" I hereby declare that I have read through this report entitle *"Breakdown Voltage of Polymer Material Under Different Shape of High Electrode"* and found that it has comply the partial fulfillment for awarding the degree of Bachelor of Electrical Engineering (Industrial Power)"

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Date : 26 JUNE 2015

Breakdown Voltage of Polymer Material Under Different Shape of High Voltage Electrode

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

Faculty of Electrical Engineering

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JUNE 2015

I declare that this report entitle "*Breakdown Voltage of Polymer Material Under Different Shape of High Voltage Electrode*" is the result 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 candidature of any other degree.

Signature : .....

Name : AMRIL REZZA BIN SAPRI

Date : 26 JUNE 2015

Dedicated to my beloved family, friends and lecturers for their never-ending support, encouragement, and understanding towards the completion of my work.

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ABSTRACT

High voltage insulation technology has undergone continuous development and improvement over time, from the shelves of ceramics to polymer composite insulating synthetic material. Some research has been done, but still has room to improve the performance of insulating polymer. A synthetic polymer is widely used in high-voltage insulation and was divided into two parts which is thermoplastic and thermoset materials. This study focuses the performance thermoplastic materials as high-voltage insulation materials. In this study the thermoplastic polymeric material has been selected is High Density Polyethylene (HDPE). Among the basic needs to examine and evaluate the performance of selected materials as external high voltage applications is its dielectric strength level. In determining the dielectric strength of the selected material, breakdown test on the specimen was conducted using three different shapes of electrode which are spherical, flat end and pin shaped electrode. The test parameters, dimensioning and condition of the specimen prepared based flat sheet material testing accordingly to international standard BS EN 60243-1:1998. The experiment was carried out by complying test methods for determining the strength of the long-term solid electrical insulating materials at power frequencies of 50 Hz. From this study, HDPE meets the requirements of the breakdown field strength of this polymer under all four different shapes of electrodes which is it does comply with the request, which must exceed the minimum requirement of 10 KV/mm with reference to the international standard BS EN 62039: 2007. Pin electrode does give the most influence on HDPE dielectric performance which gives the highest breakdown value of the polymer. Then, this breakdown results can be used to determine the characteristic of processing variables, aging condition, and other manufacturing or environmental situation in high voltage polymeric insulation application.

ABSTRAK

Teknologi penebat voltan tinggi telah mengalami pembangunan yang berterusan dan penambahbaikan dari masa ke masa, dari rak seramik kepada polimer komposit penebat bahan sintetik. Beberapa penyelidikan telah dilakukan, tetapi masih mempunyai ruang untuk meningkatkan prestasi penebat polimer. Satu polimer sintetik digunakan secara meluas dalam penebat voltan tinggi dan telah dibahagikan kepada dua bahagian iaitu bahan termoplastik dan termoset. Kajian ini memberi tumpuan prestasi bahan termoplastik sebagai bahan penebat voltan tinggi. Dalam kajian ini bahan polimer termoplastik yang telah dipilih adalah polietilena berketumpatan tinggi (HDPE). Antara keperluan asas untuk mengkaji dan menilai prestasi bahan terpilih sebagai aplikasi voltan tinggi luar adalah tahap kekuatan dielektrik penebat tersebut. Dalam menentukan kekuatan dielektrik bahan yang dipilih, ujian pecahtebat pada spesimen telah dijalankan menggunakan tiga bentuk elektrod yang berbeza daripada elektrod yang bulat, rata dan pin. Parameter ujian, pendimensian dan keadaan spesimen berasaskan ujian bahan kepingan rata yang disediakan dengan sewajarnya kepada standard antarabangsa: BS EN 60243-1 1998. Eksperimen ini dijalankan dengan mematuhi kaedah ujian untuk menentukan kekuatan pepejal bahan penebat elektrik jangka panjang pada frekuensi kuasa 50 Hz. Dari kajian ini, HDPE memenuhi keperluan dalam bidang kekuatan pecahan polimer ini di bawah keempat-empat bentuk elektrod yang berbeza yang ia mematuhi permintaan itu, yang boleh melebihi keperluan minimum sebanyak 10 KV / mm dengan merujuk kepada standard BS antarabangsa EN 62039: 2007. Pin elektrod amat mempengaruhi prestasi kekuatan dielektrik HDPE yang memberikan nilai pecahan tertinggi polimer tersebut. Kemudian, keputusan pecahatebat ini boleh digunakan untuk menentukan ciri-ciri pembolehubah pemprosesan, keadaan penuaan, dan pembuatan lain serta keadaan alam sekitar untuk aplikasi penebat polimer voltan tinggi.

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LIST OF ABBREVIATION

HDPE	- High Density Polyethylene
ANSI	- American National Standard Institute
IEC	- International Electrotechnical Commission
CIGRE	- The International Council on Large Electric System
NEMA	- National Electrical Manufacturers Association
BS	- British Standard
HV	- High Voltage
IEEE	- Institute of Electrical and Electronics Engineers
AC	- Alternating Current
OP	- Operation Terminal
DMI	- Digital Measuring Instruments
KV	- Kilovolt
R.M.S	- Root Mean Square
SEM	- Scanning Electron Microscope

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Insulation plays a very important role in specifying the performance and lifespan of high voltage equipment. The dielectric strength and electrical field being stressed on the insulating material are the main factors that lead to failure of the insulation [1]. The dielectric breakdown behaviors of these insulation materials are dependent of electrical stress conditions, chemical structures and their application environment, such as temperature [2]. Polymer materials are widely used in outdoor high voltage insulation system is gradually replacing traditional porcelain and glass used [3, 4]. A bunch of studies has been carried out to study on polymer material for electrical application [5, 6]. For this study the thermoplastic polymeric material has been selected is high density Polyethylene (HDPE) because this material widely used in high insulating system and has high performance of electrical properties [7]. Our previous breakdown studies show that the breakdown voltage drops approximately as the square root of the gap for metal surfaces with gaps between 2 and 8 mm [8]. To be precise, different shapes of electrode have to be applied for this test since different shapes of electrode have to be used to determine the dielectric strength of insulation in this project [9].

This project is conducted accordingly British Standard Institution. Selection guide for polymeric materials for outdoor use under high voltage stress. PD IEC/TR 62039.2007. This guideline states electrical property to test material and from parameter listed breakdown field

strength test was compiled using IEC 60243-1 or BS EN 60243-1 with the minimum requirement need to fulfil in order to test material.

1.2 Project Background

Since today, a plenty of high voltage test has carried out to investigate withstands voltage or other study courses. However, these tests required following the standard to get reliable results, by using the standard test procedure behavior of insulating material in actual application can be determined. The result of the testing for detecting changes can be used to determine the characteristic of processing variables, aging condition, and other manufacturing or environmental situation in high voltage polymeric insulation application. Furthermore, using this standard test procedure, the testing laboratory recognized for safety, the outcome of testing polymeric material is valid, and used for benchmarking of performance. Hence, the standard test accordingly to international standard is vital to be compiled for use by polymeric insulation material research and a safety need for high voltage application.

1.3 Problem Statement

A bunch of research has been done on the electrical properties of high voltage insulation materials. Usually, there are two types of test can be conducted, the standard test used for product test and non-standard test for research work. On previous studies, the test has been conveyed to determine the dielectric strength of different type of polymer materials where, the breakdown tests are conducted for the analysis of the dielectric strength, performance of polymeric insulation material properties. On this very day,this high voltage testing is going to be used to determine the voltage breakdown of the material using different shapes o electrode and analyze the characteristic of electrical breakdown. Since this experiment generates high voltages, compulsory handling steps and safety precaution need to be taken when handling the equipment.

The safety precautions cover the laboratory safety, equipment, safety and user safety. Therefore, the standard test procedure accordingly to international standard is vital to be complied and must follow to get reliable results. And by referring to the British Standard Institution. Selection guide for polymeric materials for outdoor use under HV stress. PD IEC/TR 62039.2007 [10]. The minimum dielectric strength to be fulfilled for outdoor high voltage polymeric insulation shall not be less than 10kV/mm. In order to do testing on the dielectric strength of the polymer insulation, the international standard BS EN 60243-1:1998 is used. [11].

1.4 Objectives

The objectives for this project are stated as below :

a) To conduct the experiment of dielectric strength based on standard BS 60243-1
b) To investigate breakdown characteristics of polymer material under different shapes of electrode.
c) To determine the type of electrode that has the most influence on performance of polymeric material

1.5 Scope of Research

The research scope is limited to:

a) High density Polyethylene (HDPE) is used as insulation specimen.
b) The shapes of high voltage electrode that will be used are spherical, flat-end and pin shaped electrodes.
c) The test was conducted by complying with international standard BS EN 60243-1:1998 with the flat sheet test requirement.

1.6 Summary

This report consists of five chapters. Chapter 1 describes the overview of overview of the project, motivation of the project, problem statement, objectives, scope and expected of this project, Chapter 2 explains the literature related to this project. Each of the facts and details of the analysis will be described. The information collected is from IEEE journals, articles, books, technical paper, standard and other. Chapter 3 explains the methodology of the project and will cover the methods and procedure that been used in carrying out the study project. Chapter 4 highlights the results obtained from the experimental data collection, preparation and discussion of the effect of electrode shape on breakdown voltage of polymer that has been tested. Lastly, Chapter 5 is the conclusion and recommendation of the achievement from the finding study that has been made.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Insulation plays a very crucial part in determining the performance and lifespan of high voltage equipment. This chapter covers all the related study the characteristic of polymer insulator and electrodes used. It also describes the Development of polymeric insulation, Reviews of Electrical Properties Test, appropriate tests, detection of surface features, standards related to methods.

2.2 Degradation and breakdown

2.2.1 Electrical field stress

The dielectric strength of insulating materials and the electric field stresses developed in them are the important elements in high voltage applications. Conductors and insulators are the basic materials used in high voltage apparatus, while the conductors carry the current and the insulators prevent the flow of currents in undesired paths. The dielectric strength of an insulating material can be defined as the maximum dielectric stress which the material can withstand. Electrical breakdown strength of insulating material depends on various parameters, such as pressure, temperature, humidity, type of applied voltage, defects in the dielectric materials, material electrodes and electrode surface conditions. The main reason for the presence of insulation failure in the release of either voids in the insulation or on the surface of the insulation [1].

2.2.2 Solid Breakdown

If the solid insulating material is truly homogeneous and is free from imperfections, its break down stress will be as high as 10kV/mm. However, in practice, the breakdown fields obtained are very much lower than this value where the breakdown occurs over the surface than in the solid itself [1].The breakdown of insulation can occur due to the mechanical failure caused by the mechanical stress produced by the electrical fields. This is called "electromechanical breakdown". Breakdown can also occur due to chemical degradation caused by the heat generated due to dielectric losses in the insulating material [2]. When the conducting path is formed, it is called "tracking", and results in the degradation of the material. Surface flush over normally occurs when the solid insulation is immersed in a liquid dielectric. Surface flash over, as already mentioned, is the most frequent cause of trouble in practice. Porcelain insulations for use on transmission lines must therefore be designed to have a long path oven the surface. The failure of solid insulation by discharges which may in the internal voids and cavities of the dielectric, called " partial discharges" is receiving much attention today, mostly because it determines the life versus stress characteristics of the material [7]

2.2.3 Electrical Breakdown

Severe loss of the insulating properties of test specimens while exposed to electric stress, which causes the current in the test circuit to operate an appropriate circuit-breaker [6].

2.2.4 Short term breakdown

Electric field due to the very high stress may not occur in the second or faster without damaging the insulation surface before failure [6].

2.2.5 Long term breakdown

Breakdown of long-term aging is also known as insulation. The main effects eventually responsible for the aging of insulation, lead to the damage arising from the heat and partial discharge [6].

a) Aging and breakdown due to partial discharge
b) Aging and breakdown due to changes in surface insulation

2.2.6 Accelerated aging test

Aging of polymer insulators depending on the chemical and physical properties of materials and stress exposure. In this case, the aging factor can be determined by careful examination whether directly or indirectly. Although, several international organizations and national standards provided for accelerated life tests such as IEEE, IEC, CIGRE, ANSI, BS and NEMA, there are no specific standards that apply to all applications and conditions. This means that the lack of standards means test all materials. As a continuation of material technology, manufacturing often adjust the current test to suit different products [5].

These tests are designed to reveal the performance of the materials and the pressure is divided into four components, test the electrical properties, mechanical properties testing, physical and chemical testing environmental testing. Typically, the surface condition of

polymeric materials under test is used as a diagnostic tool to represent the level of performance and aging. Continuity of technology, manufacturing often adjusts the current test to suit different products [5].

Due to the fact that the effect of aging is a process of long-term, the accelerated aging test is usually done either in materials or complete product samples insulating polymer. This test will be conducted on either polymer insulation under electrical stress or the environment. Usually the test is performed for insulation materials such as UV test experience, tracking and erosion tests, reducing test corona and oxidation stability test. In the meantime, a special test for complete insulation products like insulation, surge arrester and other detection and corrosion testing, salt fog test and test various environmental stresses. These tests are designed to reveal the performance of the materials and the pressure is divided into four components, test the electrical properties, mechanical properties testing, physical and chemical testing environmental testing. Typically, the surface condition of polymeric materials under test is used as a diagnostic tool to represent their level of performance and aging. A diagnostic test to measure aging is shown as in the Figure 2.1. [5, 12]

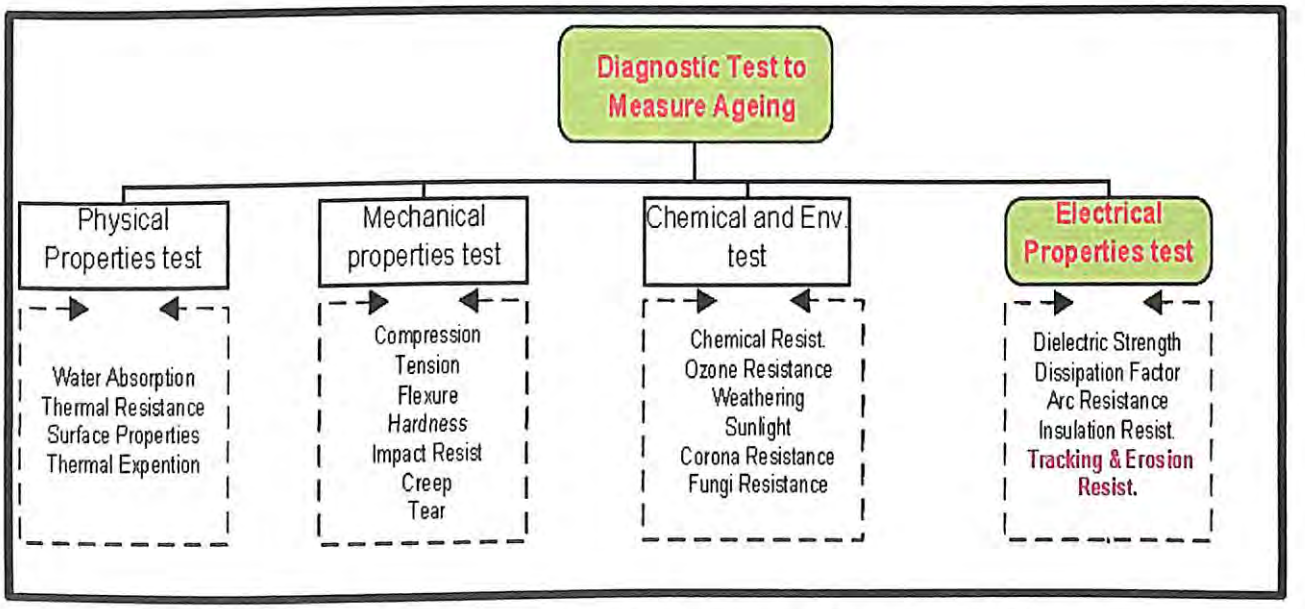

Figure 2.1 : Diagnostic test to determine the ageing [12]