"I hereby declare that I have read through this report entitled "*Grounding Resistance Improvement Using Coconut Husk*" and found that it complies the partial fulfillment for awarding the degree of Bachelor of Electrical Engineering"

Signature : ....

Supervisor's Name : ....

Date : ....

GROUNDING RESISTANCE IMPROVEMENT USING COCONUT HUSK

SITI NORNASUHA BINTI JAAFAR

A report submitted in partial fulfillment of the requirements for the degree of Bachelor of Electrical Engineering

FACULTY OF ELECTRICAL ENGINEERING

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2018

I declare that this report entitled "*Grounding Resistance Improvement Using Coconut Husk*" 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 : ....

Date : ....

To my beloved mother and father

For their boundless love, prayer and support

ACKNOWLEDGEMENT

All praises to almighty Allah for His kind gesture, love, protection, guidance, endurance, wisdom and privilege given to me to accomplish this research successfully.

Secondly, I would like to express my deepest gratitude to my supervisor, Dr Farhan Bin Hanaffi who has contributed valuable suggestions and great help to coordinate my research work. Without his guidance, precious advices and encouragement, this research might not be completed as presented here. Furthermore, I would like to express my appreciation to technical staff of Research Laboratory of High Voltage Engineering; Mr Mohd Wahyudi Bin Md Hussain for his assistance and permission to use all the required equipment and material as part of the research requirement.

My further gratitude goes to Universiti Teknikal Malaysia Melaka (UTeM) for providing the necessary infrastructure throughout my degree studies.

Last but certainly not least, my sincere appreciation to my parents, relatives and friends for their continuous support, patience, unfailing love, prayers and faith in my perseverance over the entire period of my studies.

ABSTRACT

A suitable grounding conductor for electrical installation is vital to ensure safety and grounding system performance over long term. A good grounding system has low ground resistance value to easily channel fault current straightly to the earth during fault condition. Without an effective grounding system, fault current may flow to personal or electrical appliances instead of flowing through grounding system. The purpose of this project is to investigate the effect of coconut husk as additive material on galvanized steel rod electrode and copper rod electrode. The performance of coconut husk as additive material in lowering ground resistance also will be investigated in this project. Ground resistance values are measured from different type of grounding configurations using Earth Ground Tester Fluke 1623. The ground resistance measured from this project for different type of grounding configuration which is for different type of electrode, different weight of coconut husk and different coconut husk layer configuration is continued from previous study. COMSOL Multiphysic software is used to investigate the performance of coconut husk as additive material. Model of grounding system is solved by using partial differential equation through Finite Element Method (FEM). Electrical field distribution is analyzed to compare performance of each grounding configuration. The magnitude of electric field distribution is diverged proportionally with ground resistance. This is because electric current easier to flow into lower soil resistivity. Thus, it will lead to grounding system improvement.

ABSTRAK

Pengalir yang bersesuaian bagi sistem pembumian pepasangan elektrik adalah penting untuk memastikan keselamatan dan prestasi sistem pembumian dalam jangka masa panjang. Sistem pembumian yang baik mempunyai nilai rintangan tanah yang rendah untuk memudahkan pengaliran arus berlebihan ke dalam tanah semasa keadaan tidak normal. Tanpa sistem pembumian yang berkesan, arus berlebihan boleh mengalir melalui manusia atau peralatan elektrik dan bukannya mengalir melalui sistem pembumian. Tujuan projek ini adalah untuk menyiasat kesan sabut kelapa sebagai bahan tambahan pada rod keluli bergalvani and rod tembaga. Prestasi sabut kelapa sebagai bahan tambahan untuk merendahkan nilai rintangan tanah juga akan dianalisis dalam projek ini. Nilai rintangan tanah daripada konfigurasi pembumian yang berbeza telah diukur dengan menggunakan Penguji Tanah Bumi Fluke 1623. Nilai rintangan tanah yang diperolehi daripada projek ini telah disambung daripada projek yang lepas. Perincian COMSOL Multiphysic telah digunakan untuk menyiasat prestasi sabut kelapa sebagai bahan tambahan. Model sistem pembumian telah diselesaikan dengan menggunakan persamaan pembezaan separa melalui kaedah Finite Element (FEM). Pengedaran medan arus telah dianalisis untuk membandingkan prestasi bagi setiap konfigurasi pembumian. Magnitud pengedaran medan arus adalah menyimpang secara berkadar dengan nilai rintangan tanah. Ini adalah kerana arus elektrik lebih mudah mengalir ke dalam tanah yang mempunyai nilai rintangan yang lebih rendah. Oleh itu, ia akan membawa kepada peningkatan prestasi sistem pembumian.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATION

UTeM	Universiti Teknikal Malaysia Melaka
GI	Galvanized
FEM	Finite Element Method

CHAPTER 1

INTRODUCTION

1.1 Research Background

An acceptable and safe grounding system is one of vital part to be considered and taken into account in electrical system installation at high-voltage infrastructures, commercial constructions and residential areas. The fundamental function of grounding system is to channel fault current instantaneously to the earth through grounding electrode. During system's malfunction, grounding system could prevent properties damage and provide a secure working environment for workers and people passing by [1]. In order to increase grounding system performance, the value of ground resistance should be low. The perfect value of ground resistance is zero impedance but this value is impossible to be achieved. A lot of methods have been done in practical situation to obtain ground resistance value as near as possible to zero value. Thus, the performance of grounding system is dependent on the ground resistance value. Ground resistance and soil resistivity surrounding the electrode should be lower compared to main electrical circuit. This is to enable the high in rush current to flow directly into ground as current always flows to path with lowest resistance. Soil resistivity is a main parameter to be considered in designing effective grounding and lightning protection systems. According to standard BS7430:2011, soil resistivity is measured by using Wenner Four Probe Method. This method is carried out by driving four test electrodes with equally spaced into soil to a depth of 1m in a straight line. The depth should not exceed 5% of their spacing between electrodes. Fall of potential 61.8% method is used in measuring ground resistance of the installed test electrodes.

1. 1 Problem Statement

In order to improve grounding system performance, ground resistance value must be reduced as near as possible to zero value. Soil resistivity is the most crucial factors in influencing ground resistance. Soil resistivity varies dependent on type of soil, moisture content, depth of soil, chemical composition, porosity, conductivity and temperature [3]. Moisture content of soil is the greatest effect on soil resistivity. Higher moisture content can be achieved when the depth of soil increases. The higher moisture content of soil, lower soil resistivity can be achieved. Since the soil resistivity is lower, ground resistance also will be lower. In order to achieve lower ground resistance value, driving a longer electrode deeper into soil and usage of multiple electrodes will not be a good alternative as it is costly. Therefore, soil treatment method can be implemented to solve this problem. Bentonite is usually used for soil treatment but it is expensive. As an alternative material, coconut husk can be used as additive material for soil treatment [14]. Coconut husk has hydrophilic properties that capable to store or absorb water into its structure. Thus, the moisture content of soil increases and lead to lower ground resistance value. Copper is usually used as grounding system but due to its high price in market, the number of theft activities is increased. This causes service and utility company has suffered great losses due to these theft activities. In this project, galvanized steel electrode is used as alternative to copper electrode. However, the use of galvanized steel in grounding system needs to be analyzed in term of its performance, ground resistance and economic value.

1. 2 Project Objectives

The objectives of this project are:

1. To investigate the effect of coconut husk as additive material on copper electrode and galvanized steel electrode.
2. To analyze the performance of coconut husk as additive material in lowering ground resistance.
3. To model and simulate analysis of ground electrode with coconut husk using Finite Element Method.

1. 3 Project Scope

The scopes of the research are:

1. The location where the project is conducted is at Vicinity of Faculty of Electrical Engineering, UTeM.
2. Type of ground electrode used is galvanized steel rod electrode (hollow rod) and copper rod electrode.
3. The site consist of 6 different type of ground electrode installations which is vertical copper electrode, vertical galvanized steel electrode without added with coconut husk and vertical galvanized steel electrode added with different type of coconut husk configuration. The vertical galvanized steel electrode added with different type of coconut husk configuration is by adding 1kg, 1.5kg, 2kg and addition of coconut husk layer-by-layer with local soil.
4. The apparatus used to measure ground resistance is Earth Ground Tester Fluke 1623.

5. Measurement method used to measure ground resistance is fall of potential method based on BS 7430:2011.

6. Coconut husk is used as additive material to reduce soil resistivity and ground resistance.

7. Finite Element Method using COMSOL Multiphysic Software is used to model and simulate analysis of grounding system with coconut husk.

8. The duration for this experiment is 7 weeks for ground resistance data collection and 4 weeks to simulate and analyze the ground electrodes with coconut husk.

CHAPTER 2

LITERATURE REVIEW

2. 1 Grounding system

Grounding system is a vital parameter in electrical system as it ensures overall electrical system facility is protected. Grounding of electrical installation is primarily concerned with safety. Security of people is influenced by performance of grounding system. If sudden ground fault occurs at vicinity or generating substations, the personnel involved will not exposed to critical electric shock when grounding system performance is good. Good grounding system has capability in limiting step and touch voltages to safe value. Not only that, grounding system will ensure equipment and electrical protection devices are operating correctly, capable to provide protection of building and insulation against lightning and providing good power quality and continuity of electrical equipment under extreme operation situations [7]. A good grounding system must able to provide low ground resistance path to channel fault current directly into the earth [6]. The resistance of the ground electrode itself must be lower compared to resistance of main circuit connection as current will flow through path with lowest resistanc

2.1. 1 Type of grounding system

According to Teo Cheng Yu [6], five types of grounding system can be categorized which are TT system, TN-S system, TN-C system, TN-C-S system and IT system. The first letter indicates an arrangement of earthing supply. Letter T abbreviated from French word Terre; which means earth, can be defined as the supply of one or more points directly connected to earth. Letter I represents impedance when supply system is not earthed or one of the supply points is earthed through fault-limiting impedance.

The second letter indicates an arrangement of earthing installation. Letter T represents earth is when connection of exposed conductive parts is directly to earth. Letter N indicates neutral is when exposed conductive parts are connected directly to neutral point of source supply. In this context, the exposed conductive parts means any metallic parts of electrical system that can be touched which is not live part but may become live under fault condition.

The third and fourth letter indicates the arrangement of earthing conductor. Letter S represent separate neutral and protective conductors while letter C represent combination of neutral and protective conductors in a single conductor. As shown in Figure 2.1, main type of grounding system used in residential area in Malaysia is TT system. TT network system has two earth electrode installations [5]. In TT system, the exposed-conductive-parts of the consumer’s installation are earthed through an installation earth electrode which is electrically independent of the source earth.

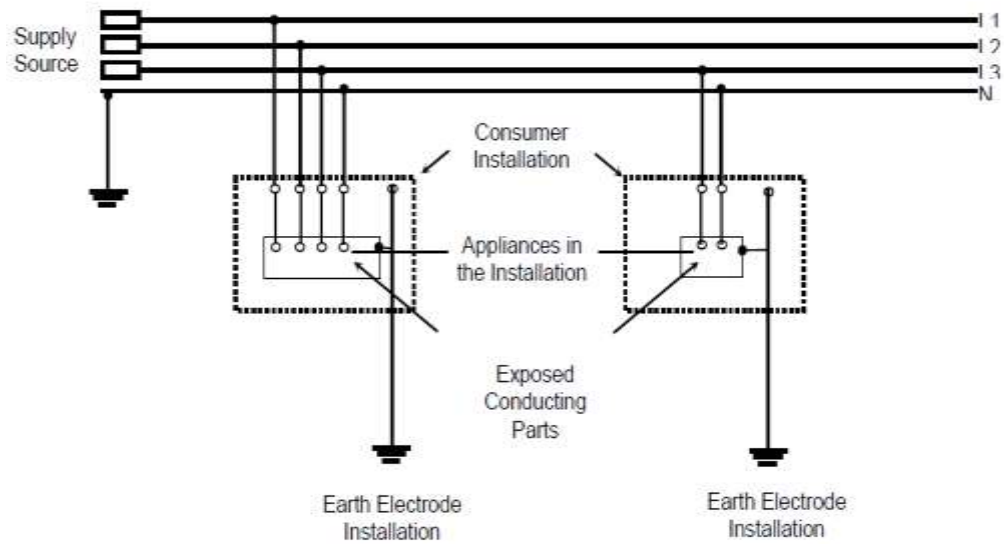

Figure 2. 1 Arrangement of TT network system [5]

2. 2 Grounding resistance

Ground resistance is one of major requirement for grounding system as ground resistance value determines the performance of grounding system. There are three components related to ground resistance which is resistance of electrode and connections to it, contact resistance between electrode and soil and resistance of soil surrounding the ground electrode. The characteristic and resistance of ground can be analyzed based on its structure, type of soil, soil resistivity, depth and type of buried ground electrode.

2.2. 1 Soil resistivity

. Soil resistivity represents the capability of volume of soil to carry electric current measured in ohm-meter [3]. In order to achieve and maintain low ground resistance value with minimum expenditure, knowledge of soil resistivity at particular site is very crucial. At different time of year, soil resistivity for different locations have different temperature, rainfall, dry spells and other seasonal variations. Soil resistivity varies depending on type of soil, temperature, moisture content, dissolved salt, porosity and conductivity.

The electricity flow in soil is largely electrolytic depending on transfer of ions dissolve in moisture. When moisture content increases, soil resistivity decreases. Furthermore, soil resistivity depends on type of soil. Table 2.1 shows different type of soil will have different soil resistivity value. Clay has soil resistivity range from 200 to 10,000 ohm-centimeters while sandstone has soil resistivity in a range of 2,000 to 200,000 ohm-centimeters. The moisture content in clay is higher compared to the moisture content in sandstone as the porosity and ionic content of pore fluid in soil is essential in governing resistivity. This causing soil resistivity for clay is lower compared to sandstone. Low soil resistivity will lead to low ground resistance value.

Table 2. 1 Soil resistivity depend on the type of soil [7]

Soil	Resistivity Ohm-cm (Range)
Surface soils, loam, etc.	100 – 5,000
Clay	200 – 10,000
Sand and gravel	5,000 - 100,000
Surface limestone	10,000 – 1,000,000
Shales	500 – 10,000
Sandstone	2,000 – 200,000
Granites, basalts, etc.	100,000
Decomposed gneisses	5,000 – 50,000
Slates, etc.	1,000 – 10,000

According to BS7430:2011, certain type of soil such as dry sand, gravel, chalk, limestone, whinstone, granite, any very stony ground and all locations where virgin rock is very close to surface is not the best location for grounding system. Moreover, the location of grounding system is ideally within the range of 15% to 20% of its moisture content. The location of grounding system where water flows over it such as bed of a stream should be avoided as beneficial salts from soil can entirely be removed by water flow [8]. Dissolved salts like sodium chloride, copper sulfate, and sodium carbonate contribute the crucial criterion to carry current. The resistivity will be lower when the amount of naturally occurring salts in the soil increases [7]. Table 2.2 shows that sandy loam soil with 15% moisture content has soil resistivity of 107 Ωm when no salt is added but the soil resistivity decreases to 99.07% when 20% of salt is added. This shows that when the soil is added with salt, the soil resistivity value decreases. The higher the content of salt in soil, the lower soil resistivity will be. Besides that, soil resistivity changes depending on variation of soil temperature. Temperature will affect the electronic and ionic conductivity of soil. When temperature of soil is low, the soil resistivity increases. Frozen ground will increase soil resistivity as freezing prohibit ionic. The soil resistivity continues to increase as temperatures go below freezing [7]. Therefore, the quantity of moisture content, mineral salt and temperature are parameters that influence the soil resistivity.

Table 2. 2 Soil resistivity value with different amount of salt [3]

For sandy loam, 15.0% moisture	
Salt content	Resistivity (Ωm)
No salt added	107
1.0% salt added	4.6
20.0% salt added	1