DEGRADATION MONITORING OF HIGH VOLTAGE POLYMERIC INSULATOR USING EXTRACTED LEAKAGE CURRENT SIGNAL PARAMETER

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This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Electrical Engineering Technology (Industry Power) with Honours.

by

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I hereby, declared this report entitled DEGRADATION MONITORING OF HIGH VOLTAGE POLYMERIC INSULATOR USING EXTRACTED LEAKAGE CURRENT SIGNAL PARAMETER is the results of my own research except as cited in references.

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Author: Mohamed Muhaimin Bin Saari

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APPROVAL

This report is submitted to the Faculty of Mechanical and Manufacturing Engineering Technology of Universiti Teknikal Malaysia Melaka (UTeM) as a partial fulfilment of the requirements for the degree of Bachelor of Mechanical Engineering Technology (Automotive) with Honours. The member of the supervisory is as follow:

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ABSTRAK

Rangkaian penghantaran melibatkan peralatan voltan tinggi yang mengandungi transformer dan penebat. Penebat bahan mesti dikekalkan untuk mencapai operasi pengagihan elektrik secara berkala. Penebat berbentuk polimer perlahan-lahan menggantikan penebat seramik. Kelebihan bentuk polimer termasuk yang mudah dipasang dan memberikan ciri unik. Setelah penebat polimer voltan tinggi di lapangan terdedah kepada persekitaran semula jadi seperti cahaya matahari, sinaran matahari, dan agen berasid kerana hujan, mengalami degradasi berterusan pada permukaan. Penyelidik di seluruh dunia telah melihat pelbagai jenis kaedah penilaian dan analisis. Penilaian dan analisis ini melibatkan penilaian fizikal, analisis dan perbandingan keadaan degradasi penebat polimer menggunakan sampel maklumat dan spektrogram yang diukur. Oleh itu, tujuan kajian adalah untuk membuat kajian perbandingan keadaan degradasi penebat polimer antara penebat berumur 6 dan 18 tahun. Ujian dan analisis projek ini terdiri daripada dua bahagian iaitu untuk bahagian perkakasan pengukuran kekasaran permukaan menggunakan penganalisis kekasaran permukaan dan ujian parameter isyarat LC menggunakan ujian satah condong (IPT). Bahagian perisian, program Labview dan Matlab digunakan untuk proses dan analisis pengambilan LC. Oleh kerana pengujian perkakasan tidak tersedia, projek-projek yang memfokuskan pada analisis data yang dilakukan oleh perisian Matlab untuk menganalisis data isyarat dalam spektrogram. Secara keseluruhanya parameter isyarat LC yang merupakan purata dua pendimensian dapat membezakan secara signifikan keadaan permukaan penebat 6 tahun dan 18 tahun berbanding dengan data kekasaran permukaan dan terdapatnya kewujudan tenaga terhasil di dalam perwakilan masa-frekuensi daripada Spektrogram yang mewakili kuantiti tenaga yang terkandung dalam sesetengah isyarat.

ABSTRACT

The transmission network involves high voltage equipment containing transformers and insulators. The insulation of the material must be maintained to achieve regular electricity distribution operations. Insulators of a polymer form have slowly replaced ceramic insulators. The advantages of a polymer form include the simple to mount and provide unique characteristic. After field aged high voltage polymer insulator being exposed to the natural environment such as sunlight, solar radiation, and acidic agents due to the rain they tended to continues the spread of degradation on the insulator surface. Researchers around the world have looked into different types of evaluation and analysis methods. This evaluation and analysis involve physical evaluate, analyse and compare the conditions of polymer insulator degradation using a sample of measured information and spectrogram. Therefore, the research goal is to conduct a comparative study of the conditions of polymeric insulator degradation between 6 and 18 year field-aged insulators. The comparison involves the physical evaluation performance of polymer insulator which is surface roughness, and to statically gather the leakage current (LC) data of the two-dimensional mean of Spectrogram of 6 and 18 year old insulators. This project's test and analysis consist of two parts which are for hardware part the measurement of surface roughness using surface roughness analyser and the LC signal parameter test using the inclined plane test (IPT). A software part, the LabVIEW and the MATLAB program are used for LC capturing process and analysis. Since the hardware testing is not available, the projects focusing on the data analysis that carried out by MATLAB software to analyse signal data in spectrogram. As overall result, the LC signal parameter which is two-dimensional mean of Spectrogram able to significantly differentiate the surface condition of 6 year and 18 year insulators compared with the surface roughness data and there is existence of energy present in time-frequency representation of Spectrogram consider as the quantity energy that contained in particular signal.

DEDICATION

I was dedicated to my beloved parent. My mother who taught me the type of knowledge she learned for herself and My father, who taught me that if it is done step by step, even greater task can be achieved.

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Lastly, I grabbed this opportunity to dedicate this PSM project for all Faculty of Electrical Engineering Technology's students, especially for my junior to provide any brilliant idea or recommendation for further improvement of this project.

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LC	-	Leakage current
Ra	-	Surface roughness
TFD	-	Time-Frequency Domain
FFT	-	Fast Fourier Transform
EAP	-	Early Aging Period
TP	-	Transition Period
LAP	-	Late Aging Period
EPDM	-	Ethylene Propylene Diene Monomer
ATH	-	Aluminium Trihydrates
LMW	-	Lower Molecular Weight
AE	-	Acoustic Emission
IR	-	InfraRed
STFT	-	Short-Time Fourier Transform
µm	-	Micrometre
µin	-	Microinch
SiR	-	Silicon Rubber
dB	-	Decibel
mm	-	Millimetre
IPT	-	Incline Plane Test

CHAPTER 1

INTRODUCTION

1.1 Background

The demand for electric power to transfer a large amount of electricity to customers has increased by using high voltage transmission network. In the transmission system, high voltage equipment's which contains transformers and insulators plays an important role to transmit the electrical energy to the consumers effectively. To achieve regular electricity distribution activities, the isolation of the equipment must be preserved. Ceramic insulators are known today and are commonly used as an outdoor insulator in transmission, distribution network and substations.

As the technology of isolation technologic has evolved rapidly, ceramic insulators slowly have been replaced by polymer-type insulators because of their Polymer-type advantages, such as the simple to mount and the special feature of hydrophobicity. However, the combined effects, for example, electrical, mechanical, and thermal stress during operation of this polymer isolator have tended to be degraded.

Besides, because of various environmental, for example, sunlight, solar radiation, condensation and acidic agents due to the rain, the degradation is still spreading on its surface. Nonetheless, these degradations occurred because of local changes in the climate and the pollution of the outdoor insulator. Those stresses therefore automatically speed up the process of decay which causes loss of weight, erosion, tracking of the surface, loss of surface hydrophobicity, partial arc releases, and increase the electrical current or the complete failure of the insulator. Researchers around the world have examined different types of methods for evaluation and analysis to minimize and prevent these issues from overcoming the possible degradation effects in the field. This assessment and analysis involve physical estimates such as surface roughness of the

insulator, chemical properties and electro-power properties, such as the analysis of leakage current (LC) in a specific system.

The goal of the research is to analyse and compare the conditions of the degradation of polymer insulators using a sample of measured information and a spectrogram of spectroscope transformation focusing on surface roughness and the two-dimensional mean averages. This sample consists of two samples with insulators for 6 and 18 years. The sample material used for the analysis intake at (Pencawang Masuk Utama, PMU), which was located in Pagoh and Simpang Renggam on the coast of Johor, Malaysia.

1.2 Problem Statement

The Polymer is commonly used in the production of electrical energy compared with traditional ceramic isolator due to its various advantages such as structural nature, simple installation and hydrophobic characteristics. However, polymer insulator needs to be well maintained and proper management. Without appropriate management, it tends to accelerate the degradation of an insulator due to electrical, mechanical and thermal stress experienced by the outdoor insulator. It can lead to weight loss, erosion, surface tracking, loss of surface hydrophobicity, partial arc discharge, increased leakage, and the insulation material failure of the insulator. Those kinds of stress will be affected by physical evaluation in term of surface roughness of Polymer due to field aged of the insulator and environmental stress. When the polymer insulator with field aged insulator that being exposed to environmental stress, the insulation surface and dielectric performance of insulator will be reduced due to pollution and contamination dust present on the surface after long-duration use. In this condition, the value of roughness will be increased and directly gives many information based on the degradation of the polymer surface. Besides, the determination of performance surface insulator can be done by the study on leakage current signal appeared on the surface by using time-frequency distribution (TFD) as analysis leakage current behaviour at different field aged insulators. In this case, Short Time Fourier Transform (STFT) will be used to extract the feature

which is two dimensional mean from TFD and collected the data of two-dimensional mean to analyse signal behaviour for different field aged insulator. Overall, these two parameters, such as surface roughness and two-dimensional mean leakage current, would be represented as the performance and strength of degradation insulator. The idea of this research to compare which of the parameters provides significant indicators for the level of the degradation between surface roughness and two-dimensional mean leakage current with different age of the insulator.

1.3 Objective or Aim for Research

The objective of the research is to do a comparative analysis of the polymeric insulator degradation conditions between 6 and 18 years. The objectives of the study are listed below and must be achieved and achieved in order for this project to be completed.

a) To investigate the physical evaluation performance of polymer insulator, which is surface roughness.
b) To statically gather the two-dimensional mean of Spectrogram for 6 years and 18 years insulator.
c) To compare the degradation performance between 6 years and 18 years insulator using the surface roughness and LC signal parameters.

1.4 Research Scope

This research is conducted by using the high voltage of Polymer, which is a field-aged insulator of 6 and 18 years insulator. In term of analysis, the research is focusing on analysis the insulator's existing data, including mechanical data from physical evaluation and electrical data from Spectrogram to extract signal parameter. Therefore, mechanical and electrical data can be taken, such as Surface roughness (Ra) parameter and two-dimensional mean leakage current, which are determining by using (TFD) spectrogram.

1.5 Research Outline

This research is made up of five (5) chapters, based on the objectives and the suggested strategy described above, which are summarised as:-

- Chapter 1. Introduction which contains the background of the study, research problem statement, goals and targets are described in this chapter.
- Chapter 2. Literature review starts with a brief overview of the polymeric insulator, followed by its hydrophobicity properties and exposed to environmental stress. Also, a brief on its hydrophobic features of the polymer insulator, which is exposed to environmental stress. This chapter presents references to surface roughness (Ra) relationships with insulator aged and ecological stress. Later, this chapter presents an overview of leakage current flow to surface polluted insulator under the wet atmospheric condition, which can cause discharge phenomena. Also, a brief discussion on leakage current analysis to analysis LC parameter using Fast Fourier Transform and Spectrogram.
- Chapter 3. This part presents for the methodology used to collect and analyze data based on each of the parameter identified; Surface roughness (Ra) and two-dimensional mean leakage current.
- Chapter 4. In this part, the result samples of field age insulator that been measured and discuss data based on response of parameter include for data analysis purposes.
- Chapter 5. Conclusion and Recommendation. This chapter summary of the main research findings and achievement and recommendation for future research

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction of Insulator

Regarding the system of high voltage, the most important component material being used is a conductor to carry a lot of current, as well as an insulator for avoiding electric current from flowing unwanted path and example of polymer insulator type, can be seen in substation line (refer Figure 2.1.1). These components shall be considered in electrical power supply to make sure substation, power lines protected and operated very well. Damage to outdoor electrical insulators will exponentially increase electrical fields, particularly near electrodes over time. Insulation technology has evolved and grows rapidly had shifted its material from using conventional ceramic type to polymeric composite started from early 1900.

Figure 2.1.1 Surge Arrester located at substation line

Compared to conventional ceramic insulating, polymer composite is more effective due to the hydrophobicity advantages, for example, as mentioned by (Abdullah and Norddin, 2013). However, Polymer has certain limitations on certain aspects that are difficult to track defection of insulation and loss of hydrophobicity properties that lead to a track and erosion and contaminated flash.

Significantly, an outdoor insulator with higher age of service which surfaces exposed to environmental stress will cause larger surface roughness (Ra) and porosity of the surface insulator (Khan, 2009). This phenomenon can be described by losing the outer polymer layer on the surface that resembles the finish of the moulding process. As the ageing times continue to grow, erosion will gradually influence the outer layer due to the substitution process. This enhances the external layer of the insulator with a polymer and exposed fillers layer. So that it increases the rough value and provides information about the degradation of the polymer surface (Saldivar-Guerrero et al., 2014);(Din et al., 2019). In the meantime, surface roughness (Ra), due to the high of environmental stress, is serious regardless of the duration of its use. The surface roughness of the insulation surface and dielectric strength have been reduced for a long time by massive contamination and dust.

Furthermore, the study of the current leakage signal is widely accepted for the performance determination of the polymer insulator in use or accelerated laboratory tests. The leakage current signal contains details about the state of the polymer surface and the pollution seriousness. Leakage current measurement is common because insulation performance can be monitored online or offline (Abdullah and Norddin, 2013). Some researchers used peak current measurement, accumulated load and discharge time to give information about degradation.

Several studies have been carried out based on LC research in particular on harmonic characteristics and the low harmonic content and leakage current ratio. For examples, (G.P Bruce and S.M Rowland, 2010) analyzed lower harmonic current leakage components as a method for diagnosing ageing and surface status. During this time (N. Bashir et al., 2010) the lower harmonic components were verified as a significant factor in surface condition Most Fast Fourier (FFT) transform are used to evaluate and analyze the present signal of leakage.

Yet, FFT also does not include temporary information and is not appropriate for non-stationary signalling but for time-frequency distribution (TFD) analysis such as Spectrogram and s-transformation. Spectrogram can be used for high or low-frequency