" I hereby declare that I have read through this report entitle "*Analyzing Effect Of Moisture Content In The Transformer Oil Using Weibull Technique*" and found that it has comply the partial fulfillment for awarding the degree of Bachelor of Electrical Engineering (Industrial Power)"

Signature : .....

Supervisor's Name : MR. IMRAN BIN SUTAN CHAIRUL.

Date : …….

ANALYZING EFFECT OF MOISTURE CONTENT IN THE TRANSFORMER OIL USING WEIBULL TECHNIQUE

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

Faculty of Electrical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2015

I declare that this report entitle "*Analyzing Effect Of Moisture Content In The Transformer Oil Using Weibull Technique*" 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 : NURUL AFIZA BINTI ABU BAKRI

Date : ……..

DEDICATION

To my beloved father and mother

ACKNOWLEDGMENT

Firstly, I would like to give my thanks to Allah for giving me strength and ability to complete the project from beginning until the end. Without His permission, I would not finish my final year project in successful.

The special thank goes to my helpful supervisor, Encik Imran bin Sutan Chairul. The supervision and support that he gave truly help the progression and smoothness in order to complete my final year project. I really appreciate for all the guidance and advice that have been given for me.

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ABSTRACT

Power transformer is an important electrical equipment in power system. Fault happen in transformer when insulation in a poor condition. Failure in insulation might be happen when moisture or air ingress in the insulation and its affect the insulating of transformer. The aim of this project is to determine the moisture level of in service transformer and to categorize the condition of moisture according to the standard IEEE C57.106-2006. By differ to determine the effect of moisture in liquid insulation and to analyze the data by using weibull method. Weibull method is used to analyze the data life with using various parameters. The research is to compare the weibull plot between excel, reliasoft and least regression. The technique was used in the research is a weibull in life data analysis. In this method, contain of data life is a failure and successful. The data is consists of age and the condition of the moisture level. From the age of transformer, it can obtain the value of median rank to plot graph. All of this parameter is considered to analyze the data and to determine whether the end life of transformer is depends on the quantity of the moisture. The consistency of each data is based on the interpretation made from the analysis of 33/11kV,15MVA & 30MVA power transformer.

ABSTRAK

Kuasa pengubah adalah peralatan elektrik yang penting dalam sistem kuasa. Kesalahan berlaku di transformer apabila penebat dalam keadaan miskin. Kegagalan dalam penebat mungkin berlaku apabila lembapan atau kemasukan udara di penebat dan yang memberi kesan kepada penebat pengubah. Tujuan projek ini adalah untuk menentukan tahap kelembapan dalam perkhidmatan dan pengubah untuk mengkategorikan keadaan kelembapan mengikut standard IEEE C57.106-2006. Oleh berbeza untuk menentukan kesan kelembapan dalam penebat cecair dan untuk menganalisis data dengan menggunakan kaedah Weibull. Kaedah Weibull digunakan untuk menganalisis data yang hidup dengan menggunakan pelbagai parameter. Kajian ini adalah untuk membandingkan plot Weibull antara excel, reliasoft dan kurangnya regresi. Teknik yang digunakan dalam kajian ini adalah Weibull dalam analisis data kehidupan. Dalam kaedah ini, mengandungi hidup data adalah kegagalan dan berjaya. Data adalah terdiri daripada umur dan keadaan tahap kelembapan. Dari usia pengubah, ia boleh mendapatkan nilai pangkat median untuk plot graf. Semua parameter ini dianggap menganalisis data dan untuk menentukan sama ada kesudahannya ialah hidup yang pengubah adalah bergantung kepada kuantiti kelembapan. Konsistensi setiap data adalah berdasarkan kepada tafsiran yang dibuat daripada analisis 33 / 11kV, 15MVA & 30MVA kuasa pengubah.

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LIST OF ABBREVIATIONS

UTEM	Universiti Teknikal Malaysia Melaka
FKE	Fakulti Kejuruteraan Elektrik
IEEE	Institute of Electrical and Electronics Engineer
KFT	Karl Fischer Titrators
MVA	Mega Volt Ampere
PPM	Parts per million

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CHAPTER 1

INTRODUCTION

1.1 Research Background

Distribution transformer is required component that allows the delivery of electricity with a high degree of flexibility. Transformers as a static electrical device used to transfer power between circuits through the coil of the transformer. In a power plant, transformer is an essential thus it is important to take caution and to monitor its condition to avoid any problems. It should go through by monitoring the transformer's condition to reduce the damage and diminish the cost to fix it. In addition, the lifetime of the transformer will be longer with expectations. However, any fault still can occurs when the protection its not good enough. The most factor can affect the transformer through oil is effect of moisture to liquid insulation life. The existence of moisture in a transformer is a concern because it causes several detrimental effect on the insulation. Moisture in insulation cannot be directly measured but is reach by the moisture level in oil. Temperature is a factor effect on moisture because with increasing temperature, the moisture in oil goes up. Therefore, a protecting oil filtered at excessively high a temperature may lose a substantial rate of its dielectric quality on cooling on the grounds that the dissolved dampness is then changed to an emulsion. This project aim is to analyze the effect of moisture to liquid insulation life assessment for power distribution transformer by using weibull technique.

1.2 Problem Statement of Research

When there is a fault occurs in transformer by presence of moisture to liquid insulation, this is a critical for transformer life because the transformer life is highly dependent on its insulation condition. Transformer insulation can be deteriorates due to

many factors such as temperature rise, high dissolved gases in oil and moisture content. Thus, this project will be carried out to analyze the distribution transformer oil condition based on transformer aged, and moisture content in the transformer oil by using weibull technique.

1.3 Project Objective

The objective of this study are:

i. To determine the moisture level of in service power distribution transformer.
ii. To determine the adequate moisture level in transformer oil according to C57.106-2006 IEEE Guide.
iii. To analyze life assessment for the effect of moisture content in transformer oil using Weibull method.
iv. To compare the weibull plot between excel, reliasoft software and least square method.

1.4 Project Scope

The scope of this research are:

i. Parameters levels were obtained from in-services transformer.
ii. Parameters obtained are moisture level and age of transformer.
iii. 33/11 kV, 15MVA & 30MVA power distribution transformer.
iv. Analysis using Weibull plot.

1.5 Project outline

Insulation is important in each transformer. There are many factors that cause of breakdown voltage which is causes by moisture content in oil. For this thesis, it contains of five chapters which is include of the parameter to be determined, method to be used, review on the previous researcher, discussion of the result regarding of this thesis. For the chapter 1 is view on the distribution power, aim of this thesis and scope of the thesis. Chapter 2 is review on the previous journal to compare and to find the similar or to make

comparison on this thesis. From this chapter, it is more to find the literature review regarding to the moisture, insulation and the technique that will used in weibull analysis. In chapter 3, it is review on the project methodology. This part is to describe the methodology that applied for this thesis. The data will differentiate between failure and success according to the standard. Other than that, the parameter, formula and plotting regarding to analyze in weibull it will shows on this chapter. Chapter 4 the results are analyzed. End life of transformer is depends on moisture level. The weibull analysis is used in three method to get the same value of parameter. Chapter 5 consists of conclusion and recommendation for this thesis.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

This chapter will describe of literature review for type of insulation, moisture present in a insulation, accelerates aging, temperature and water solubility. Other than that, it will discuss the Karl Fischer technique and Weibull method. This can be utilized to direct this venture and all the related data was focused around the past examination done by others.

2.1 Type of Insulation

Insulation is one of the most important elemental of a transformer. The strength and stability of the transformer depends upon the proper utilization of insulating materials in it. Transformer failures are normally due to degradation and aging of paper and oil. Life assessment of a transformer is crucial when it reaches the age of 20-25 years [1]. Transformer failure have related to the dielectric response of the insulation system. To determine the life expectation of transformer periodic insulation assessment based on condition monitoring is extremely important, in specific for an aged transformer or the one with distrustful behavior. According to a study transformer failure rate due to insulation related problem is 11% and is increasing [2]. Age levels of protection in a transformer is a mind boggling and unalterable phenomena. Pressure is due of the operation (ordinary to the great), situation and contamination help the crumbling of protection chain therefore shortening the life of the transformer plan.

The protection is all that much responsive in transformer serving closer to plan life. The condition of existing unit has been unerring assessed, when have are best formulated on strategic maintenance and operational procedures.

The presence of moisture in solid and liquid transformer insulation plays a critical role in transformer life [3]. Dielectric breakdown will happen when any increase in moisture content and it can reduce the insulating. This is of a certain importance with rise and fall temperature because as the transformer cools down, any dissolve water will get to be free, resulting in a poor insulating power and fluid degradation. In transformers, the most part for three insulating materials are utilized which is transformer oil, paper and pressboard. In these insulation, provides initial drying to a moisture content of 0.25% to 0.50% moisture by weight, and after processing, the insulation system will be sealed to prevent the ingress of air (oxygen) and moisture.

2.1.1 Insulating oil - Transformer oil.

Transformer oil is the main protecting material utilized as a part of transformer. It is one of the essential factors that determine the life and satisfactory operation of the transformer. Transformer oil serves fundamentally two reasons one it is fluid protection in electrical power transformer and two it dissipates heat high of the transformers act as coolant. Oil analysis is the key source to detect incipient faults, fast developing fault, insulation trending and aging [4]. Oil is the main factor of the transformer to prevent oxidation of the core. Oil surrounding core-coil assembly enhance the dielectric strength of the winding. Other than that, oil has a greater electrical withstand than air occur by dielectric improvement. The stress on the insulation is reduce at the point when oil replaces air in a dielectric system. Polar compounds found in transformer oil usually contain oxygen, nitrogen, or sulphur. Ionic compounds would typically be organic salts found only trace quantities [5]. Polar and ionic compound are some of minor element that found in oil which can greatly influenced the chemical and electrical properties. Polar compound can describe which the electric charge is not symmetrically distributed, there have positive and negative poles. It is different with ionic compound because it is conduct electricity when they dissolve in water. Mineral insulating transformer insulating oils are refined from predominantly naphthenic crude oils[3].

The "crude oil" pumped out of the ground is a black liquid called petroleum. There have two type of transformer oil used in transformer that is consist of paraffin and naphtha based transformer oil. Naphtha oil is more effortlessly oxidized than Paraffin oil. Therefore

sludge of naphtha based oil is not brought about in base of the transformer. In our country is still used paraffin that have disadvantages because it easy availability.

2.1.2 Paper Insulation (cellulose)

Insulation paper is one of the most important in transformer. The function is same with oil transformer but the different between paper and oil is material. The insulation system of a power transformer is understand as the complete assembly of dielectric insulating material. Aging is a factor on this insulation paper. Ageing of cellulose is a function of temperature. Moisture and oxygen has significant influence on the aging [1]. Increasing the failure risk is due to the forces produce by fault current as well, tensile strength and insulation dielectric decrease with aging due to the increase in moisture and contaminants. If the temperature is decreased, the infused paper lost a part of tensile strength. Impregnation effect is occurs by the thickness of oil impregnated.

Oil impregnated papers gradually age due to thermal stress, moisture and acidity and their degradation affects the lifetime of the power transformer [6,7]. This is affect the electrical, mechanical and physical characteristic of oil impregnated paper. Paper was the first insulation applied for used in high voltages technologies. This paper insulation was used in high capacity cable and transformer. The thermal contraction of paper is low and flexible at a low temperature is sensible without leading to the mechanical issue. The dielectric strength of an oil cellulose insulation system rely on the period of voltage application, field improvement factor, its temperature and pressure, kind and degree of contamination of the oil, its temperature and pressure [8]. This transformer paper insulation designed must be prepared and careful with consideration of these aspect.

2.2 Moisture Presence in Insulation

Moisture content of oil and paper is important have an effect on the dielectric behavior of insulation. There are many factor affect this insulation such as raising temperature and the ageing of transformer. In general, the mechanical life of the insulation is reduced by half for each doubling in water content [9]. The presence of moisture in a transformer will become worse in quality or condition of the transformer insulation by

diminishing both electrical and mechanical strength. The parameter moisture content of oil in parts per million (PPM). A major causes of failures by moisture is partial discharge, bubble formation, dielectric breakdown and deterioration of insulating liquid and paper.

2.2.1 Moisture in Oil Insulation

Insulating oil have a low affinity for water. Moisture like an oxygen, can enter the transformer from main tank through loss of integrity of mechanical seal. This will be leading to failure which is oil level drop, exposing the winding and moisture contamination. The moisture presence in oil system have been recognized since the 1920'. Knowing moisture in oil can also predict the steady state moisture content in transformer board in equilibrium with oil [10]. The main thing of parameter in oil moisture measurement is water solvability. If the moisture in oil exceeds the ability in temperature, so the free water will form. This table below show the temperature is place at 20C, since the temperature below 20C the rate of dispersion of water is so moderate it is not possible attain harmony in operational equipment. The study confirmed that moisture equilibrium process in oil-paper insulation system of a transformer highly temperature dependent and a clear knowledge about the state of equilibrium is necessary for accurate determination of oil and paper moisture content[11].

Table 2.1 Guidelines for interpreting data expressed in percent saturation[12]

Percent saturation water in oil, adjusted to 20C	Condition of cellulosic insulation
0 – 5 %	Dry Insulation
6 – 20 %	Moderate wet, low numbers indicate fairly dry to moderate levels of water in the insulation. Value toward the upper limit indicate moderately wet insulation.
21 – 30 %	Wet Insulation
>30 %	Extremely wet insulation

The migration of a small amount of moisture has been associated with flow electrification at paper/oil interfaces and is presumed to be due to charge accumulation on highly insulating interfacial dry zones [3,13]. Water in mineral oil transformer also bring the risk of bubble formation when desorption of water from the cellulose increase the local

concentration of gases in the oil [14]. Water can originate from two sources such as atmospheric and internal sources it shows in table 2.2. The table 2.3 show acceptable water content for new and in-service fluid. There are consist of 3 type of value of voltage. Each type have a different value of water content.

Table 2.2: Origin of water

Atmospheric	**Internal Sources**
Via the silica gel breather (dry silica gel is always blue).	Paper degradation produces water.
Via leaks into the power equipment, i.e. bad gasket, cracked insulation, a loose manhole cover, a ruptured explosion diaphragm etc.	Oil degradation produces water.
(if oil can get out, water can get in).	Wet insulation contaminates the oil, (temperature dependent).

Table 2.3: water content for new oil in 3 different voltage class [15].

Test and method	**Value for voltage class**		
	≤69 kV	69 – <230 kV	>230 kV & above
Water content IEEE C57.106-2006 mg/kg maximum (ppm)	35	25	20
Oxidation inhibitor content Type II oil	0.09% minimum, if in original oil.		

2.2.2 Moisture Accelerates Aging

Insulation is important to keep the transformer in good condition within the range. There are many factor to take prevent and avoid to give a long lasting for the transformer.

Aging is the one factor can affect the insulation and water is the element to influence with the age. Once a device is put into operation, its insulation will deteriorate and produce certain amount of moisture, which then act as catalyst for further aging [16]. Figure describes life expectancy for the insulation at various temperatures and moisture content [3]. At 90°C, cellulose with 1% moisture has a life expectancy of about 12 years. At 3% moisture the life expectancy is only 3year.

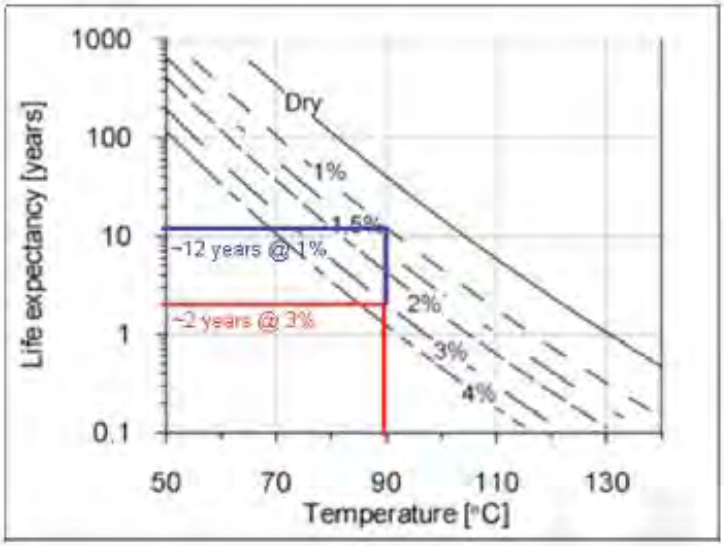

Figure2.1: Life expectancy for cellulose at different temperature and moisture content [17]

2.2.3 Water solubility

Solubility is a concept that sometimes is a quite difficult to understands, but this is essential when attempting to get to the drought or humidity of transformer. The water solubility known as the amount of water that can be dissolve in the insulation oil at particular temperature. The solubility of water is not fixed in insulating oil but it can change due to changes in temperature [18]. This is related, if the temperature is raise up, the amounts of water can be dissolve in insulating oil is increase. This increases is not a linear but exponential in a function. The calculation of solubility limits for oil at different temperatures are shown in Table 2.4.

The solubility can be calculated by using Arrhenius Equation 2.1 [18]:

$$\text{Log } S = -A/T + B \text{ equation} \qquad (2.1)$$