CONDITION MONITORING OF FIELD-AGED HIGH VOLTAGE POLYMERIC HOUSING INSULATOR

NUR SYUHADA BINTI ZAIDOON
B071710773

UNIVERSITI TEKNIKAL MALAYSIA MELAKA
2020

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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 and Electronic Engineering Technology (Industrial Power) with Honours.

by

NUR SYUHADA BINTI ZAIDOON

B071710773

980805-56-5380

FACULTY OF ELECTRICAL AND ELECTRONIC ENGINEERING

TECHNOLOGY

2020

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

Tajuk: Condition Monitoring of Field-Aged High Voltage Polymeric Housing Insulator

Sesi Pengajian: SEMESTER 1 2020/21

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NUR SYUHADA BINTI ZAIDOON

Alamat Tetap:

NO 10, JALAN CEMPAKA 6.

TAMAN CEMPAKA,48200,

SERENDAH,SELANGOR.

Tarikh: 18th of February 2021

Disahkan oleh penyelia:

.....

TS.ASRI BIN DIN

Cop Rasmi Penyelia

Ts. ASRI BIN DIN
Pensyarah Kanan
Jabatan Teknologi Kejuruteraan Elektrik
Fakulti Teknologi Kejuruteraan Elektrik dan Elektronik
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Date : 18th of February 2021

APPROVAL

I hereby declare that I have checked this project report and in my opinion, this project report is adequate in terms of scope and quality for the award of the degree of Bachelor of Electrical Engineering Technology (Power Industry) With Honours

Signature : 

Name : TS. ASRI BIN DIN

Date : 18th of February 2021

ABSTRACT

Maintaining high reliability in power networks is very important hence condition assessment of naturally aged polymeric insulators was aiming to get a better understanding towards the involved aging process. This project introduces the condition monitoring of field-aged high voltage polymeric housing insulator by making comparison of degradation between shed of 12 years insulator using the hydrophobicity properties and leakage current (LC) signal parameters. The purpose of this project is to investigate the status of hydrophobicity on the surface of the insulator. The input signal parameter used spectrogram to extract electrical signal parameter using MATLAB software and the data obtained would only focusing on mechanical and electrical part that used spectrogram to extract signal parameter such as 2-dimensional mean. Due to some factors and harsh environmental conditions that accelerate the process of aging, the performance and degradation of polymeric insulators was able to be evaluated by testing and comparing their sheds.

ABSTRAK

Mengekalkan kebolehpercayaan yang tinggi dalam rangkaian kuasa adalah sangat penting. Oleh itu penilaian keadaan penebat polimer yang berumur secara semula jadi bertujuan untuk mendapatkan pemahaman yang lebih baik mengenai proses penuaan yang terlibat. Projek ini memperkenalkan pemantauan keadaan penebat perumahan polimer voltan tinggi berumur di lapangan dengan membuat perbandingan degradasi antara penebat polimer yang berumur 12 tahun menggunakan sifat hidrofobik dan parameter isyarat arus kebocoran (LC). Tujuan projek ini adalah untuk menyiasat status hidrofobik pada permukaan penebat. Parameter isyarat input menggunakan spektrogram untuk mengekstrak parameter isyarat elektrik menggunakan perisian MATLAB dan data yang diperoleh hanya akan fokus pada bahagian mekanikal dan elektrik yang menggunakan spektrogram untuk mengekstrak parameter isyarat seperti min 2-dimensi. Oleh kerana beberapa faktor dan keadaan persekitaran yang teruk telah mempercepatkan proses penuaan, prestasi dan penurunan penebat polimer dapat dinilai dengan menguji dan membandingkan antara kepingan insulator.

DEDICATION

To my beloved mother and father.

ACKNOWLEDGEMENT

Firstly, I would like to express my gratitude to Allah SWT who gave me strength to bear all circumstances and obstacles during finishing my final year project. The research was able to be done with so much determination and great enthusiasm due the supports from many people.

I want to thank my supervisor, Ts. Asri bin Din for giving me the opportunity to do this research and for his endless guidance. I have been inspired by his sincerity and vision throughout this research as he keeps on sharing experiences and knowledge from beginning until the end. It was such a great privilege and honour for be able to learn and work under his guidance.

I am also extremely grateful towards my parents and siblings for their love, prayers and supports whom especially have influenced me a lot in good ways and for their understanding during the process of accomplishment on this research. I would also like to thank my friends for being such a great help and show interests making me to be able completing this research successfully.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS AND ABBREVIATIONS

D,d	-	Diameter
kV	-	Kilovolt
Mn/m	-	Millinewton/metre
N/m	-	Newton/metre

CHAPTER 1

INTRODUCTION

1.0 Introduction

This starting chapter will explain about the project background, problem statement, scope, expected outcomes and objectives of the project.

1.1 Background

Outdoor insulators play a major role in preserving the device's stability in a power network. The main aspect for the reliability of power systems is the performance of high voltage insulators that were used in overhead transmission and distribution lines. Outdoor insulators undergo multiple stresses during operation such as mechanical, chemical, electrical and thermal stresses. Although the long-term service performance and the projected service life of these projected service life were complicated and time-consuming, but it was still an important problem and issue.

Since a long time ago, ceramics insulators were commonly used in distribution lines and power transmission. Due to certain particular advantages, conventional ceramic insulators were replaced with polymeric composite insulators consisting of core fibre reinforced polymer insulators covered with polydimethylsiloxane (PDMS) housing, in particular for high-outdoor power transmission line. In recent times, polymeric insulators are favoured in terms of contamination durability compared to traditional ceramic insulators but polymers have relatively shorter life compared to ceramics. Polymeric materials that relatively are resistant to aging are used in various applications for outdoor

such as roof coverings, coatings, automotive, paints and homes or in power transmission lines for outdoor composite insulators.

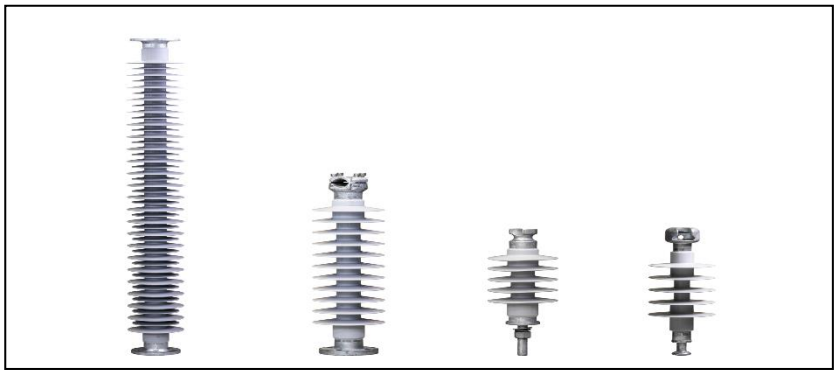

Figure 1.1: High quality electrical polymeric insulators

Power transmission are one of a global necessity and as a result, insulators face different climatic conditions throughout the service. The deterioration of polymers at the open atmosphere are slow-going and moderate, as demonstrated by the degradation of various mechanical properties and the changes of appearance. They are one of organic materials that degrade slowly over time due to various environmental factors such as humidity, pollutants, ozone, UV radiation, heat, and oxygen. These factors automatically speed up the degradation process which causes surface tracking, loss of surface hydrophobicity, erosion, increase an electrical leakage current or causing the total failure of the insulator.

In this project, the 2-dimensional mean of spectrogram of 12 years old insulator shed were statistically gathered and the degradation performance between sheds using the hydrophobicity properties and leakage current signal parameters was being observed. The condition of the field-aged insulators is related to their physical performance and the hydrophobicity in particular. The surface hydrophobicity of different insulators then was measured in terms of contact angles.

1.2 Problem Statement

Polymeric insulators have a lot of advantaged such as lightweight, show a good performance in contaminated environment, easy to operate, maintenance free and significantly cheaper if compared to ceramic and glass insulators. These properties become the major reason on why it was widely used in electrical energy development.

However, polymeric insulators have relatively short life and without a proper management, the degradation of an insulator will accelerate due to the electrical, mechanical and thermal stress experienced. The performance of the insulator under different conditions has been deeply analysed to investigate the status of hydrophobicity on their surfaces.

Hydrophobicity become of the indicators and important parameter to characterize the electrical properties of insulated materials. The research happened to study about comparative of the degradation performance between sheds of 12 years old insulators using the hydrophobicity properties and leakage current signal parameters. The degradation between sheds of insulators need to be compared as one problematic shed can affect to the others shed of insulators. Some parameters that can be gained from this study are including root mean square (RMS) and total harmonic distortion (THD)

1.3 Objectives

The project consists of three main purposes which are:

1. Investigate the status of hydrophobicity of the surface of the polymer insulator.
2. Statistically gather the 2-dimensional mean of spectrogram of 12 years insulator sheds.
3. To compare degradation performance between sheds of 12 years insulator using the hydrophobicity properties and leakage current (LC) signal parameters.

1.4 Scope

This project is restricted to:

1. 12 years polymeric type of housing insulator material.
2. Focusing on mechanical and electrical data.
3. Using spectrogram to extract electrical signal parameter which is 2-dimensional mean of spectrogram.

1.5 Report Outline

This report contains total of five chapters. A summary of high voltage polymeric housing insulator is described in Chapter 1. The problem statement, objectives and scope of work are also included in this chapter. The second chapter in this report is Literature Review that gives an overview and development of polymeric insulators, status of hydrophobicity and 2-dimensional mean of spectrogram of 12 years insulators. Chapter 3 of this report consists of methodology of this overall project including the software part. The input signal parameter used spectrogram to extract electrical signal parameter using MATLAB software. In Chapter 4, there are also data focusing on mechanical and electrical part that used spectrogram to extract signal parameter such as 2-dimensional mean. Finally, in the last chapter which is Chapter 5 presents the conclusion and suggestion on future work.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

The background and basic concept of condition monitoring of field aged high voltage polymeric housing insulator was explained in this chapter. The principles ideas are established before this project was continued. Furthermore, many information from previous works and research related to this project have been studied in this chapter. This will ensure clearer information and understanding of the investigation and its performance.

2.1 Polymer Insulator

Polymer insulator is an electrical device which consisting of insulation section made of polymeric materials and metal fittings. It also made of fiberglass core rod covered by weathersheds of skirts of polymer such as silicone rubber, polutetrafluoroethylene, EPDM (ethylene propylene diene monomer) and equipped with metal end fittings. The insulation unit of polymer insulators was made of fiberglass. The protective ribbed mould is made of organic rubber made from silicon and flanges are made of anti-rust alloy which ensures safe and stable long-term services under different climatic conditions. In the recent years, polymeric insulators have been highly in demand due to its developments in design and manufacturing making them attractive to utilities. Some benefits of polymer insulators are low in costs for its cleaning, not brittle and can reduce the purchase

quantities for spare parts. Other than being an easy and economical to transportation and installation, it also does not need of zero value check despite being a light weight (Amin & Salman, 2006).

2.1.1 Development of Polymer Insulator

The first polymeric insulators, consisting of monolithic designs made of structural materials such as epoxy were developed around 1950s. During that time, conventional porcelain and glass insulators were state-of-the-art and the first IEC standards were being issued to assist for the specification. In Germany, polymeric insulators for transmission line were developed as early as 1964 followed by other manufactures in England, Italy, France and in the U.S. The units for field-testing were developed in 1967 in Germany too. As of late 1960s and early 1970s, the manufacturer has introduced the first generation of commercial polymeric transmission line insulators.

The development of technology in our world making the possible designs of polymer insulators that being presented as the passage of time is different. The reasons for the failure of the initial designs about 30 years ago due to the slipping of sheds from rod or opening of rod shed interface. This is because the insulator has a rod coated with silicone rubber and shed that were separately mounted on them. The following designs then corrected this failure by mounting shed in the rod directly and encapsulating it with silicone rubber.

Unfortunately, this design also failed shortly but molding and fabrication techniques have much advancement in the last 15 years. The recently developed design that being introduced have a rod covered with silicone rubber having sheds in its own mould as a one unit which the entire outer portion is called sheath and this structure has been successfully adopted until today.

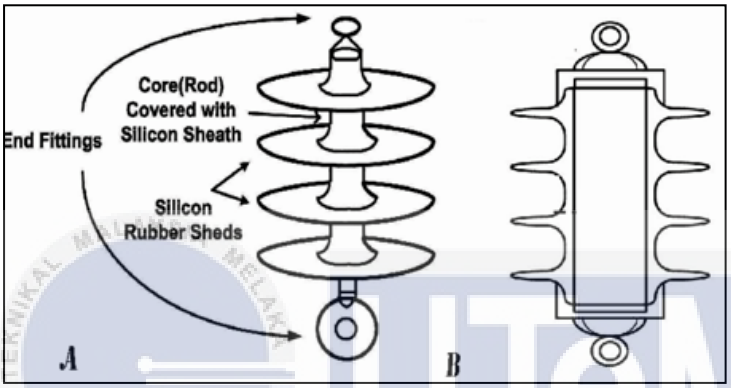

Figure 2.1: The old and new style of polymeric insulator