UNIVERSITI TEKNIKAL MALAYSIA MELAKA

STUDY ON THE ELECTRICAL CONDUCTIVITY-TEMPERATURE RELATIONSHIP IN SEAWATER USING CHI-SQUARE INDEPENDENCE TEST

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

by

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2019

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

TAJUK: **STUDY ON THE ELECTRICAL CONDUCTIVITY-TEMPERATURE RELATIONSHIP IN SEAWATER USING CHI-SQUARE INDEPENDENCE TEST**

SESI PENGAJIAN: **2018/19 Semester 1**

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This report is submitted to the Faculty of Electrical and Electronic Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Electrical Engineering Technology (Industrial Power) with Honours. The member of the supervisory is as follow:

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ABSTRAK

Kekonduksian elektrik boleh dicapai bukan pada bentuk pepejal, tetapi juga dalam bentuk cecair atau separa cecair. Satu sumber tenaga boleh diperbaharui seperti air laut boleh menjadi medium ideal untuk kekonduksian. Untuk membuktikannya, satu kajian pengujian suhu dilakukan pada sampel air laut untuk mengaitkannya dengan kekonduksian elektrik. Tujuan kajian ini adalah untuk meneroka variasi suhu dan mengaitkannya dengan kekonduksian dengan membangunkan hubungan menggunakan Ujian Kemerdekaan Chi-square dan membandingkan prestasi kekuatan kekonduksian dua langkah suhu yang berbeza. Kaedah statistik lain untuk mengaitkan kedua-dua parameter telah dilakukan untuk mencari perhubungannya. Sampel suhu air laut biasa di atmosfera diambil dari Pantai Klebang, Melaka dan menjalani proses pemanasan ohmik. Kedua-dua pengukuran telah diambil dan dibandingkan dengan prestasi kekonduksiannya. Pengukuran parameter dilakukan dengan menggunakan alat Meter EC dan alat kawalan suhu pengawal PID. Kedua-dua pemboleh ubah yang diuji ialah suhu (˚C) dan kekonduksian elektrik (µS / cm) air laut. Analisis statistik Ujian Kemerdekaan Chi-square pada sampel menggunakan perisian Minitab menunjukkan kebergantungan kekonduksian pada suhu. Prestasi kekuatan konduktiviti dua langkah suhu telah diuji menggunakan Ujian Hipotesis. Ujian menunjukkan bahawa kekonduksian pada suhu pemanasan ohmik adalah lebih besar daripada kekonduksian yang diambil pada suhu normal air laut.

ABSTRACT

Electrical conductivity can be achieved not only on solid form, but also in liquid form or semi-liquid. A renewable source of energy such as seawater could be the ideal path for conductivity. To prove this, a study of temperature testing was done on a few samples of seawater to relate it with electrical conductivity. The aim of this study is to explore the relation between temperature variation and conductivity by developing a relationship using Chi-square Independence Test and compare the conductivity strength performance of two different temperature measures. Other statistical method to relate both parameters were applied to find its correlation. Few samples of normal seawater temperature at atmosphere were taken from Pantai Klebang, Melaka and underwent ohmic heating process. Both measurement were taken and being compared for the conductivity strength performance. Measurement of conductivity and temperature were taken by using EC Meter and PID controller. The two variables being tested were the temperature (˚C) and the electrical conductivity (μS/cm) of seawater. The statistical analysis of Chi-square Independence Test on the samples using Minitab software had shown the dependency of conductivity on temperature. Conductivity strength performances of two temperature measures were tested using Hypothesis Testing. The test show that conductivity at ohmic heating temperature was greater than conductivity taken at normal temperature of seawater.

DEDICATION

This report is dedicated to my beloved family who educates and supports me till the very end, lecturers and friends.

AKNOWLEDGEMENTS

I proudly would like to thank the education system of Universiti Teknikal Malaysia Melaka, especially the Dean of Electrical and Electronic Engineering Technology Faculty (FTKEE), Prof Madya Mohd Rahimi Bin Yusoff by giving a platform for me to prove my ability in bachelor"s degree project with the help and guidance of my supervisor, Madam Nor Hafizah Binti Hussin.

Special thanks to the University for providing the fund in order to execute the project. Not to forget, thank you to lecturers for guiding me in any form of motivation and help throughout this journey.

Last but not least, I would love to thank my family who had mentally supported me throughout the journey of completing my project. Not to forget, thank you to all my friends for always been willing in helping and encouraging me since the first semester.

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STD	-	Salinity-Temperature-Depth
EC	-	Electrical Conductivity
PPT	-	Parts per notation
H^+	-	Hydrogen ions
OH^-	-	Hydroxide ions
MPa	-	Mega Pascal
ρ	-	Resistivity
R	-	Resistance
A	-	Cross-sectional Area
L	-	Length
Ω	-	Ohm
V	-	Voltage
I	-	Current
Q	-	Heat content per unit volume
O	-	Observed Frequency
E	-	Expected Frequency
T	-	Temperature
kJ	-	Kilo-Joule
E	-	Electromotive force
S	-	Siemens
d	-	Distance between electrodes

ρ	-	Density
c_p	-	Specific heat of the seawater
κ	-	Electrical conductivity
C_p	-	Specific Heat
M	-	Sample Mass
T_i	-	Initial Temperature
T_f	-	Final Temperature
r	-	Correlation Coefficient
$\hat{y}$	-	Regression Line
m	-	Slope
b	-	y-intercept
χ^2	-	Pearson's Chi-squared Test
r	-	Number of Rows
c	-	Number of Columns
d.f.	-	Degree of Freedom
H_0	-	Null Hypothesis
H_a	-	Alternative Hypothesis
σ	-	Standard Deviation
t	-	Standardized Test Statistics
m	-	Metre
cm	-	Centimetre
˚C	-	Celcius
g	-	Gram
kg	-	Kilogram

Cl%	-	Chlorinity percentage
$^{o}/_{oo}$	-	Salinity

CHAPTER 1

INTRODUCTION

1.1 Background

Conductivity of electricity is one of the important elements in making sure how strong the medium opposes the flow of electric current. One of good conductor for electricity is copper metal. Ohm‟s Law prove that with a low resistance, the medium or material is said to be efficient enough to let the flow of electric current.

However, while for measuring electrical resistivity of a material as an example Copper metal, $\rho = \frac{RA}{L}$ is used where R is the resistance of material with known length, L and known as uniform cross-section, A. From Lu *et al.*, (2004) paper, it was appeared from an examination of the exploratory confirmation that blended unadulterated copper tests with a high thickness of Nano scale development twins demonstrated rigidity around 10 times higher than that of traditional coarse-grained copper, while holding an electrical conductivity tantamount to that of unadulterated copper.

While in Dauphinee and Klein, (1977) research, instead of current flow through a solid metal conductor, liquid medium such as seawater is an ideal study of electrical conductivity-temperature relationship to measure its conductivity using Chi-square Independence Test. The impact of temperature on electrical conductivity of seawater for the assurance of saltiness from temperature, conductivity, and weight information is given by *in situ* salinity-temperature-depth (STD) estimations. Dauphinee, and Klein, (1977) experiment was carried out on samples of standard seawater from -3.2˚C to 35˚C verified that the distinctions of temperature coefficients of

different heaps of water characteristic are not going to display significant issues in change of STD information or adjustment of STD instruments.

1.2 Problem Statement

Renewable sources such as seawater are mostly used for hydropower generations in Malaysia. The content of salinities of seawater could be beneficial in terms of salt production for cooking or even to act as a medium to conduct electricity.

For this modernize globalization, the production of conductor also apply the use of chemicals which some ways affect the working environment and the health of the workers. According to Lu *et al.*, (2004) copper, aluminum and silver of high conductivities examples of pure metals need the strengthening with the solid solution alloying, cold working, and grain refinement which cause the decrease of conductivity.

Seawater could be as an alternative to the copper metals or other pure metal productions as an electrical conductivity. This may lead to a safer surrounding and working environment aside from a highly cost reduction as the sources are renewable. A tools development of seawater into mediums as electrical conductors can help people with small industries. A replacement medium of conductor metal should be concerned due to its short life span because of the rust and fragile characteristic. However, pure seawater cannot conduct electricity on itself, other supporting materials, method and procedure involving chemical are needed.

1.3 Objectives

Based on the problem statement discussed above, the objectives of this study are as follows:

1.3.1 To explore the temperature variation of seawater for electrical conductivity.

1.3.2 To develop a relationship between temperature and electrical conductivity using Chi-square Independence Test.

1.3.3 To compare the conductivity strength performance of the seawater using Hypothesis Testing with Two-Samples.

1.4 Scope

This project study was on relationship of seawater ability in conducting electricity at different temperature. A method used to find the correlation of both parameters by using Chi-square independence test. Data collected was used to relate the ionic content of seawater to the value of conductivity in S/cm and the temperature that affect it.

Electrical conductivity (EC) meter was used to test various temperature of seawater samples without measuring it salinity as this study only apply the function of statistic in collecting data to find its correlation which was a way in expressing the relation between a change in a physical property which in this study were the electrical conductivity and the change in temperature that cause it. The temperature samples were taken depending on the climate and the time; morning, day and night depending on its temperature. The possible goal ranges were between 30˚C to 32˚C of seawater, however

temperature at higher temperature of 32 ˚C to 80 ˚C were taken using ohmic heating process.

The electrical conductivity versus temperature data were keyed in into the Minitab software to find the linear plot graph using characteristic of conductance, σ. Then temperature and conductivity correlation coefficient was known. The formula was derived to represent the relationship between seawater temperature and the electrical conductivity using regression line interpretation.

The further step was to heated up samples of seawater and seawater using Voltage-Temperature Controller equipment to measure its conductivity effect. The performance was then being compared based on the different of samples of conductivity at normal temperature and during ohmic heating process using Hypothesis Testing.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction to Physical Properties of Seawater on Electrical Conductivity

Roger W. Pryor, (2013) stated in his paper that about 71% of Earth surface made up of seawater, which during evaporation, seawater controls the atmosphere moisture properties. The climate is said to change through some mechanisms such as heat transfer by conduction, convection and radiation. The main properties of seawater are the temperature (T), the salinity (S), and the pressure (P) said by Nayar *et al.*, (2016). Salinity is the crucial part of the seawater that differentiates it from fresh clean water without dissolve solids as Gregg and Cox, (1971) agreed that electrical conductivity is principally component of temperature, salinity and pressure.

The British National Institute of Oceanography in 1960 had done an investigation of the relationship among chlorinity, conductivity, and thickness on a few hundred examples of seawater gathered from generally dispersed areas over the world seas. (Fofonoff, 1985) Dissolved salts in pure water are also called as seawater. However, the paper did mentioned that salinity and chlorinity are two different things that should not be described as far as chlorinity in view of the over the top changeability of its relationship to density.

Figure 2.1 shows the salts disintegrate in water to create a positive (anion) and a negative (cation) charge ion. These particles make up the premise of conductivity in water.