Testing Transformers of one Phase Flows With Inductive Variation Loads

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Abstract, Transformer is an electrical device that is often used to increase and decrease the voltage, either high voltage or low voltage. Transformer testing in this study aims to determine the ability of the transformer when using several variations of inductive loads that are in a single phase current transformer. This research is expected to find a difference in characteristics after testing, including to find out the inductive loading experiment, zero load testing and testing using cos A. After testing with several experiments obtained different data results. Transformer parameters can be obtained from two tests, namely zero load and load test. Zero load testing can be known V1, I0, P1. Loaded testing must pay attention to the nominal current value of the test transformer. A large size transformer will get a large current compared to a smaller size transformer.

Keyword : Transformer, Single phase current

1. Introduction

Transformers have become a necessity for equipment used in various aspects of life. Transformer is a device that can convert electrical energy into electrical energy with the same frequency. Changes in electrical energy that occur are changes in voltage and current. At the transformer voltage and current used are alternating voltage and current (AC). Voltage and direct current (DC) cannot be converted by the transformer.

The development of the type of transformer is generally known, but not many people know about the transformer. An example of a transformer used in everyday life is a single-phase transformer. Most of them know their form but not many also know the transformer. Then we need a test on the transformer in order to know the characteristics of the transformer.

problems and characteristics of the transformer, some of which are the understanding of single-phase current transformers, the working principle of single-phase current transformers, inductive loading testing, no-load testing, and also cos tests that can be tested in variations using inductive loads

2. Theory

2.1 Transformer

A transformer is an electrical device that can move and convert electrical energy from one or more electrical circuits to another electrical circuit, through a magnetic coupling based on the principle of electromagnetic induction. Single phase transformers are the same as transformers in general only using them for small capacities. Transformers are widely
used, both in the electric and electronic fields. Transformers are widely used in electrical engineering. In communication systems, transformers are used in the range of audio frequencies to radio and video frequencies, for various purposes.

In the distribution of electrical power is widely used large capacity transformers and also high voltage. With this high voltage transformer the distribution of electrical power can be done remotely and the shrinkage of power on the network can be suppressed. In the power distribution network many voltage reducing transformers are used, from a medium voltage of 20 kV to 380 V for distribution to houses and offices at 220 V.

2.2 Construction and Working Principles of Transformers.

In an experiment Michael Faraday using materials in the form of a coil, magnetic bar and galvanometer can prove that if we push the magnetic field of the rod into the coil, with its north pole facing the coil, when the magnetic rod is moving, the galvanometer needle shows a deviation that is indicates that a current has been generated in the coil. If the magnetic bar is moved in the opposite direction, the direction indicated on the galvanometer is in the opposite direction which indicates that the current direction is opposite.

Figure 2.1 Induction Current Experiment

In another experiment Michael Faraday tried a ring made of soft iron, then the ring of soft iron was wrapped with insulated copper wire. When the switch (S) was closed, a closed circuit would occur on the primary side, so that current I₁ would flow. Below is a picture:

Figure 2.2 Induction Experiments

The construction of the transformer consists of two coils, namely primary and secondary. When the primary coil is connected to an alternating voltage source, then alternating flux will occur in the primary side coil, then the flux will flow in the transformer core, and then this flux will impact on the coil that is on the secondary side resulting in the emergence of magnetic flux on the secondary side, so that on the secondary side voltage will arise. Below is a picture of a magnetic flux:
2.3 No Load Transformer

A transformer is said to be ideal, if in the calculation there are considered no losses that occur in the transformer, such as losses due to resistance, inductance, magnetization currents, or due to leakage flux. If a transformer without a primary coil load is connected to a sinusoidal alternating current voltage source $V_1$, then the primary current $I_0$ will flow which also has a sinusoidal waveform, if it is assumed that coil $N_1$ is pure reactive, then $I_0$ will be left behind 90o from $V_1$. This primary current will cause a sinusoidal flux in phase.

![No Load Transformer Diagram](image)

Figure 2.4. No Load Transformer

When the primary coil of a transformer is connected to a sinusoidal voltage source $V_1$, the sinusoidal current $I_0$ will flow by assuming that the winding $N_1$ is pure reactive. $I_0$ will lag behind 900 from $V_1$. The primary current $I_0$ gives rise to flux ($\phi$) which is in phase and also has a sinusoid shape: $\phi = \phi_{\text{max}} \sin \omega t$.

2.4 Load transformer.

When the transformer is loaded, a current will flow in the secondary circuit ($I_2$). The magnitude of the primary reactance is stated $X_1$ and the secondary reactance is called $X_2$. The resistance loss indicated by the primary is $R_1$ and the secondary resistance is $R_2$. this happens because of a loss in the transformer coil. If the transformer is given a load of $Z_L$, the current $I_2$ will flow at that load, this flowing current will result in the emergence of the magnetic force $N_2 I_2$ in which the direction tends to oppose the direction of the flux along with which has been caused by the magnetization current $I_m$.

![Load Transformer Diagram](image)

Figure 2.5. Load Transformer
The secondary side is loaded and the primary side is given a fixed voltage, with a load on the secondary side, the current will flow in both transformer coils.

3. Methodology

The transformer that will be used in this test is to use a current transformer, a self-designed transformer. Namely the value of the coil and the current has been determined. The design of this transformer aims to be used with inputs from 0 - 220 V or the voltage can be adjusted as needed. The maximum voltage of the transformer is 220 V. This test uses two transformers with different diameter of wire used and also the nominal current.

Table 3.1 First transformer with a coil ratio of 1000: 500 turns.

| Primary Transformer | Secondary Transformer |
|---------------------|-----------------------|
| Coil = 1000 turns   | Coil = 500 turns      |
| Wire Diameter = 0.25 mm | Wire Diameter = 0.35 |
| Nominal Current = 164 mA | Nominal Current = 300 mA |

Table 3.2. Second transformer with a coil ratio of 1000: 500 turns.

| Primary Transformer | Secondary Transformer |
|---------------------|-----------------------|
| Coil = 1000 turns   | Coil = 500 turns      |
| Wire Diameter = 0.30 mm | Wire Diameter = 0.45 |
| Nominal Current = 215 mA | Nominal Current = 500 mA |

3.1 Preparation of measuring instruments.

before conducting the experiment it is best to prepare the supporting equipment that will be used to maximize results in measurements, some of the equipment used as follows

a. Ampere Meter.

Ampere Meter used is an analog ampere meter that serves to detect currents in the circuit, both small and large currents. The current flowing in the coil is surrounded by magnetic flux.

b. Volt meter

The voltmeter used is analog and digital type. Is a tool that serves to measure the voltage both in the direction and back and forth. Magnetic force will arise from interactions between magnetic fields and strong currents. The magnetic force will be able to make the volt meter needle move when there is an electric current.

c. Watt meter.

The wattmeter the tester uses is the analog watt meter. An instrument for measuring electrical power in watts for any circuit.

d. Single phase current transformer.

The transformer used to conduct the test is a type of current transformer that has different turns, the first transformer n1: 1000 - n2: 500.
e. Load L (Inductive).

Testers in testing using load L (Inductive) with a load of 6.0 H 0.25 A, 4.8 H 0.25 A, 2.4 H 0.25 A, 1.2 H 0.5 A, 1.0 H 0.5 A, 0.8 H 0.5 A, 0.6 H 0.65 A, 0.4 H 0.65 A, 0.2 H 0.65 A.

3.2 No Load Transformer / Zero Load Measurement.

Measurement of zero load on the transformer is aimed at getting the price of parameters of the transformer, such as the value of Rc (iron loss resistance), Xm (magnetizing reactance) and the value of Z0 (zero load impedance). In this experiment we will measure the voltage, current, and power when the secondary side is not connected to the load (open). While the primary side mounted measuring devices such as voltmeter, Ampermeter and Wattmeter.

![No-load Transformer Experiment Circuit](image1)

**Figure 3.1. No-load Transformer Experiment Circuit.**

Zero load transformer measurement is when the primary is connected to the voltage source while the secondary is left open. In this condition, measurements are made of the current flowing on the primary side and is called I0 and the voltage on the primary side, V1 is called V0 and the electrical power on the primary side P1 used at zero load is called P0.

3.3 Load Transformer Experiments.

If the primary coil is connected to an alternating current (AC) power source, then the coil arises primary current I1. With the ZL load attached to the secondary coil, the secondary current I2 flows back and forth. For the ZL load to be inductive, the transformer works at the power factor (PF) lagging at $\phi$. With the presence of I2 due to mounting ZL load on the secondary coil, then the secondary coil arises the secondary magnetic force of $N_1X_M$, so that the shared magnetic flux does not change in magnitude on the primary coil there must be a current flowing of $i_2 = i_2$ so that the current flowing in the primary coil becomes: $I_1 = i_0i_2$.

![The transformer experiment is loaded.](image2)

**Picture. 3.2. The transformer experiment is loaded.**
4. Results and discussion

In this test, there will be two kinds of testing. Namely the first test is the zero load or zero transformer test which aims to get zero load voltage on the primary side (V1), no-load current at primary (I0) current that is only used by the transformer, and no-load power at the time of the primary side (P1) or called P0. The second test is a full load or load test which aims to get efficiency and cos. Of the two tests above will certainly get a difference in each test. The difference that can be seen when the current entering the transformer will certainly be greater in the transformer with a larger size. Likewise with the coil used, if the coil used is greater, the incoming current will also be large. In contrast to the transformer with a smaller size, the incoming current will also be less than the larger transformer.

Table 4.1. The results of the transformer zero load step-down transformer to 1.

| V1 (Volt) | V2 (Volt) | I1 (Ampere) | P1 (Watt) |
|-----------|-----------|-------------|-----------|
| 25        | 12.54     | 0.018       | 1         |
| 30        | 15.12     | 0.021       | 1         |
| 50        | 25.24     | 0.03        | 1.5       |
| 75        | 37.3      | 0.045       | 2.5       |
| 100       | 49.2      | 0.06        | 3.5       |
| 110       | 54.1      | 0.063       | 4.5       |
| 125       | 61.5      | 0.072       | 5.5       |
| 150       | 74.1      | 0.075       | 6.0       |
| 175       | 86.4      | 0.087       | 6.5       |
| 200       | 98.6      | 0.141       | 9.0       |
| 220       | 108.5     | 0.171       | 10.0      |

Table 4.2. the calculation results.

| V1 (Volt) | V2 (Volt) | I1 (Ampere) | P1 (Watt) | I2 (Ampere) |
|-----------|-----------|-------------|-----------|-------------|
| 25        | 12.54     | 0.018       | 1         | 0.035       |
| 30        | 15.12     | 0.021       | 1         | 0.041       |
| 50        | 25.24     | 0.03        | 1.5       | 0.06        |
| 75        | 37.3      | 0.045       | 2.5       | 0.1         |
| 100       | 49.2      | 0.06        | 3.5       | 0.121       |
| 110       | 54.1      | 0.063       | 4.5       | 0.128       |
| 125       | 61.5      | 0.072       | 5.5       | 0.146       |
| 150       | 74.1      | 0.075       | 6.0       | 0.145       |
| 175       | 86.4      | 0.087       | 6.5       | 0.176       |
| 200       | 98.6      | 0.141       | 9.0       | 0.286       |
| 220       | 108.5     | 0.171       | 10.0      | 0.346       |

4.1 Transformer No-Load Test Results

No-load transformer testing can be selected in the circuit drawings, where this test is based on those contained in the drawings.

Figure 4.1. No-load Transformer Experiment Circuit
Table 4.3. The results of the transformer zero load step-down transformer.

| V₁ (Volt) | I (Ampere) | P₁ (Watt) | V₂ (Watt) |
|-----------|------------|-----------|-----------|
| 25        | 0.018      | 1         | 12.54     |
| 30        | 0.021      | 1         | 15.12     |
| 50        | 0.03       | 1.5       | 25.24     |
| 75        | 0.045      | 2.5       | 37.3      |
| 100       | 0.06       | 3.5       | 49.2      |
| 110       | 0.063      | 4.5       | 54.1      |
| 125       | 0.072      | 5.5       | 61.5      |
| 150       | 0.075      | 6         | 74.1      |
| 175       | 0.087      | 6.5       | 86.4      |
| 200       | 0.141      | 9         | 98.6      |
| 220       | 0.171      | 10        | 108.5     |

Based on test results in the measurement of transformer without load can be seen in Table 4.3, where the measurement results include several general variables such as voltage, current, and power. The following measurement results in graphical form can be seen in the image below.

Figure 4.2 Electrical flow to Voltage.

Figure 4.3 Power to Voltage.
4.2. Transformer Testing Results are loaded

Tests on transformers that use inductive loads carried out in variations aim to get efficiency and \( \cos \theta \). The following will be presented a picture of the load transformer circuit.

Based on Figure 4.4 series of experiments the measurement results are obtained according to the table below:

| Beban (Henry) | V1 (Volt) | I1 (A) | P1 (Watt) | V2 (Volt) | I1 (A) | P2 (Watt) | Cos\( \theta \) |
|---------------|-----------|--------|-----------|-----------|--------|-----------|-----------|
| 0.2 H 0.25 A  | 204       | 0.6    | 7.5       | 90        | 1.11   | 14.5      | 0.15      |
| 0.4 H 0.25 A  | 204       | 0.3    | 3         | 99        | 0.59   | 6.5       | 0.15      |
| 0.6 H 0.25 A  | 204       | 0.24   | 2         | 99        | 0.4    | 4.5       | 0.15      |
| 0.8 H 0.5 A   | 204       | 0.18   | 1.6       | 99        | 0.3    | 3.5       | 0.15      |
| 1.0 H 0.5 A   | 204       | 0.15   | 1.4       | 96        | 0.23   | 3         | 0.15      |
| 1.2 H 0.65 A  | 204       | 0.12   | 1.2       | 99        | 0.2    | 2.5       | 0.15      |
| 2.4 H 0.65 A  | 204       | 0.09   | 0.9       | 102       | 0.1    | 1.5       | 0.15      |
| 4.8 H 0.65 A  | 204       | 0.06   | 0.8       | 99        | 0.05   | 0.75      | 1         |
| 6.0 H 0.65 A  | 201       | 0.06   | 0.7       | 99        | 0.03   | 0.5       | 1         |

Based on test results in the measurement of transformer without load can be seen in table 4.4, where the measurement results include several general variables such as voltage, current and power. The following measurement results in graphical form can be seen in the image below.
5. Conclusion
From the One Phase Current Transformer Test with Inductive Variation Load the authors get the conclusion, which is as follows:
1. Loads with 0.2 H 0.25 A - 6.0 H 0.65 A do not affect the magnitude of cos Ø.
2. When the current reaches a voltage of 190 V - 210 V then the current will increase.
3. P2 is greater than P1 because of the step-down transformer.

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