (FFT).

1.2 Problem Statement

Leakage current is the current that flows through the protective ground conductor to ground. In the absence of a grounding connection, it is the current that could flow from any conductive part or the surface of non-conductive parts to ground if a conductive path was available. Leakage current may cause erosion when it hit the material used as it cover. The erosion pattern is depend on the leakage current condition. In order to understand the erosion pattern on the material used, an analysis and an experiment will be done to study the pattern of the leakage current on the surface of the polymeric which is the insulation material that will be used in this project.

1.3 Objectives

The objective of this project are:

a) To compare the leakage current signal for material with erosion and without erosion on its surface.
b) To use Fast Fourier Transform (FFT) in determine the surface condition of material.
c) To identify the surface condition of insulating material based on quality of the signal.

1.4 Scope

This project use leakage current signal only, Fast Fourier Transform (FFT) and spectrogram as signal processing and MATLAB as a tool. LABVIEW software also been used to make the simulation of the leakage current. The erosion pattern in the insulation material will be compared.

1.5 Project Significant

This project is significant to be used as insulator for electric current flow protection such as cable, wire and distribution box with can be made using this material. The result of this project will ensure that leakage current can be endure the duration from pass through the material surface.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

This section will explain about the basic element that will be involve in this project such as leakage current, insulating materials, simulation used to simulate the waveform create by the leakage current and the chemical used for the project.

2.1 Insulator

An insulator very important when it involve in using current and voltage. It is also used to protect cable or wire or anything that need insulator from the current flowing outside the cable. Without insulator, living thing or people that touch the cable flowing with current can cause accident happen. Thus, an insulator is very important in giving protection to living thing and people.

According to (Shugg, 2002), insulating materials, also called dielectric materials, are essential to the electrical and electronic equipment to be functioning in good condition. In fact, the amount of material required for insulation are depend on the size of the equipment and the operating limitation. Insulating materials are available in many form and materials had been made, and the problem becomes one of selecting rather than adapting.

2.2 Insulation System and Service Life

Base on (Shugg, 2002), an insulation system is an assembly of insulation materials in a particular type of equipment. Although there are other opinions on the subject among some authorities, this specification states the case for the determining service life of equipment as follows:

Based on the experience that has shown that the thermal life characteristic of composite insulation system cannot be reliably base on the information only. It must be support by testing it on real thing or known as accelerated life test. Accelerated life tests are being used increasingly to evaluate a new synthetic insulating materials that are available. Before it can be used with confidence shortening the period of service are required. The test that have been conduct and complete are necessary to confirm the performance of materials for their specific functions in the suitable equipment. Insulation equipment can be made up from different type of component. The component selected will be tested to withstand the different condition in electrical, mechanical and thermal stresses occurring in different part of the structure. The life of the insulation service will depend on tit effectiveness on supporting the current flow or forces acting on it. Therefore, the period of useful life of this system will depend on the arrangement of the components.

2.3 Material Aging and Breakdown

According to (Shugg, 2002), the factors that causing the aging and deterioration of an insulation are the following:

a) *Thermal stresses* occurring in electrical and electronic equipment. These are cause by due to overloads of current plus the ambient temperatures or it can know as internal heating. When the material are exposing for prolonged periods above a temperature specific for each material, chemical breakdown rapidly accelerates.

b) *Electrical stresses* caused by the voltage gradient in the material. Most equipment is designed base on the dielectric strength that the equipment can withstand, so under normal operating conditions aging will not been detected because the high voltage gradients are below breakdown voltage. However, at elevated temperatures electrical stresses may act causing accelerate material degradation.

c) *Mechanical stresses* caused by assembly configurations, manufacturing techniques, centrifugal forces, and vibration. These stresses tend to physically damage material.

d) *Environmental conditions,* such as exposure to oxidation, ozone, radiation, and chemicals. The resistance of insulating materials to many chemicals is well documented, so in selecting candidates for a specific application, only those materials should be considered that are resistant t encounter by chemicals.

The rate of voltage rise and is another factor of affecting dielectric strength and whether it is continuous or step by step. A slow rate of increase usually encourages time-dependent thermal degradation due to local heating, resulting in lower dielectric strength values. Dielectric breakdown strength values should include a statement of the following:

a) Specimen thickness and conditioning
b) Method of voltage application
c) Type and size of electrodes
d) Test temperature
e) Any unusual environmental conditions

2.4 Dipole Moment and Polarization

According to (Shugg, 2002), dipole moment is defined molecules in which the atoms and their electrons and nuclei are arranged one molecule has positive charge and the other part contain negative charge. Then the molecule will becomes a small magnet or so called dipole. When a magnetic fields occur of electrical changing it charge, the molecule will rotate in one direction or another term depend on the charge of the field. The dipole moment (μ) known as the distance between the charges multiplied by the quantity of charge in electrostatic units.

Dipole polarization occurs when normally randomly oriented permanent dipoles of a molecule are aligned by an applied electric field. This phenomenon is facilitated at higher temperatures where dipoles are bound less tightly and are freer to align with the field.

The type and arrangement of the atoms in a molecule determine its polarity. In general, the degree of molecular symmetry and the affinity of an atom for its electron influences polarity. Thus, polyethylene is nonpolar. Polymonofluoroethylene is strongly polar, and polytetrafluoroethylene exhibits low polarity (because of symmetry and the high affinity of fluorine for its electrons.

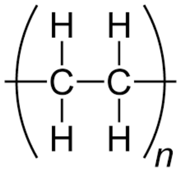

Figure 2.1:Polyethylene

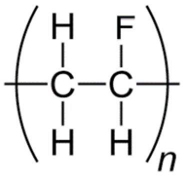

Figure 2.2: Polymonofluoroethylene

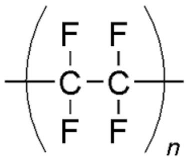

Figure 2.3: Polytetrafluoroethylene

The aligned dipole molecules produce a net polarization across the material which has the effect of increasing the dielectric constant. In general, the dielectric constant at one Megahertz of nonpolar polymers ranges from 2.2 to 2.6, and for polar polymers from 2.6 to over 6. Example of nonpolar and polar polymers are shown in table 2.1.

Table 2.1: Typical Nonpolar and Polat Polymers

Nonpolar	**Polar**
Polyethylene	ABS resin
Polyphenylene oxide	Nylon 6/6
Polypropylene	Polycarbonate
Polystyrene	Polymethyl methacrylate
Polytetrafluoroethylene	Polysulfone
	Polyvinyl chloride

2.5 Principal Thermoplastic Polymers for Electrical/Electronic Uses

There are many type of thermoplastic polymers widely use nowadays, such as homopolymer, copolymer, terephthalate, polycarbonate, polypropylene and etc. For this project, polypropylene (PP) will be used as the insulator for testing.

2.5.1 Polypropylene

According to (Shugg, 2002), polypropylene is a highly versatile resin suitable for processing into moulded insulation parts, extruded wire and cable insulation, and dielectric films. Base on (Johnson.2015), one of the benefits of using this type of plastic is that it can be use in any application in the industry or in household. Others type such as a fiber-type plastic also useful.

2.5.1.1 Chemical Bond

Base on (Shugg, 2002), polypropylene is formed by polymerizing propylene ($CH_3CH{=}CH_2$). The reaction is carried out commercially in several ways. The newest process, introduced by Rexene in mid-1980, is based on high efficiency catalysts which reduce process energy consumption. This gas-phase process increases yield of isotactic (crystalline) polymer per pound of catalyst with low