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Performance Study of Unbalanced Load on Delta Transformer

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Abstract: A transformer is a device that can transfer (channel) and convert electrical energy from one circuit to another at the same frequency based on the principle of electromagnetic induction.
The transformer to be used in this study is a three-phase delta connection transformer, which can be used to transmit three-phase electrical power to the load, which is connected to the delta-connected load. The performance of the unbalanced load on the open delta transformer, when loaded with an unbalanced load that is not the same size in each phase, causes an increase in current in each phase, so that there is an increase in input power absorbed by the unbalanced load resulting in greater power losses (loses) with reduced efficiency. The purpose of the study is to study the performance of unbalanced loads in delta transformers and The research method is an experimental method in the laboratory, which includes testing on three-phase transformers of delta connection in an unbalanced load state.
The measurement results showed that there was a difference in the performance (yield of the discharge) effect of the unbalanced load between the average current with the loss and with the efficiency of the delta transformer.

Keywords: Delta transformer, Unbalanced Load.

INTRODUCTION

A transformer is a device that can transfer (channel) and convert a large amount of electrical power from one circuit to another at the same frequency based on the principle of electromagnetic induction. Panjaitan, R. (1989), explained that the voltage received can be increased or decreased according to the magnitude of the current in the circuit. The electrical power that is transferred and changed is voltage and alternating current (AC).

The types of transformers vary greatly, but they can be generally classified into three types, namely Power Transformers, Distribution Transformers, and Measurement Transformers. In general, the type of transformer used as a Power Transformer and Distribution Transformer is a three-phase transformer, as a distributor of electrical power from the plant to the load. Three-phase transformers have two main winding relationships, namely delta relationships and stellar relationships. The delta-delta (Δ-Δ) relationship is the most effectively used for low voltage with large load currents. This winding relationship is also the most widely used winding relationship, when compared to a wide variety of other winding relationships.

Abdul Kadir, (1993), explained that if only two one-phase transformers are available, it is still possible to make a three-phase system using two one-phase transformers or the remaining two windings can be used to distribute electrical power using an open-delta winding relationship.

Removing one of the windings can also be done on a three-phase transformer of delta-delta connection, if the load served is too small for the present, but it needs to be anticipated if there is a load growth in the future, namely by reinstalling the opened winding, The power capacity of the delta transformer can serve the load system 100%,
In general, the load served by a transformer is tried to be balanced. But in reality often the load served by a transformer is unbalanced. The load imbalance results in the current in each phase being unbalanced so that the resultant load current is not equal to zero. As a result, for the same output power, an unbalanced load transformer will have greater losses and will absorb more power, resulting in less efficiency. The current in each phase is unbalanced due to the impedance of the unbalanced phase load. If the open delta transformer is unbalanced then the phase currents will be unbalanced resulting in the secondary voltage on the transformer being unbalanced, thus reducing the input power (Pin) channeled to the load. So before operation, it is necessary to carry out a test. The test is intended to discuss the performance of unbalanced loads in the delta transformer.

RESEARCH METHOD

The methodology used in this study is a test/measurement and analysis method, namely conducting tests in the laboratory to obtain test data.
The steps of the research methodology that will be carried out in this thesis proposal are shown in the flow chart in figure 1.

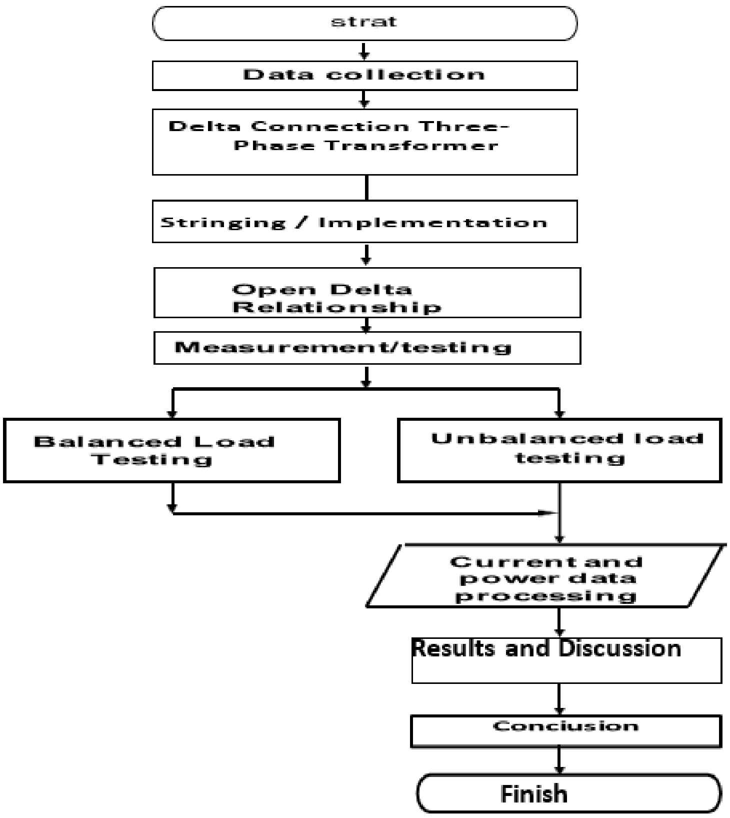

Figure1. Research Methodology Flow Chart

RESULTS AND DISCUSSION

Data Name Plate Transformer Three Phase Open Delta And Delta Relationship

The Name Plate data listed on the three-phase transformer body is as follows:

Transformer Capacity	: 2100 VA
Frequency	: 50 Hz
Primary side tension	: 50-64 Volt
Primary side current	: 22 Barely
Secondary side tension	: 110 – 220 Volt
Secondary side current	: 10 Barely

Determine the Average Value of Load Flow Unbalanced for Each Phase on a Delta Transformer.

The series of open transformers As for the Delta connection, it is obtained:
Trnsformator Capacity : 2100 x 1 = 2100 vA, 50 Hz
Primary/secondary side voltage : 55 / 220 Volts
Primary side current:

$$Ip = \frac{2100}{\sqrt{3}\ x\ 55} = \frac{2100}{95,26} = 22\ A$$

Secondary side current:

$$Is = \frac{2100}{\sqrt{3}\ x\ 220} = \frac{2100}{380} = 5,3\ A$$

This delta relationship also has three windings and each has the same rating, as shown in Figure 2 below.

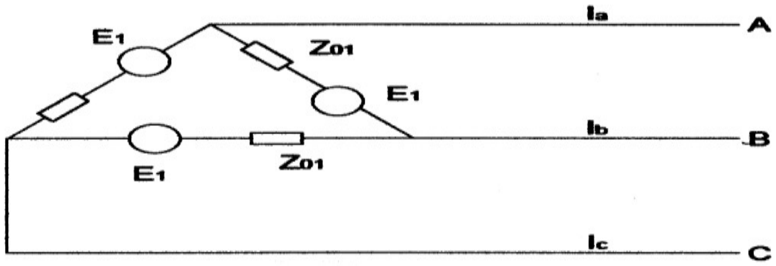

Figure 2. Delta Connection Transformer

According to Panjaitan R. (1989) explained that from the picture above we can know as follows.
IA = IL □□Iph (amperes)

IL = I ph (Ampere) Where: IL = Line current/ Mesh current
Iph = If = Arus fasa

And,

Where:

VAB = VBC = VCA = VL-L (volts)
VL-L = Vph = Vf = E1 (volts)

VL-L = Phase-to-phase voltage
Vph = Vf = Phase voltage to neutral

Measurement and analysis of three-phase transformers of delta relationships in a loaded state

The measurement data is unbalanced loaded, with 2 phases balanced while the other phase is unloaded, on the delta relationship transformer, With V1 setting = 55 volts

Table 1. Data excavation with 2 phases
balanced while the other phases are not loaded, on the delta relationship transformer, obtained as follows:

Yes	**Primary Current (Amp)**			**Input Power (Watts)**			**Vout (Volt)**	**Current Seconds (Amp)**			**Output Power (Watts)**		
	I1	**I2**	**I3**	**P1**	**P2**	**P3**	**V2**	**I4**	**I5**	**I6**	**P4**	**P5**	**P6**
1	17,2	19,1	17,3	665	738	669	190,75	8	8	0	983	983	0
2	19,2	17,2	17,3	741	664	667	190,35	8	0	8	981	0	981
3	17,3	19,3	17,2	667	743	662	190,55	0	8	8	0	982	982

The analysis of the load measurement data is unbalanced, with 2 phases balanced while the other phase is unloaded, on the delta relationship transformer.
Example for No. 1 :

P input total :
P in = P1 + P2 + P3
= 665 + 738 + 669 = 2072 watts
P output total:
P out = P4 + P5 + P6
= 983 + 983 + 0 = 1966 watts
Rugi-rugi transformator : Loses = P in – P out
= 2072- 1966 = 106 watts
Transformer efficiency:

$$= \frac{Pout}{P\ in}\ x\ 100\ \%$$

$$= \frac{1966}{2072}\ x\ 100 ⊠ 94.88\ \%$$ While the average load current is:

For unbalanced load phase currents = (8, 8, 0)
With I = 4 amperes = average phase current / phase current in a balanced load state. IAB = a x I, point a = 2
IBC = b x I, maca b = 2 ICA = c x I, maca c = 0

So that the average current is:

$$= \frac{\{|2-1| + |2-1| + |0-1|\}}{3}\ x\ 100\ \% = \frac{3}{3}\ 1\ x\ 100 = 100\%$$ In the same way, the next data can

Determined so that the table of data analysis results is obtained:

Table 2. Results of measurement data analysis
with 2 phases balanced while the other phase is not loaded, in the delta relationship transformer, as follows:

Yes	**Daya Input (watt)**	**Daya output (watt)**	**Loses (watt)**	**Efficiency (%)**
1	2072	1966	106	94,88
2	2072	1962	110	94,69
3	2072	1964	108	94,78

Table3. Results of the analysis of the average current data

The load, on the delta relationship transformer, is as follows:

Average Current (%)	**Loses (watt)**	**Efficiency (%)**
100	106	94,88
50	98,83	95,20
33,33	97,33	95,66
0	73	96,41

From the table of the results of the analysis of unbalanced load measurement data, the performance (characteristics) of the relationship between the average load current and loses, in the three-phase transformer of the delta relationship, as shown in Figure 2, is as follows:

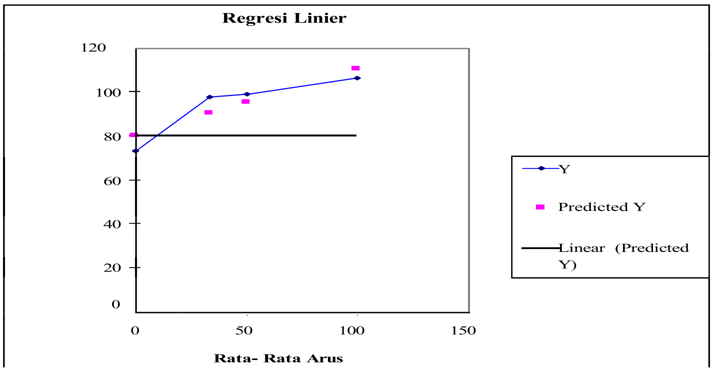

Figure 2. Characteristics of the relationship between the average load current and the loses

In addition, from the table of the results of the analysis of unbalanced load measurement data, the performance (characteristics) of the relationship between the average load current and efficiency, in the three-phase transformer of the delta relationship, as shown in Figure 4.3, the following page:

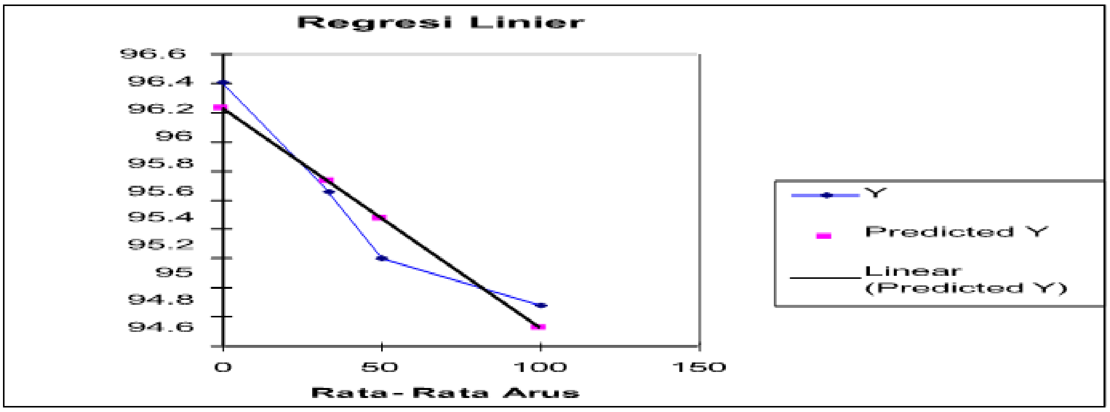

Figure 4.3 Characteristics of the relationship between average load current and efficiency

CONCLUSION

Based on the discussion that has been carried out, the following conclusions are obtained:

1. A performance study (output results) based on data analysis obtained from the delta transformer experiment shows that the average phase load current in the delta transformer is 100% of the active power capacity used.
2. The performance of the balanced load is not the same as the performance of the unbalanced load on the delta transformer, when it is loaded with a balanced load and an unbalanced load that is the same size, this is due to the increase in current in each phase of the load being unbalanced, so that there is an increase in input power absorbed by the unbalanced load resulting in greater power losses with reduced efficiency.

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