“ I hereby declare that I have read through this report entitle “Correlation Between Resistivity And Dielectric Performance Of Polymeric Material Insulation Under Standard Test Procedure” and found that it has comply the partial fulfilment forwarding the degree of Bachelor of Electrical Engineering (Industrial Power)”

Signature :

Supervisor’s Name : DR AMINUDIN BIN AMAN

Date :

Correlation Between Resistivity And Dielectric Performance Of Polymeric Material Insulation Under Standard Test Procedure

NUR NABILA BINTI NOOR AZMAN

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

Faculty of Electrical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

JUNE 2016

I declare that this report entitle “Correlation between resistivity and dielectric performance of polymeric material insulation under standard test procedure” 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 : NUR NABILA BINTI NOOR AZMAN

Date :

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

ACKNOWLEDGEMENT

Firstly, my biggest thanks to Allah S.W.T who gave me opportunity in doing this project and always giving me hope and ways in completing the tasks.

My great appreciation goes to my supervisors, Dr. Aminudin Bin Aman for his guidance, skill, knowledge, and patience in helping his final year students for the two semesters.

I also want to give my appreciation to other lecturers, technicians, and friends who are wiling to help me whether directly or indirectly in completing this final year project. Their good deed will always been remembered.

CORRELATION BETWEEN RESISTIVITY AND DIELECTRIC STRENGTH PERFORMANCE OF POLYMERIC MATERIAL INSULATION UNDER STANDARD TEST PROCEDURE

NUR NABILA BINTI NOOR AZMAN

This report is submitted in Partial Fulfillment of Requirements for the Degree of Bachelor of Electrical Engineering (Industrial Power)

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ABSTRACT

High voltage insulation technology has gone through a continuous developments and improvements, starting from ceramics to polymer composite insulating synthetic material. Some researches has been done, but there are still available spaces of improvements in terms of the performance of insulating polymer. Synthetic polymer is widely used in high voltage insulation. It is divided into two types which are thermoplastic and thermoset materials. This project focuses on the performance of a thermoplastic material, Polypropylene (PP) as insulators. Among the essential needs to evaluate and examine the performance of selected materials as extra high voltage applications is its resistivity and dielectric strength level. In determining the dielectric strength of the selected material, breakdown test on the specimen was conducted using a flat shaped electrode. The test parameters, dimensioning and condition of the specimen are prepared based on the international standard, BS EN 60243-1:1998. The resistivity test is divided into two terms which are the surface, and the volume of the material based on international standard BS 6233-1982. The experiment was carried out by determining the strength of long term solid electrical insulating materials at power frequencies of 50 Hz. Based on this project, Polypropylene (PP) satisfies the requirements of the breakdown field strength under flat shapes of electrodes which exceeds the minimum requirement of 10 KV/mm with reference to the international standard BS EN 62039:2007. Pin electrode does give the most impact on Polypropylene (PP) dielectric performance that results on the highest breakdown value of polymer. Hence, the breakdown results can be used to determine the characteristic of the resistivity test, processing variables, against condition and other manufacturing or environmental situation in high voltage polymeric insulation application.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Insulation plays a big part on the performance and life expectancy of high voltage equipment. The dielectric strength and electrical field are the main elements that lead to failure of insulation [1]. The dielectric breakdown behaviors of an insulation material depend on the electrical stress conditions, chemical structures and their implementation environment [2]. Polymer traditional porcelain and glass are used in this project [3, 4]. An assemble of studies has been carried out to review on polymer material for electrical application [5, 6]. Polypropylene (PP) is chosen because this material is widely used in the high insulating system as it has high performance electrical properties [7]. Our foregoing breakdown review shows that the breakdown voltage drops approximately as the square root of the gap for metal surfaces with gap 2 and 8 mm [8]. To be specific, this project determines the resistivity insulation and dielectric strength of insulation applied [9, 12].

This project is conducted by following the British Standard Institution, the selection guide for polymeric materials for outdoor use under high voltage stress, PD IEC/TR 62039.2007. This guideline states the electrical property to test material and for parameter listed breakdown field strength test was compiled using IEC 60243-1 or BS EN 60243-1 and test for volume and surface resistivity of solid electrical insulating using IEC93:1980 or BS 6233:1982 with the minimum requirement need to fulfill in order test material.

1.2 Project Background

Nowadays, a lot of high voltage test has achieve to investigate withstands voltage or other review courses. However, these tests demand following standard to get reliable results, by using the standard test procedure behavior of insulating material in actual implementation can be determined. The result of the testing for observe 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. A part from that, by using this standard test procedure, the testing laboratory identify for safety, the outcome of the testing polymeric material is valid, and used for benchmarking of performance. Therefore, the standard test according to international standard is vital to be compiled for use by polymeric insulation, material research and a safety need for high voltage implementation.

1.3 Problem Statement

A mass research has been right on the electrical properties of high voltage insulation materials. Generally, 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 reviews, the test has been impart to determine volume resistivity and surface resistivity of solid electrical insulating and the dielectric strength of flat polymer material where the breakdown test are conducted to investigate the dielectric strength. Both tests are to analysed performance of polymeric insulation properties. In this modern era, this high voltage testing is going to be used to determine the voltage breakdown and method resistivity of material using flat shape of electrode and analyse the characteristic of electrical breakdown beside volume and surface resistivity. Since the 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 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 10 kV/mm while minimum volume resistivity isΩm. In order to do testing on the dielectric strength of the polymer insulation, the international standard BS EN 60243-1:1998 and for surface and volume resistivity test used BS 6233:1982.

1.4 Objectives

The objectives for this project are stated as below**:**

i. To determine volume resistivity and surface resistivity of polymeric and non-polymeric material.

ii. To investigate relationship between resistivity and dielectric strength of material under standard test procedure

iii. To compare the dielectric strength of material under test based on their resistivity.

1.5 Scope of research

The research scope is limited to:

i. Used Polypropylene (PP) and glass as insulation specimen

ii. The parameter to be studied are volume, surface and dielectric strength

iii. The standard to be complied for surface and volume resistivity are BS 6233:1982

iv. The standard to be complied for dielectric strength is BS EN 60234-1:1998

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Insulation plays a vitally important in determining the performance and lifetime of high voltage equipment. This chapter covers all correlated study the characteristic of polymer insulator and electrodes used. It also characterized the development of polymeric insulation, Reviews of Electrical Properties Test, appropriate tests, detection of surface features, standard correlated to methods.

2.2 Degradation and breakdown

2.2.1 Electrical field stress

The dielectric strength of insulating materials and the electrical field stresses evolved in them are the important elements in high voltage applications. Conductors and insulators are the basic material used in high voltage apparatus, while the conductors bring the current and 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 resisted. 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 electrode and electrode surface conditions. The main reason for existence of insulation failure in the release of either void in the insulation failure in the release of either void in the insulation or on the surface of insulation [1].

2.2.2 Solid breakdown

If the solid insulating material is truly homogenous and is free from imperfections, its breakdown stress will be high as 10kV/mm. Nonetheless, in practice, the breakdown fields achieved are very much lower than this value where the breakdown results over the surface than in the solid itself [1]. The breakdown of insulation can result due to mechanical failure caused by mechanical stress produced by the electrical fields. The termed is "electromechanical breakdown". Breakdown can also results due to chemical degradation caused by heat generated due to dielectric losses in the insulating material [2]. When the conducting path is developed, it is called "tracking", and results in degradation of the material. Surface flush over normally results when the solid insulation is absorbed 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 line must accordingly be design to have a long path over the surface. The failure of solid insulation by discharges which may the internal voids and cavities of the dielectric, called "partial discharges" is receiving much attention today, mostly because it determine the life versus stress characteristics of the material [7].

2.2.3 Electrical breakdown

Strict loss of the insulating properties of test specimen while exposed to dielectric stress, which causes the current in the test circuit to operate an appropriate circuit breaker [6].

2.2.4 Short term breakdown

Electrical field due to the very high stress may not result in the second or quickly 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].

i. Aging and breakdown due to partial discharge

ii. 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 these cases, the aging factor can be determined by careful test whether directly or indirectly. Other than that, several international organizations and national standards provided for accelerated life tests such as IEEE, IEC, CIGRE, ANSI, BS, and NEMA. There are no specific standard that apply to all implementation and conditions. That's mean the lack of standard means all materials. As a continuation of material technology, manufacturing often adjust the current test to suits different product [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 diagnostic tool to represent the level of performance and aging. Continuity of technology, manufacturing often adjust the current test to suit different products [5].

Due to fact that the effect of aging 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 performance of the materials and the pressure is divided into four components, test the electrical properties, mechanical properties testing, physical and chemical testing environmental test. Typically the surface condition of polymeric materials under test is used as a diagnostic tool to represent their level performance and aging. A diagnostic test to measure aging is shown as in a figure 2.1 [5, 12].

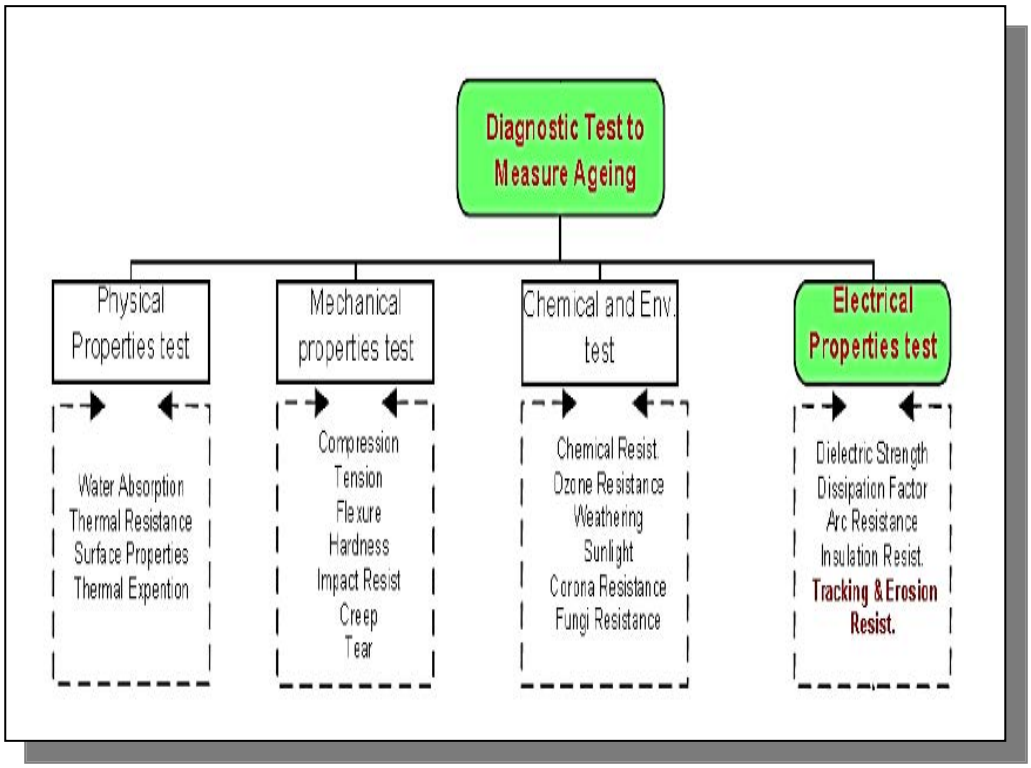

Figure 2.1: diagnostic test to determine the ageing

2.3 Selection material

For this study polymeric material to be studied are Polyvinyl Chloride (PVC), Polypropylene (PP), and high density Polyethylene (HDPE). For this project the thermoplastic polymeric material has been selected in Polypropylene (PP) and stainless steel electrode with flat end shaped.

1. Polypropylene (PP)

Polypropylene or PP can be used to make medical syringes, beakers, and insulating materials. It has high lubricated, high resistance to bending (excellent material to rely on), excellent dielectric strength and chemical resistance, good impact strength, and high solvent resistance. Polypropylene (PP) has the best balance of electrical and mechanical properties. PP is a highly versatile resin suitable for processing in molding or extruded parts and it is one of the lowest in cost [1].

2. Glass

Glass is an organic compound that consists of a complex system oxide (SiO2). Glass dielectric strength varies from 3000-5000kV/ cm and decrease with increasing temperature, reaching half its value at 100°C. glass is typically created as a tool of protection and internal support in electrical bulb, X-ray equipment, capacitors and insulation on the phone. The glass insulations have strong chemical stability to resist ageing, which means it has a high surface energy. With high surface energy, glass is easily wetted as well as surface adhesion of contaminants and can lead to flashover at contaminated area. It does not perform well under polluted conditions [1].

2.4 Type and shape of electrode

Since the standard test assured the stainless steel is the most reliable electrode to be used in the experiment, flat-end shaped electrode is prepared.

a. Flat-end

i. Unequal diameter electrode

The electrode shall consist of two metal cylinders with the edges rounded to give a radius of 3mm ± 0.2mm. One of the electrode shall be 25mm ± 1mm in diameter and approximately 25mm high. The other electrode shall be 75mm ± 1mm in diameter and approximately 15mm high. These electrodes shall be arranged coaxially within 2mm as shown in figure 2.2 and figure 2.3 shows the actual arrangement of this electrode.

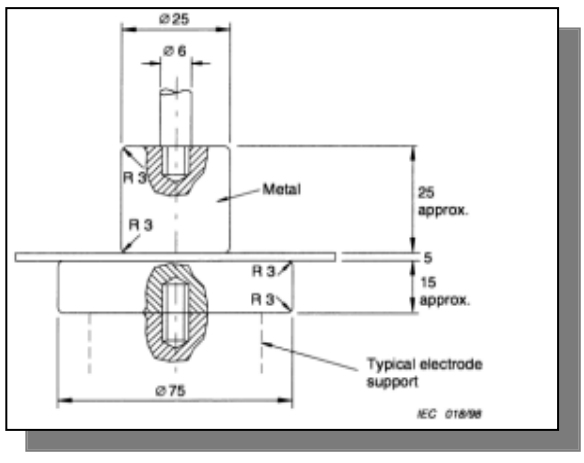

Figure2.2: electrode arrangement of unequal electrodes [11]

Figure 2.3: actual arrangement of unequal electrode

ii. Equal diameter electrode

If a fixture is employed, which accurately aligns upper and lower electrodes within 1.0 mm, the diameter of the lowest electrode may be reduced to 25mm ± 1mm, the diameters of the electrodes differing by no more than 0.2 mm. the results obtained will not necessarily be the same as those obtained with the unequal electrodes. Figure 2.4 and figure 2.5 shows the electrode arrangement for equal diameter test.

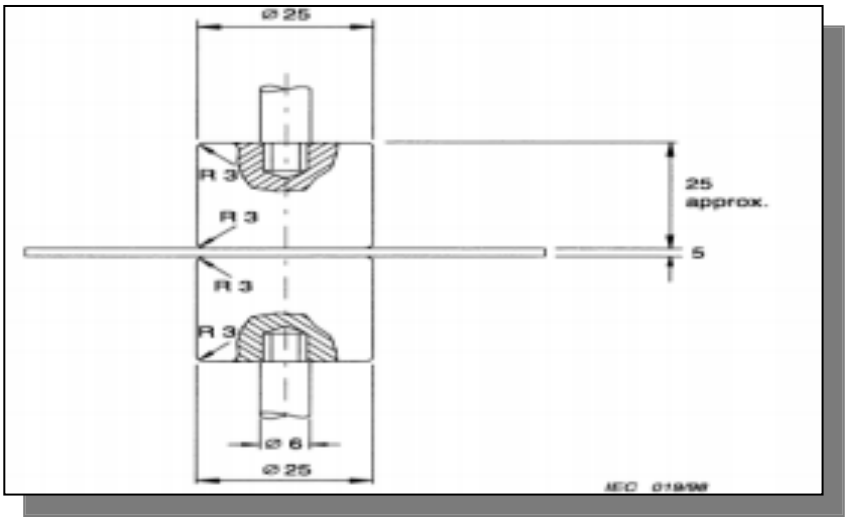

Figure 2.4 electrode arrangement of equal diameter [11]