Design and Construction of a 100kV, 10kVA Testing Transformer

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October 12, 2018

Abstract

This paper presents a report on the design of 1-phase, 50 Hz, 100 kV, 10 kVA transformers insulated with Transformer Oil. The 3 coil transformer consists of a low coil, a high coil and a coil. Each coil has 220V / 100 kV / 220V coil tension, low coil, flat copper wire size 2.6x7.6 mm. The high-voltage coil is a PVF Class 1 insulated copper wire with a diameter of 0.45 mm and PVF Class L insulated copper insulated copper sheath, diameter 2.90 mm Core Type M-4 silicon steel and Kraft paper are insulated during the stage of the coil. All dipped in insulated transformer oil inside the PVC insulated tank. The design emphasizes the complete insulation structure and strength to be used to test the high voltage in the laboratory. Continuously distributed pressure can be supplied without affecting the transformer. By testing the properties of this transformer designed. It has been designed and conformed to IEC 60076 [1993] in all respects.

Key Words: Transformer Tester; Transformer Oil; Insulation Paper
1 Introduction

High Voltage Technology in Thailand It has been growing so much that it requires the production of more powerful electrical equipment. These devices need to be tested and standardized before use. For security reasons, and the same standard. But in providing the tools that will be used to test the equipment manufactured. It still has to be imported from abroad, which is expensive. From the problem. It should be developed to produce the tools to be used. The test is a High-voltage AC power source. To test the equipment itself and also reduce the cost of importing from abroad. Therefore, a 100 kV, 10 kVA, 1 phase, 50Hz type of transformer is installed. It can also be connected to a cascade. It is used to test electrical equipment at various coordinates.

2 THEORIES

A. Testing Transformer
Testing transformers are high voltage transformers for testing insulation materials. Or equipment to be used in high-voltage transmission. To investigate the presence of high strength, such as research on fouling problems on insulators. Find the characteristics of the snake at various atmospheres. Partial discharge in insulating materials, liquid insulators and solid or mixed insulation, etc. Testing transformers are generally single-phase. Low power compared to power transformers. But high pressure. The discharge pressure depends on the input pressure. The regulator is used to adjust the pressure (Regulator).

B. Transformer Oil
Transformer oil is used for internal insulation. It acts as an insulator and helps to cool it. Electrical physics must be considered in accordance with IEC Publication 56, 1963. The properties are as follows.

C. Insulated paper
Insulation is used as insulation between coils. Between high strength and low force and between the coil and the iron core. Because the paper is porous. So it must be dried. And soaked transformer oil. Insulation paper is commonly used. 1) Kraft paper has a thickness ranging from 0.045 mm to 0.38 mm, which has the same voltage
stability as in Table 1.

Table 1: Kraft Breakdown Voltage

<table>
<thead>
<tr>
<th>Thickness (mm)</th>
<th>Break Down Voltage (kV) per sheet</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>0.2</td>
<td>3.5</td>
</tr>
<tr>
<td>0.5</td>
<td>5.0</td>
</tr>
</tbody>
</table>

2) Paper is harder and thicker than kraft paper. Thickness range from 0.8 mm to 3.2 mm, which is highly durable. As shown in Table 2.

Table 2: Breakdown pressure of compressed paper

<table>
<thead>
<tr>
<th>Thickness (mm)</th>
<th>Break Down Voltage (kV) per sheet</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>1.6</td>
<td>9.3</td>
</tr>
<tr>
<td>3.2</td>
<td>20.0</td>
</tr>
</tbody>
</table>

3 DESIGN METHODOLOGY

A. Coil Design
The design of the steel rod must take into account the width of the steel plate can be cut in the production. The thickness of the M-4 core is 0.5 mm. The core type of the core is cross-sectional in a five-tiered rectangular shape. (b) is 100 mm. Step 3 (c) is 80 mm. Step 4 (d) is 60 mm and step 5 (e) is 40 mm.

Figure 1 Cross-sectional area of the steel core
The core type transformer is a core type transformer, which coils the coils into a steel core. And because the iron core of the transformer is grounded. In order to be easy to insulate, low-tension coils are insulated. And high coil winding over low tension coil. In this case, the coil will be coiled over the high voltage coil to send power to the upper transformer, as shown in Figure 2.

Figure 2 Coiling of steel coils

B. Coil Design
Transformers at a small size. Less than 50 kVA coil windings are cooled by the infiltration of the transformer oil. The current density in the coil will not exceed 3.5 A / mm. Avoid combining SI and CGS units, such as current in amperes and magnetic field in oersteds. This often leads to confusion because equations do not balance dimensionally. If you must use mixed units, clearly state the units for each quantity that you use in an equation.

• Design of low tension coils
The low-tension coil defines a cross-sectional area of 13.44 mm, which corresponds to the size of the wire sold commercially. The higher the coil, the lower the current density. However, the number of coils of the coil increases, which may cause the short circuit percentage to be too high. Determine the density of the coil.
$A_{LV} = \frac{I_{LV}}{J_{LV}}$  \hspace{1cm} (1)

$J_{LV} = \frac{45.45}{13.44}$

$J_{LV} = 3.382 \text{ mm}^2$

Actual cross-sectional area $A_{LV}$ 13.44 mm$^2$

Determine Number of Coils

$E_1 = 4.44 f N_1 \phi_{\text{max}}$  \hspace{1cm} (2)

$N_1 = \frac{220}{4.44 \times 50 \times 0.01723} = 57.515$ Rounds

- The high-tension coil shall be cylindrical. If the transformer has a pressure rating the pressure on the coil is uneven. The coil is divided into three layers together. The average radius in each step multiplied by the width of the inner layer is similar. Stage 1 has 30 layers, each 300 rounds, totaling 9000 rounds. Stage 2 has 36 layers, each with 260 rounds, totaling 9360 rounds. The third stage has 40 layers. There are 220 cycles totaling 8800 cycles and 113 cycles per 113 cycles, totaling 27273 cycles.

C. Sorting plan and coil assembly

![Image of steel and coil assembly](image_url)

Figure 3 Planning the steel and coil assembly.
4 RESULTS

A. Insulation resistance measurement
Insulation resistance measurement using MR-40 MICRO-OHMMERER
It is measured in the insulation between the coil winding eyes with high tension. Low tension coil with coil High tension coil with coil Each coil with coil Insulation resistance values are shown in Table 3.

<table>
<thead>
<tr>
<th>Test Voltage</th>
<th>HV-LV = 189900 MOhm</th>
<th>X-G = 2006 MOhm</th>
<th>LV-G = 160900 MOhm</th>
</tr>
</thead>
<tbody>
<tr>
<td>X-G = 2000 MOhm</td>
<td>X-LV = 17800 MOhm</td>
<td>LV2-G = 285 MOhm</td>
<td></td>
</tr>
</tbody>
</table>

B. Measurement of lost and unloaded current
YOKOGAWA WT1600 DIGITAL POWER METER is a measurement of power loss and unloaded current. At normal voltage and frequency, the input power is constant static electricity. The test is shown in Figure 4. Figure 5 shows the relationship between current and loss.

Figure 4: Measurement, measurement of lost and unloaded current
C. Measurement of coil resistance

DC resistance measurement machine MICRO-OHMMERER Model MR5-40 is tested as shown in Figure 6 with the temperature measured 27.4°C as shown in Figure 6.

5 SUMMARY

Transformers have designed and assembled this build. It is an insulated tank using PVC pipe as a transformer tank. Kraft paper is insulated between layers of coil slope. And the transformer oil is insulated in the cooling. The design of the transformer is designed to accommodate future ladders in order to operate at a voltage of 100 kV 10 kVA. This transformer has been tested by actual use. It has the qualities and quality as designed in all respects. The key is. Can create high pressure as required.
5.1 Transformer Configuration

1) Electric power:
- Voltage: 10 kVA

2) Low voltage coil
- Voltage: 220 V

3) High voltage coil
- Voltage: 100 V

4) Coil Tension Voltage:
- Voltage: 220 V

5) Low voltage coil Current:
- Current: 45.45 A

6) High voltage coil Current:
- Current: 0.1 A

5.2 Details of steel core

1) Silicon steel (M-4):
- Cross Section (AFe):
  - Value: 101.87823 cm²
- Flux Density (Bm):
  - Value: 1.67 wb/mm²
- No Load Current:
  - Value: 4.01 A
- No Load Power Loss:
  - Value: 199.037 W

5.3 PVC Detail

1) PVC Insulation Pipe Inlet Diameter:
- Diameter: 60 cm

2) Thickness:
- Thickness: 1.53 cm

3) High:
- Value: 90 cm

4) Resistance to flash point:
- Value: 400 kV/m

5) The temperature began to weaken:
- Value: 75 °C

6 Acknowledgment

Thank you for the Electrical Engineering Faculty of Engineering, Rajamangala University of Technology PhraNakhon To support the research successfully.
References


