Electric Field and Voltage Distribution (EFVD) Analysis for 132kV Bushing Transformer Using Finite Element Analysis

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Electric Field and Voltage Distribution (EFVD) Analysis for 132kV Bushing Transformer Using Finite Element Analysis

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Abstract. The electric field and voltage distribution (EFVD) are an important parameter for assessing high voltage bushing transformer performance. In order to understand how EFVD being distributed along the bushing transformer, Finite Element Method (FEM) has been employed for simulation purposed. 2 dimensional (2D) object designed using Computer Aided Design (CAD) using actual dimension of 145kV bushing transformer from manufacturer data sheet. The model is then exported to Finite Element Method (FEM) software for further analysis. Using FEM, the EFVD can be obtained. From this study, an understanding of electric field and voltage distribution along bushing transformer and between aluminium foils are attained.

1 Introduction

Electrical energy is the major requirement for all over the world. Nowadays, it can't be neglected the importance of electrical energy in various sectors such as industrial production, agriculture, health facilities, machineries and transportation [1, 2]. The modern day of life is so much dependent on electrical energy so that it is not affordable to have an outage of electricity even for a few minutes. There are three main component for power system. It begins with generation, then transmit the energy through transmission line and finally distribute it to consumers.

Transformer is considered as an among the highest investment in power system. Transformer plays and important role in generation, transmission and distribution. It's main function is to convert high voltage to low voltage or vise versa depending on whether to transmit or to distribute the electrical energy. There are two category of transformer ie. power transformer and distribution transformer. Usually the rating for power tranformers are 500kV, 275kV, 132 kV and distribution transformer rated at 33kV and 11kV.

Bushing transformer are the fundamental component of high voltage power. Figure 1 shows the position of bushing transformer. As shown there, HV bushing are the connection between an incoming line and LV bushing are the connection for an outgoing to the lower voltage. There are three types of main insulation in bushing transformer [2]; polymer, resin impregnated paper (RIP) dan oil impregnated paper (OIP). In this paper, only OIP types of bushing transformer will be discussed. High voltage bushing are an integral part of electrical equipment for carrying one or more high-voltage conductors through a grounded barrier, e.g. a transformer tank or wall [2]. Therefore, bushing must be designed to

cater electrical, mechanical, thermal dan environment stress [2]. The bushing position at transformer is shown in figure 1.
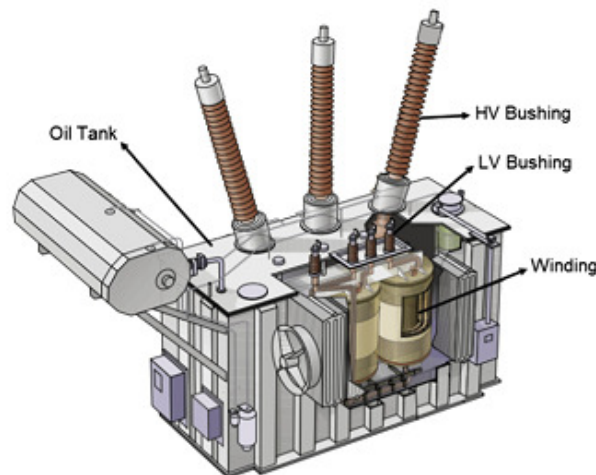

Figure 1. Power transformer

Electrical stress is the most important types of stress to be considered compared to other stress as mention above [2] . Based on [5], it is reportted that, 25% to 30% failure of bushing transformer contribute to transformer failure. Hence, it is important to study and analyze the effect of Electric Field and Voltage Distribution (EFVD). There are several research but found very little focusing in bushing transformer [1-6]. Most of the research shared their EFVD results to be discussed. In this paper, finite element methord (FEM) software is employed to evaluate the performance of EFVD for 132kV OIP bushing transformer. The results from simulation shows good agreement with several result from [3-6].

2. Methodology

2.1 Modelling of Bushing
Computer Aided Design (CAD) software was used to design the bushing transformer model. The dimension for bushing transformer is taken from [1]. It is a model GOB 145kV OIP type. The structure of bushing transformer is depicted in Figure 3. The construction of bushing transformer consist of this six main items and it is shown in Figure 2.
Figure 2, shows the 2D and 3D bushing transformer design using CAD software. In order to reduce the computer processing time, only half of the bushing or 2 dimensional analysis will be consider. It is shown in Figure 2. The dimension for the modeled bushing is taken from [1, 2].
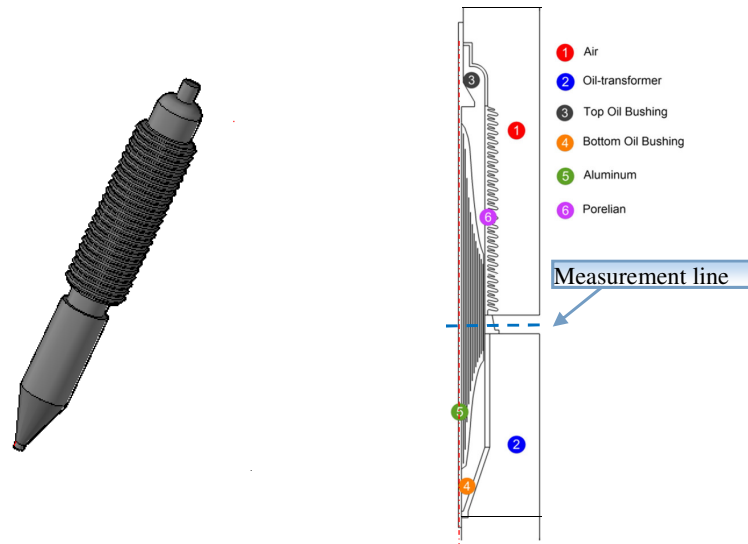
Figyre 2. Bushing transformer modeled in 3D and 2D model.

2.2 Finite Element Analysis

Finite Element Method (FEM) software using a numerical method used to solve problem in engineering and mathemathics. It is useful to solve problems with complicated geometries, loadings, and material properties where analytiacal solutions can be obtained. The module of FEM used to simulate was AC/DC electrostatic model. The equation related to electrostatic are given below :

$$E = -\nabla V \tag{1}$$

$$\nabla . D = \rho_f \tag{2}$$

$$D = \varepsilon . E \tag{3}$$

$$\nabla . \varepsilon \nabla V = 0 \tag{4}$$

Where **D** is the electric displacement field, **E** is electric field, ρ_f is the charge density and **V** is electric potential. After the model drawn and imported to FEM software, the permittivity and electrical conductivity were assigned to the model with the value shown in Table 1 [tesis]. Then, the boundary setting is done. The bushing boundaries along the zero axis which is in red colour are taken as electric potential. Aluminium foils, OIP boundaries and porcelain sheds are set as continuity. Air and oil outer boundaries are set as electric insulation. Metal flange and last foil are grounded. The Relative Permittivity, ε_r for air is 1, oil is 2.2, porcelain is 5, oil impregnared paper (OIP) is 4 dan aluminium foils is 10^8.

3. Results and Discussion

3.1 Electric Field and Voltage Distribution

Figure 3 shows the simulated results for electric field and voltage distribution in the OIP bushing transformer.

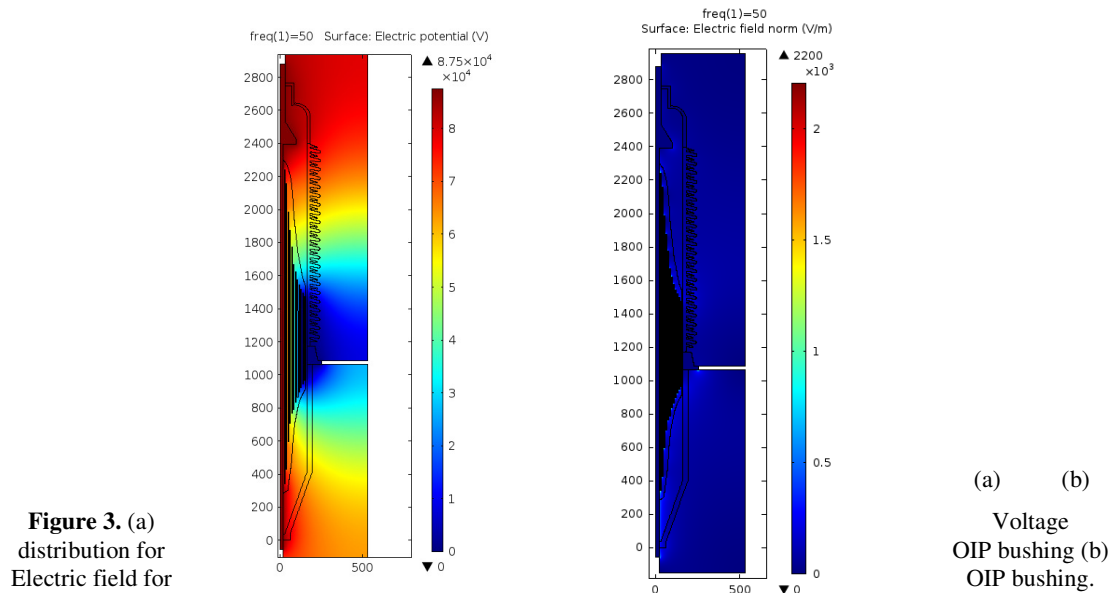**Figure 3.** (a) distribution for Electric field for Voltage OIP bushing (b) OIP bushing.

Figure 3 (a) shows the voltage distribution in terms of surface plot for voltage distribution for bushing transformer. On the other hand, Figure 3 (b) shows a surface plot for electric field distribution for bushing transformer. For voltage distribution, the stress is low at the bushing transformer flange. This is because of the flange is connected to ground. The voltage distribution also distribubed uniformly at each aluminium foils. However for electric field, the intensity become higher especially at the sharp edge of bushing transformer.

In Figure 4(a) , the voltage distribution is measure at flange bushing transfore as represented by dash line Figure 2. The value of voltage at last foil is zero because the last foil is connected to the bushing flange and both of it are grounded. It is also clear that the distribution of voltage is uniform between each 12 aluminium foils.

On the other hand, in Figure 4(b), the electric field is uniformly distributed between foils as voltage distribution. The value of electric field for the last foil also zero as it is connected to ground. It is proven that the foils is actually used to distribute electric field so that there is no cencetrated electric field at certain point in insulation.
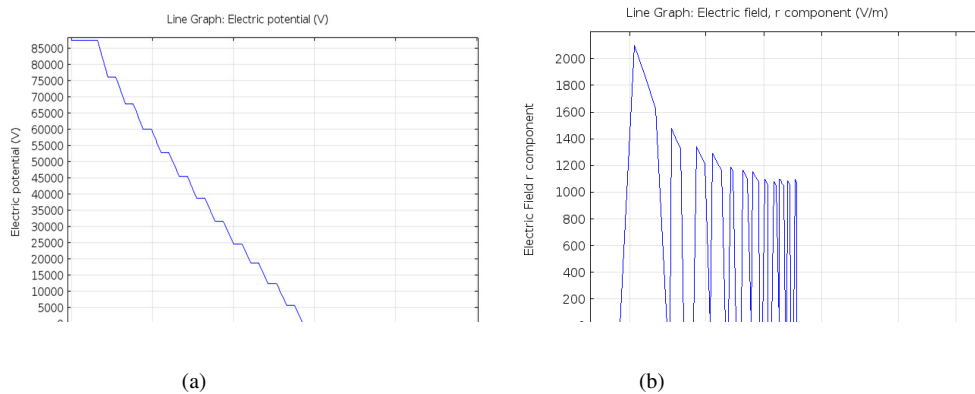
Figure 4. (a) Voltage distribution for OIP bushing measured along flange (b) Electric field for OIP bushing measured along flange

4. Conclusions

From the research, we can conclude several conclusions which are;

i. In this paper, the simulation of EFVD have been successfully carried out to 2D axial-symmetry geometry decribing OIP bushing transformer.

ii. The results of EFVD shows an agreement with other researchers.

iii. The aluminium foils plays an important role in reducing the electric stress for bushing transformer.

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