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Pole-mounted transformer (Operation & Maintenance)

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Abstract

Electricity is an essential element in our daily life. Most of our daily uses are not without it. It goes through several steps, from its creation to its delivery to the consumer. The most critical factor in this organization is the transformer. It is responsible for the process of increasing and decreasing the electrical voltage. It is essential to know the converter's components and how they work. In addition, how to run and maintain the transformer to endure natural circumstances and provide the longest tender period without problems. The transformer is called the nerve of the electrical network.

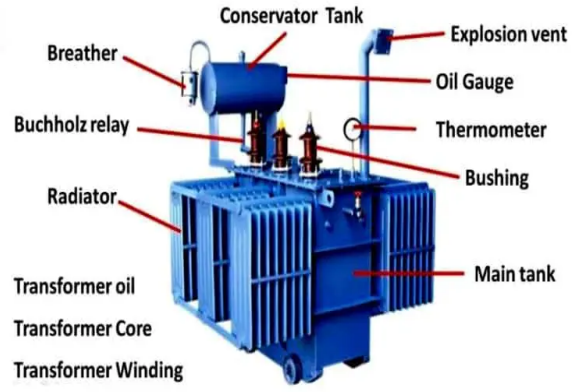
Keywords: Transformer, Maintenance, Operation, Windings, Oil test, Voltage.

* Introduction

Transformers are Mechanical and electrical machines that convert electricity from a specific amount to another. Transformers can be either oil transformers or dry transformers. Both mechanical circumstances and electrical are converted on the machine. It contains several processes. The research will be about pole-mounted transformers (11 KV/ 0.433 KV). Starting from receiving electricity from the external source and entering the transformer. Then, the conversion process will appear inside through different parts. The primary

windings will receive the electricity from the HT bushing and deliver it to secondary windings. The secondary windings will drop the voltage and reach 0.433 KV. After that, the electricity will go out and serve the consumer's needs. That was the general idea of the transformers and how it works. The different parts of the transformers will be explained in depth.

Transformers: The figure below shows us different parts of PMT. Some parts are mechanical, while the others are Electrical. Both are affecting each other. Electrical parts first receive electricity, and mechanical parts help convert the electricity and increase the system's performance (efficiency).



Parts of Transformer

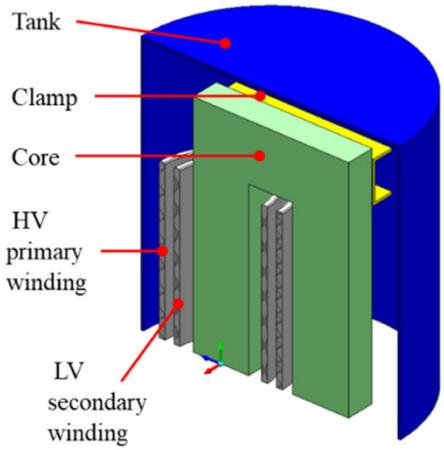
*** Methods**

1- Bushing

Bushing is the part that receives electricity from the cables 11 KV. Then, deliver it to the Primary windings.

*** Windings**

The inner parts are depicted in the diagram below. HV primary tank is responsible for 11 KV. Furthermore, it is the outer windings. Then through the circle shape, it will be delivered to LV secondary winding 0.433 KV. It is the inner windings.



2- Main Tank

The tank contains oil for cooling the transformer and controlling the temperature. The cleaner the oil, the better the transformer performance. The main goal of the tank is to hold and protect the core and windings. It is also for protecting it from external factors.

3- Conservator tank

It is an extra space if the oil expands. A pipe on the side is used to connect it to the main tank.

3- Breather

It is a part that sticks beside the conservator tank. The aim of the part is to absorb moisture from the tank oil.

4- Oil gauge

To show the level of the oil inside the tank.

5- Thermometer

The part shows the temperature of the oil inside the transformer.

6- Buchholz relay:

It is the component in charge of the pressure inside the tank. This part aims to decrease the pressure inside the tank. It is located in a pipe between the primary and conservator tanks.

7- Radiator

The body of the tank is the radiator. It cooled the transformer with air. The transformer produces heat while converting the electricity. So, the radiator helps decrease the process's temperature through air cooling.

8- Tap changer

It is the responsible part for controlling the output voltage. It is accrued by changing the number of windings turned (from primary to secondary windings).

*** types of transformers**

There are two types of transformers. One is the oil transformer. The other one is a vacuum transformer.

*** oil transformer**

It is used for outdoor areas. It can resist high temperatures, humidity, vibration, and air pressure. Oil is the central part of the transformer. The primary purpose is to extinguish the spark when we turn on the circuit breaker. Pmt is an oil transformer.

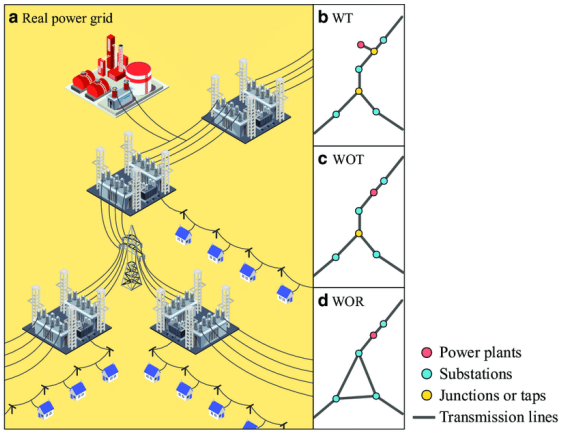
*** Dry transformer**

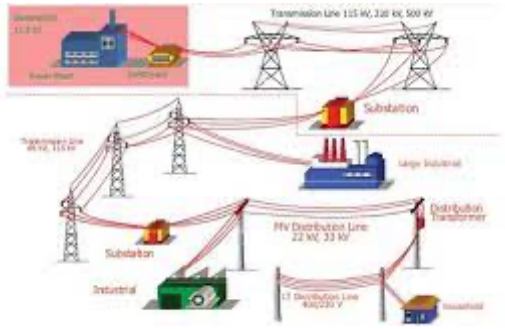
It is mainly used for indoor areas. It depends on the airflow in it for the cooling process. It needs a large cooling area.

*** Electrical and Mechanical operation**

First, power plants generate electricity. Then, it is delivered by high-voltage overhead lines. Second, it is delivered to Stations. Then, in a station, circuit breakers control the movement of electricity. It also controls the operation of transformers. It has two switches: trip and close. Trip means to make an opening in the electrical connection circuit. Close means closing the electrical circuit. This station was known as a low-voltage station (substation). Because it receives high voltage electricity, approximately 33 KV, and drops the voltage to 11 KV by transformers. It is

known as step-down transformers. After that, it will step down the voltage to 0.433 KV. This voltage is going to be delivered to the consumers. In Kuwait, consumers receive o.433 KV. It is divided into two ways. Three phases mean voltage 0.433 KV for high voltage devices at houses (such as ACs). The second is a single phase of approximately 240 KV for low-voltage devices. (Such as TV and refrigerator).





*** Equations**

When current flows into the transformer, the electrical capacity P flows from the primary to the Secondary winding. If the transformer works with high performance, then all the electricity will be converted without any loss. That depends on the quality of the transformer.

We use these equation:-

P incoming = I * V (primary) = P outgoing = I * V (Secondary)

Vs/Vp = Ns/Np = Ip/Is

P: Power (Joule)

V: Voltage (volt)

I: Current (Amber)

N: Number of windings

All of these equations are taken from Ohm's Law:

V = I * Resistance (ohm).

These are the main principles for calculating the income and outcome voltage of the transformer. Moreover, it is tested by specified devices. I will explain the purpose of each device and how to use it.

*** Maintenance**

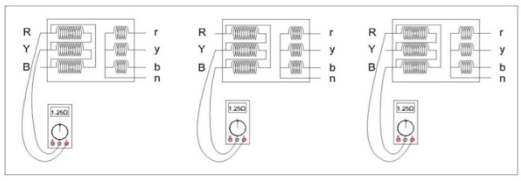
Damage and consumption of electrical equipment are normal. The central part of this process is to do a high-quality maintenance job for the transformer. So, it can produce high-performance and long-term work without issues. The maintenance is divided into many parts. It will be discussed clearly. Maintaining an eye helps us to reduce emergency

accidents. Also, to avoid turning off the electricity and damaging the consumer.

1- windings test

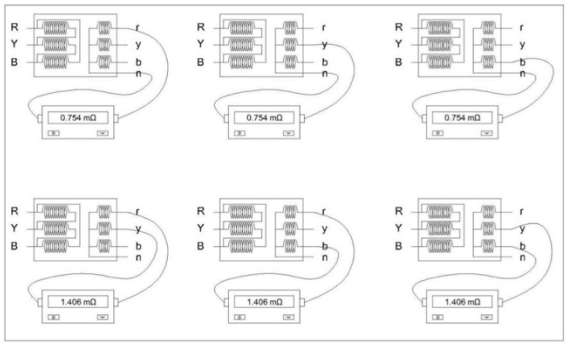
A- Winding Resistance Test

In this test, we test the primary and secondary windings of the transformer to ensure there is no cut in windings or partial or complete breakdown of the insulation material between the windings of a single coil. The test is done by a multimeter device. First, we test primary windings by connecting like the figure below. It must give us the same value for the red, yellow, and blue phases. For primary windings, the test is done on the HV side.



Different Connections for Testing HT Winding Resistance

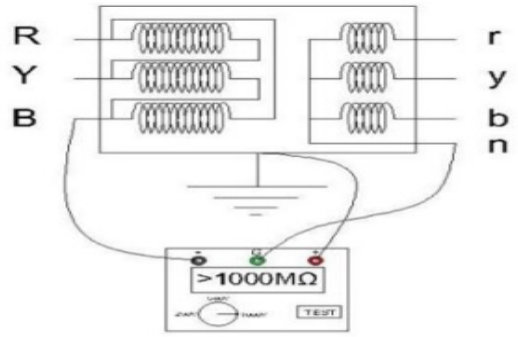
Then, we test the secondary windings. It is as same as the process for primary windings. However, here, we will test the LT side so that we will have four phases (red, yellow, blue, and neutral). Neutral is added for any receding current to the transformer. It will be tested as figure below.



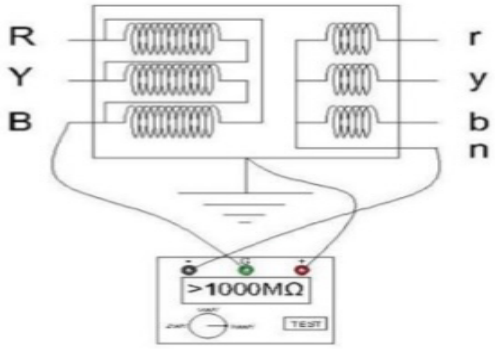
Different Connections for Testing LT Winding Resistance

B- Insulation Test

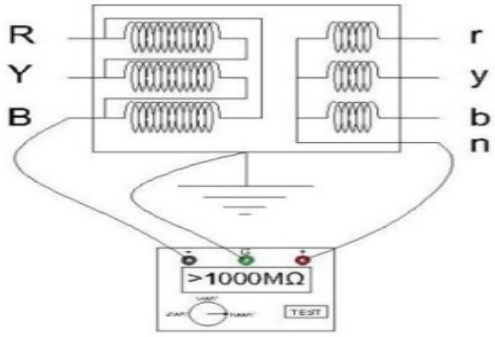
This test is done to check the quality of the insulation material inside the transformer. This test is done by an insulation resistance meter (Megger) device. First, we check the insulation between HV windings and the ground. We will connect the negative part to the HV side and the positive part to the transformer body (ground. Then, we test as shown in the figure below. The result must be a high number (infinity).



Second, we will measure the insulation resistance between the LV side and the ground. The test will do the same as the HV side.



Third, we will measure the insulation resistance between HV and LV windings. We will do as same as the two processes before.



2- Transformer oil test

The sample is withdrawn from the transformer through the oil valve. We take 4-5 samples for testing the oil.

A- Breakdown voltage test (BDV)

BDV oil test device

We wash the sample and wait until it dries. Then we put the sample inside the BDV oil test device. Note that the required value is approximately 33.4 KV according to the specification of IEC 60156.

B- Dissolved gas analysis test (DGA)

DGA Test Device

Gas Detected	Interpretation
Oxygen (O_2)	Transformer seal fault
Oxide and Dioxide Carbon (CO and CO_2)	Cellulose decomposition
Hydrogen (H_2)	Electric discharge (corona effect, low partial discharge)
Acetylene (C_2H_2)	Electric fault (arc, spark)
Ethylene (C_2H_4)	Thermal fault (overheating local)
Ethane (C_2H_6)	Secondary indicator of thermal fault
Methane(CH_4)	Secondary indicator of an arc or serious overheating

Interpretation gas dissolved in the oil

After taking the sample from the transformer, it is closed tightly to prevent moisture or dust from leaking. Then, we put the sample inside the DGA test device.

C- Water content test

It is called Karl Fisher titration. It is a measurement of water content in transformer oil. For this experiment,

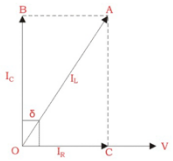
we need a container filled with alcohol and two platinum electrodes and it must be immersed in the solution. Water will react chemically with iodine, sulfur dioxide, CH3OH alcohol, and C5H5C. Iodine will be consumed until water molecules run out. Then, Karl Fisher's reactions are done.

Karl Fischer Test Set

D- Dissipation factor test (DF)

It is a measure of the rate of energy loss (Mechanical, Electrical, electromechanical). It represents quality. The dissipation coefficient is called the Loss Factor in transformer oil.

Oil Tan Delta & Resistivity Kit



Loss Angle

3- Oil leakage test

We check the transformer visually and look for any oil leaks from the transformer parts.

4- Transformer Turn Ratio test (TTR)

The advantage of this test is to: measure income and outcome voltage precisely, measure accurate turn ratio, measure phase shift between primary and secondary windings, and measure excitation current. It is one of the commonly used tests.

Transformer Turn Ratio Kit

*** Discussion**

Experience in the field of electrical and mechanical engineering. It is necessary to know the components on which electrical networks operate. For example, it is necessary to know how electricity is generated and connected to stations through conductors until it reaches the consumer without harming the consumer and his electrical equipment. From here begins curiosity in humans. Thanks to scientists and how developed electrical equipment to what it has reached today. The transformer is a critical piece of equipment. It consists of two basic types, step-down

transformer, and step-up transformer. Research has been highlighting the step-down transformer. How to operate it mechanically and electrically, as well as how to maintain it properly. This equipment has gone through several stages in the past years to what it has reached today. At its inception, it was hazardous in terms of operation and way of working. Nevertheless, nowadays, it has reached high quality and professionalism in operation and work methods.

*** Conclusion**

In conclusion, electricity is widely used nowadays. We use many devices that do not work without electricity, such as TV, phones, ... etc. Electricity generation and connection wouldn't be easy, and needs a high-quality team to do this job. One time is responsible for generating electricity. The second team is responsible for electrical transmission networks. The last team is responsible for electrical distribution networks. As I mentioned, we cannot deliver electricity directly to consumers without going through the three steps. The nurse of electrical networks is the transformer. It is responsible for stepping up or down the electricity. The transformer is considered an essential element; therefore, we must follow up and maintain it so that it functions correctly and the electrical networks will not disrupt.

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