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Energize Distribution Transformer 1 at Electrical Engineering Workshop State Polytechnic of Samarinda

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ABSTRACT: Distribution transformers play a vital role in the electrical infrastructure by converting high voltage from the primary voltage source to a voltage suitable for use by end consumers. The energizing process, which is connecting the distribution transformer to the power source, is a critical stage in the implementation and operation of the electrical network. However, a thorough understanding of the factors that affect the efficiency, safety, and reliability of energizing is needed to ensure optimal transformer performance. The transformer energizing process begins with the secondary side of the transformer being given a voltage of 220/380 V 3 phase 50 Hz as input and making the secondary polarity of the transformer primary. Then the primary side of the transformer changes to the secondary side which outputs a voltage of 20 kV 3 phase 50 Hz. During the energizing process, the current flowing on the input or source side was measured at ± 5 A for each phase, 16.83 A at neutral, and 0.06 A at ground. The results of this process successfully energized the 25 kVA distribution transformer to a step-up with a note of the loss for the induction process indicated by the current flowing on the input side under no-load conditions.

KEYWORDS: Cubicle, Energize, Performance, Transformer, 20 kV, 220/380 V

1. INTRODUCTION

Distribution transformers are vital components in the electrical network that convert medium voltage from the main utility medium voltage lines to a voltage suitable for use by end consumers[1][2]. The energizing process, which is connecting the distribution transformer to the power source, is a critical stage in the implementation and operation of the electrical network. Failure in this process can cause power supply disruptions, damage to equipment, and even serious fire risks[3]–[6].

At the Electrical Engineering Workshop of the Samarinda State Polytechnic, distribution transformer 1 plays a role in the stage of changing low voltage to medium voltage, which is an important part of operational activities related to education, research, and development of electrical infrastructure[7]–[9]. However, in this context, it should be noted that the safety, operational efficiency, and maintenance aspects of distribution transformer 1 are the main focus[10]–[13].

Although the energizing procedure has been carried out, further research is needed to ensure that this process can be improved in terms of efficiency, safety, and operational reliability[14], [15]. In addition, with the continuous growth in demand for electric power and technological developments in the electricity industry, there is a need to explore new innovations in distribution transformer energization to meet future demands[16]–[19].

Therefore, the applied research in this stage is to investigate and analyze the distribution transformer energization process 1 at the Electrical Engineering Workshop of Samarinda State Polytechnic in order to improve understanding of the factors that affect the efficiency, safety, and reliability of energization, and to identify potential improvements or innovations that can be applied in the process[20]–[23]. Thus, this research is expected to provide a positive contribution to the practice of distribution transformer energization not only in the Electrical Engineering Workshop of Samarinda State Polytechnic, but can also be adapted and applied on a wider scale in the context of national electricity infrastructure[24]–[27].

2. METHODS

2.1 OBJECT RESEARCH

The object of this applied research is about energizing distribution transformer 1 at the Electrical Engineering Workshop of the Samarinda State Polytechnic in order to obtain the availability of electrical system utilities at the Electrical Engineering Workshop of the Samarinda State Polytechnic in the form of equipment modules as research objects and learning practicum objects and competency tests according to the required standards. Distribution transformer 1 is part of a series of distribution transformers 1 and 2 located in the Electrical Engineering Workshop of the Samarinda State Polytechnic. Distribution transformer 1 is operated as a step-up distribution transformer, while distribution transformer 2 is operated as a step-down distribution transformer. This applied research is based on the policy direction of the Samarinda State Polytechnic Research Master Plan for 2021-2025 in the form of New Renewable Energy and Energy Management, namely supporting appropriate technology and security systems, supporting electrical control, and supporting intelligent control automation. In the context of New Renewable Energy to support the government's program in order to meet the target of 23% energy mix in 2025, green energy, and net zero emission in 2060. While in the context of Energy Management to implement quality, efficient and energy-saving technology and products according to the Energy Consumption Intensity criteria[28].

2.2 RESEARCH PREPARATION STAGE

The research preparation stage is the research design stage related to energizing distribution transformer 1 at the Electrical Engineering Workshop of the Samarinda State Polytechnic which is raised based on the problems that occur in distribution transformer 1 located at the Electrical Engineering Workshop of the Samarinda State Polytechnic in the stage of changing low voltage to medium voltage according to its specifications and required standards which include aspects of safety, operational efficiency, and maintenance in the context of technological development and innovation in the electricity industry based on the context of New Renewable Energy and Energy Management. The preparation stage of the applied research is in the form of a research concept framework, research hypothesis, operational definition and measurement of variables, and an operational research framework[29].

2.3 RESEARCH HYPOTHESIS

Based on the research conceptual framework, a research hypothesis was formulated to obtain the distribution transformer 1 energization model located in the Electrical Engineering Workshop of the Samarinda State Polytechnic, namely as follows.:

1. Distribution transformer energize model 1 located in the Electrical Engineering Workshop of the Samarinda State Polytechnic is operated as a step-up distribution transformer, namely in the stage of changing low voltage to medium voltage according to its specifications and required standards which include aspects of safety, operational efficiency, and maintenance of distribution transformers.
2. The distribution transformer 1 energized equipment module located in the Electrical Engineering Workshop of Samarinda State Polytechnic can be used as a research object for lecturers in the context of technological development and innovation in the electrical industry.
3. The distribution transformer 1 energizing equipment module located in the Samarinda State Polytechnic Electrical Engineering Workshop can be used as an object for learning practicums and competency tests.

2.4 OPERATIONAL DEFINITION AND MEASUREMENT OF VARIABLES

Based on the research concept framework and research hypothesis, the operational definition and measurement of variables for the concept of energizing distribution transformer 1 located at the Electrical Engineering Workshop of Samarinda State Polytechnic can be described as follows:

1. Model *energize* transformator distribusi 1 yang berada di Bengkel Teknik Elektro Politeknik Negeri Samarinda diuji dan 1. Distribution transformer energize model 1 located in the Electrical Engineering Workshop of Samarinda State Polytechnic is tested and operated as a step-up distribution transformer according to its specifications and required standards which include aspects of safety, operational efficiency, and maintenance of distribution transformers based on the criteria for insulation resistance testing, routine and special testing, and transformer oil testing.
2. Operation and performance show performance as a step-up distribution transformer that is energized through a PLN electricity source through the Distribution Network located at the Samarinda State Polytechnic Electrical Engineering Workshop in accordance with the magnitude of variables and constants based on the required specifications and standards including phase sequence polarity, coil connection, power, voltage, and frequency in meeting optimal operating conditions with certain limits.

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2.5 RESEARCH OPERATIONAL FRAMEWORK

The operational framework of the research as shown in Figure 1, shows that the research process begins with preliminary research in the form of literature studies and case studies related to the characteristics of step-up and step-down power transformers applied to substations and how they are relevant to the application of step-up and step-down distribution transformers in distribution substations. Then the research process is continued with data collection in the form of reference data and field data.

Reference data in the form of distribution network system data includes medium voltage networks, distribution substations containing distribution transformers, low voltage networks, and grounding systems, where the reference data is related to the application of distribution transformers in the electric power distribution network that converts medium voltage (TM) to low voltage (TR). In collecting reference data, observations were made on the application of distribution transformers in the electric power distribution network that converts low voltage (TR) to medium voltage (TM) according to the required standards.

While the field data in the form of distribution transformer data as part of the distribution substation which also contains a cubicle panel, namely electrical equipment or equipment that functions as a controller, connector and protector and divides electric power from an electric power source containing incoming cubicles, metering cubicles, and outgoing cubicles. In the field data collection, observations were also made on the energize process, namely connecting Distribution Transformer 1 to the power source through the 3 Phase TR Panel at the Electrical Engineering Workshop of the Samarinda State Polytechnic.

The supporting research tools consist of programs (software) used in the form of AutoCAD 2015 applications: Acad.dwt; Etap 19.0.1 software: Power Flow Analysis, Transient Stability; MATLAB Online Versions software; MS Office Professional Plus 2016 applications: MS Excel, Data Analysis Tool; and the main research tools obtained from the results of literature studies in the form of equipment specifications and functions of step-up/step-down Transformers, as well as implementation of methods related to transformer testing techniques.

The research was continued using deductive and inductive processes, where reference data and field data were verified and analyzed using Etap 19.0.1 Software; MATLAB Online Versions; MS Office Professional Plus 2016 Application Software: MS Excel, Data Analysis Tool; so that it produces a processed data format in the form of energize data and testing of Distribution Transformer 1 at the Electrical Engineering Workshop of the State Polytechnic of Samarinda, and compares it to the reference data of energize and testing of the Step-up Distribution Transformer.

The results of the analysis of the processed data format are then reprocessed using the Etap 19.0.1 Software program; MATLAB Online Versions; MS Office Professional Plus 2016 Application: MS Excel, Data Analysis Tool; so that processed data is obtained in the form of model test results carried out through testing and simulation and comparing them to the magnitude of the analysis parameters and system performance according to the specified standard limits.

Furthermore, in the final stage are the results and discussions that will show the results of applied research in the form of an energize model of Distribution Transformer 1 at the Electrical Engineering Workshop of the State Polytechnic of Samarinda which contains the magnitude of the analysis parameters and system performance, including the required technical specifications and standards covering aspects of safety, operational efficiency, and maintenance of distribution transformers[30].

2.6 DATA COLLECTION STAGE

As previously described in the operational framework of the research above, the data processing stage activities include reference data, field data, and data from literature studies through data compilation and validation, namely as follows.:

1. It is an activity to group qualitative and quantitative data in the Electrical Engineering Workshop of Samarinda State Polytechnic including data on distribution transformer 1 which functions as a step-up distribution transformer containing data on power capacity, voltage, current, frequency, reluctance, resistance, reactance, primary - secondary coil connections, and grounding systems; then cubicle panel equipment data containing electrical equipment or equipment that functions as a controller, connector and protector and divides electrical power from an electric power source containing incoming cubicles, metering cubicles, and outgoing cubicles; PLN electricity source data through the Low Voltage Distribution Network, electrical installations, and grounding systems. While the measurement and test results data include the insulation resistance of the conductor and transformer body, grounding resistance, transformer oil, and coil and terminal connections.
2. Conducting data compilation from survey and observation results, research and assessment results, secondary data collection (secondary data review), laboratory testing and certification results, interviews with related experts, and database development.

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3. Using the data format used to group data, which is very dependent on the researcher's needs.

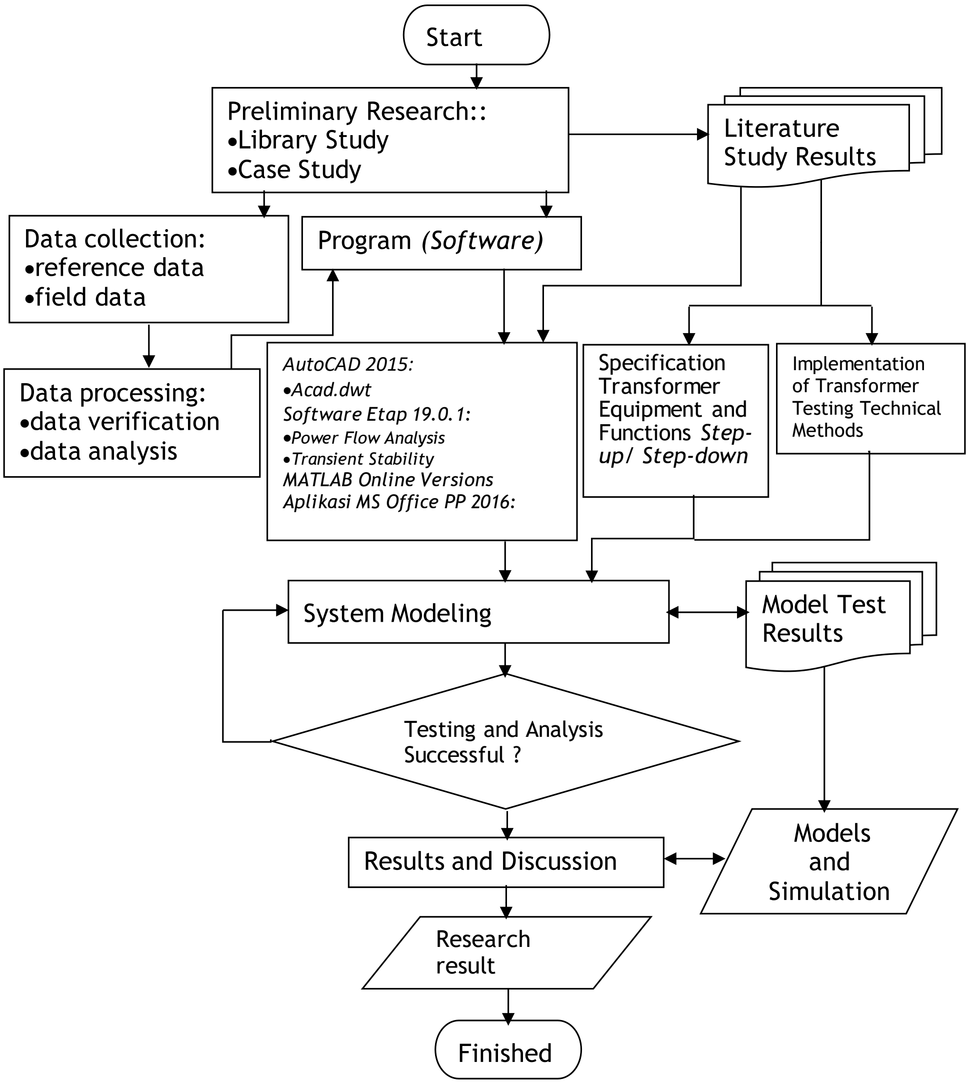

Figure 1. Research Operational Framework

2.7 ANALYSIS AND DISCUSSION STAGE

The analysis and discussion stages related to applied research on energizing Distribution Transformer 1 at the Electrical Engineering Workshop of Samarinda State Polytechnic are as follows:

1. Conducting analysis and discussion related to the distribution transformer 1 energize model located in the Electrical Engineering Workshop of the Samarinda State Polytechnic is tested and operated as a step-up distribution transformer according to its specifications and required standards which include aspects of safety, operational efficiency, and maintenance of distribution transformers based on the criteria for insulation resistance testing, routine and special testing, and transformer oil testing using the Qualitative - Descriptive Analysis and Quantitative - Descriptive Analysis methods.
2. Conducting analysis and discussion related to performance that shows the performance level of the step-up distribution transformer equipment system at the Samarinda State Polytechnic Electrical Engineering Workshop that has been energized through energy supply from the PLN Low Voltage Distribution Network as low voltage input (TR) to the primary side of the distribution transformer, while the secondary side as a medium voltage output (TM) to the cubicle panel

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equipment, where the magnitude of the variables shown in the equipment system meets the required standards including power capacity, no-load and loaded power, voltage, current, frequency, resistance, reactance, primary - secondary coil relationship with certain limits, namely by using the Linear Model approach and the Statistical Analysis - Descriptive, Qualitative Analysis - Descriptive, and Quantitative Analysis - Descriptive methods.

3. RESULT

3.1 DETERMINATION OF STEP-UP DISTRIBUTION TRANSFORMER MODEL

The distribution transformer energize model 1 located in the Electrical Engineering Workshop of the Samarinda State Polytechnic will be tested and operated as a step-up distribution transformer according to its specifications and required standards which include aspects of safety, operational efficiency, and maintenance of distribution transformers based on the criteria for insulation resistance testing, routine and special testing, and transformer oil testing using the Qualitative - Descriptive Analysis and Quantitative - Descriptive Analysis methods..

Analysis and discussion related to performance show the performance level of the step-up distribution transformer equipment system at the Electrical Engineering Workshop of the Samarinda State Polytechnic which has been energized through energy supply from the PLN Low Voltage Distribution Network as a low voltage input (TR) to the primary side of the distribution transformer, while the secondary side as a medium voltage output (TM) to the cubicle panel equipment, where the magnitude of the variables shown in the equipment system meets the required standards including power capacity, no-load and loaded power, voltage, current, frequency, resistance, reactance, primary - secondary coil relationship with certain limits, namely by using the Linear Model approach and the Statistical Analysis - Descriptive, Qualitative Analysis - Descriptive, and Quantitative Analysis - Descriptive methods.

3.2 DETERMINATION OF STEP-UP DISTRIBUTION TRANSFORMER MODEL BASED ON SPECIFICATION TESTING

The step-up distribution transformer model located in the Electrical Engineering Workshop of Samarinda State Polytechnic was determined based on specification testing, where by using the Qualitative - Descriptive Analysis and Descriptive Quantitative Analysis methods, it was obtained:

1. Distribution transformer model-1 which functions as a step-up distribution transformer is determined based on testing the power capacity specifications with smaller power losses, so that 25 kVA 3 Phase 50 Hz 400 V / 20 kV is obtained. While distribution transformer-2 with a capacity specification of 400 kVA 3 Phase 50 Hz 20 kV / 400 V functions as a step-down distribution transformer or functions as a testing facility
2. The electricity source through the Main Distribution Panel (MDP) Low Voltage (TR) 3 Phase 50 Hz 380/ 220 V 4 x 70 mm2 which is available as Incoming has a power capacity of 105 kVA, categorized as lower than the capacity of the distribution transformer-2 with a capacity of 400 kVA.
3. Distribution transformers are generally designed to step down voltage from medium voltage levels to lower voltage levels for end use. However, in some situations, transformers originally designed for step-down may be converted or used in a step-up configuration to meet specific needs. The expected results to be improved from energizing a step-down distribution transformer to a step-up transformer include several variables including voltage and current, efficiency and losses, voltage regulation, thermal effects, life and reliability, economic analysis, and overall performance..

The distribution transformer model-1 step-up with a capacity of 25 kVA 3 Phase 50 Hz 400 V / 20 kV, and the Cubicle panel model 24 kV CB SF6 630 Ampere as shown in Figure 2, Figure 3, and Figure 4. The power source Main Distribution Panel (MDP) Low Voltage (TR) 3 Phase 50 Hz 380 / 220 V 4 x 70 mm2 as Incoming for power supply Energize Step-Up Distribution Transformer Capacity 25 kVA 3 Phase 50 Hz 400 V / 20 kV as shown in Figure 2. Meanwhile, several examples of the application of Step-Up and Step-Down Distribution Transformers in Medium Voltage Distribution Substation Systems and Cubicle Panels are in the form of MVMDB Power House and LVMDB, as well as MDP - TM 20 kV Power House.

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Figure 2. 25 kVA 3 Phase 50 Hz 20 kV/ 400 V Distribution Transformer Model which functions as a Step-Up Transformer

Figure 3. 24 kV CB SF6 630 Amp Cubicle Model

3.3 DETERMINATION OF STEP-UP DISTRIBUTION TRANSFORMER MODEL BASED ON RESISTANCE TESTING ISOLATION

The step-up distribution transformer model located in the Electrical Engineering Workshop of Samarinda State Polytechnic was determined based on insulation resistance testing, where using the Qualitative - Descriptive Analysis and Descriptive Quantitative Analysis methods, it was obtained:

1. According to the standard, the insulation resistance value for a good distribution transformer is ≥ 1,000 MΩ, while the minimum value that is still allowed is ≥ 670 MΩ. According to SE PLN No.032/PST/1984, the measurement of insulation resistance is 1 MΩ/kV or 1 kΩ/V, where the insulation resistance of the transformer coil according to the VDE standard (catalog 228/4), that the minimum insulation resistance of the transformer coil at operating temperature is calculated as "1

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kilo Volt = 1 MΩ (Mega Ohm)" and for the minimum limit of a transformer in good condition is 20 GΩ for an inject of 5,000 V.

2. According to PUIL 2011, the minimum insulation resistance value of the conductor is ≥ 1.0 MΩ with a test voltage of 500 V. The insulation resistance value for electrical equipment and installations according to PUIL 2000, the minimum insulation value for electrical equipment and installations is 1,000 Ω x Working Voltage. While in grounding, where the maximum resistance value of the distribution or grounding resistance is 5 Ω. The Indonesian National Standard for the NYM cable type is regulated by SNI 04-2699: 1999. In addition to the Indonesian National Standard, another standard used in Indonesia is SPLN 42-2: 1992, which is the standard used by PLN.

Figure 4. Main Distribution Panel (MDP) Low Voltage (LV) 3 Phase 50 Hz 380/ 220 V 4 x 70 mm2 as Incoming for power supply Energize Step-Up Distribution Transformer Capacity 25 kVA 3 Phase 50 Hz 400 V/ 20 kV

3. Insulation resistance is measured from the insulation between the parts that are energized with the energized parts or with the parts that are not energized. The tool used to measure insulation resistance is a Mega Ohm Meter or Insulation Tester.
4. Distribution transformer model-1 which functions as a step-up distribution transformer is determined based on insulation resistance testing with good conditions that meet the required standards, so that the polarity index (IP) value is obtained on the 25 kVA 3 Phase 50 Hz 400 V / 20 kV transformer, namely IP 1.25 - 2 Good and IP> 2 Very good. The insulation condition between the winding and the body, and between the two windings, has an IP value of 1.25 - 2 Good and IP> 2 Very good, which is expected to prevent leakage currents in the windings which can cause interference to the transformer so that it can cause damage to the transformer
5. The results of the insulation resistance measurements on the 25 kVA distribution transformer include primary windings with secondary windings ranging from 16.20 GΩ to 21.80 GΩ, primary windings with body ranging from 9.42 GΩ to 13.30 GΩ, secondary windings with body ranging from 1.09 GΩ to 1.54 GΩ, and neutral with body ranging from 1.62 GΩ to 1.82 GΩ, while the insulation resistance of the 20 kV conductor/cable ranges from 4.46 GΩ to 9.52 GΩ. The data from the results of the insulation resistance measurements of the 25 kVA 3 Phase 50 Hz 400 V/20 kV distribution transformer include primary windings with secondary, primary windings with body, secondary windings with body, neutral with body, and cables on the 20 kV voltage side as shown in Table 1.

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Table 1

Data on Insulation Resistance Measurement Results of 25 kVA 3 Phase 50 Hz 400 V/ 20 kV Distribution Transformer Including Primary Winding with Secondary, Primary Winding with Body, Secondary Winding with Body, Neutral with Body, and Cable on 20 kV Voltage Side

Primary-Secondary Winding

Phase R - R (GΩ)	Phase R - S (GΩ)	Phase R - T (GΩ)	Phase S - R (GΩ)	Phase S - S (GΩ)
16,40	17,30	16,80	18,00	18,40
17,70	18,70	17,80	19,80	18,60
19,50	19,00	18,80	20,60	20,70

Primary Winding - Body **Secondary Winding - Body**

Phase R (GΩ)	Phase S (GΩ)	Phase T (GΩ)	Phase R (GΩ)	Phase S (GΩ)
9,42	9,56	9,95	1,27	1,09
13,30	12,50	12,70	1,31	1,46
12,10	12,00	12,40	1,40	1,54

20 kV Voltage Side Cable

Phase R - S (GΩ)	Phase R - T (GΩ	Phase S - T (GΩ
9,52	4,46	5,42

3.4 DETERMINATION OF ENERGIZE MODEL OF STEP-UP DISTRIBUTION TRANSFORMER BASED ON TRANSFORMER OIL TESTING

The step-up distribution transformer model located in the Electrical Engineering Workshop of Samarinda State Polytechnic was determined based on transformer oil testing, where using the Qualitative - Descriptive Analysis and Descriptive Quantitative Analysis methods, it was obtained:

1. According to the standard, transformer oil has met several requirements, including: (a) having high insulation strength; (b) as a good heat conductor; (c) having a low specific gravity; (d) various particles in the oil can settle quickly; (e) having low viscosity; (f) circulating more easily; (g) having better cooling ability; and (h) having stable chemical properties.
2. According to PLN standard (SPLN) 49-1/1992, that transformer oil test has met the minimum breakdown voltage of 30 kV/2.5 mm according to the test standard, where the lower the breakdown voltage produced, the worse the quality of the transformer oil. Other test standards are that transformer oil has met the water content standard. While through crack testing, and laboratory testing, where the detection of the presence of water in the lubricating oil has met the standard
3. Transformer oil test results according to the test report on a 25 kVA 3 Phase 50 Hz 400 V/ 20 kV TR. Centrado 25 kVA SN. 1511009 distribution transformer include Temperature data 29°C, Humidity 91% RH, Mean 41.8 kV, Std. Dev. 9.7 kV, with details of the breakdown voltage test data, namely 1) 28.2 kV, 2) 34.3 kV, 3) 41.6 kV, 4) 40.9 kV, 5) 47.3 kV, and 6) 58.9 kV.

The data on transformer oil test results according to the test report on a 25 kVA 3 Phase 50 Hz 400 V/ 20 kV TR. Centrado 25 kVA SN. 1511009 distribution transformer includes temperature, humidity, and breakdown voltage as shown in Figure 5 and Figure 6.

As explained above, according to the PLN standard (SPLN) 49-1/1992, the transformer oil test has met the minimum breakdown voltage of 30 kV/2.5 mm according to the test standard, where the lower the breakdown voltage produced, the worse the quality of the transformer oil. Other test standards are that the transformer oil has met the water content standard. While through crack tests, and laboratory tests, where the detection of the presence of water in the lubricating oil has met the standard.

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*********** TEST REPORT *********

Tester:_______ _

Date:2028.05.27 Time:13:53:17
Temperature:29℃ Humidity:91%RH
Mean: 41.8kV
Std.Dev.: 9.7kV
SD/Mean: 0.232

1) 28.2kV 2) 34.3kV
3) 41.6kV 4) 40.9kV
5) 47.3kV 6) 58.9kV

Figure 5. Transformer Oil Test Report Result Data on Distribution Transformer 25 kVA 3 Phase 50 Hz 400 V/ 20 kV - TR. Centrado 25 kVA SN. 1511009

Figure 6. Transformer Oil Sampling Data and Breakdown Voltage Test on Distribution Transformer 25 kVA Phase 50 Hz 400 V/ 20 kV - TR. Centrado 25 kVA SN. 1511009

3.5 ENERGIZE MODEL OF STEP-UP DISTRIBUTION TRANSFORMER

The energize model of the step-up distribution transformer located in the Electrical Engineering Workshop of the State Polytechnic of Samarinda was selected based on the results of analysis and testing which included specification testing, insulation resistance testing, and transformer oil testing. As previously described, the distribution transformer model-1 functions as a step-up distribution transformer with a specification of 25 kVA 3 Phase 50 Hz 400 V/ 20 kV. While the distribution transformer model-2 with a specification of 400 kVA 3 Phase 50 Hz 20 kV/ 400 V with several technical considerations only functions as a means of testing. The energize model of the step-up distribution transformer with a power capacity specification of 25 kVA 3 Phase 50 Hz 400 V/ 20 kV located in the Electrical Engineering Workshop of the State Polytechnic of Samarinda has been successfully energized and operated with the procedures and mechanisms as required as shown in Figure 7.

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Figure 7

The energization model of a step-up distribution transformer with a power capacity specification of 25 kVA 3 Phase 50 Hz 400 V/ 20 kV located in the Electrical Engineering Workshop of the Samarinda State Polytechnic has been successfully energized and operated with the procedures and mechanisms as required.

3.6 OPERATIONAL ANALYSIS OF STEP-UP DISTRIBUTION TRANSFORMER ENERGIZE MODEL

Furthermore, related to the analysis of the operation of the step-up distribution transformer energize model as previously described, namely conducting analysis and discussion related to the distribution transformer energize model 1 located in the Electrical Engineering Workshop of the Samarinda State Polytechnic tested and operated as a step-up distribution transformer according to its specifications and required standards covering aspects of safety, operational efficiency, and maintenance of distribution transformers based on insulation resistance testing criteria, routine and special testing, and transformer oil testing using the Qualitative - Descriptive Analysis and Quantitative - Descriptive Analysis methods.

Distribution transformers converted from step-down to step-up can be observed in technical aspects, such as changes in electrical parameters and design, as well as economic impacts. A quantitative approach with experimental methods and secondary data analysis on distribution transformers converted to step-up through technical modifications to the primary and secondary windings, which shows that there is a significant increase in output voltage after conversion, in accordance with the operating principle of step-up transformers. Transformer efficiency shows a slight decrease after conversion, which is identified as originating from changes in the turns ratio and additional losses in the modified windings.

Changes in design parameters through modification of primary and secondary windings result in changes in transformer impedance and reactance. Thermal performance shows an increase in thermal load on the windings after conversion requiring adjustments to the cooling system. Meanwhile, the economic impact is related to the cost of conversion, where through cost analysis it is shown that this conversion can be economical on a certain scale, especially if it is done on an existing transformer rather than buying a new step-up transformer. Likewise for energy savings, although there is a decrease in efficiency, increasing the distribution voltage can reduce power losses in the distribution network.

The results of applied research show that converting distribution transformers from step-down to step-up is possible and can be profitable in certain situations. However, it is important to consider the technical changes and the overall economic impact. Further applied research is needed to optimize the design and operation of this converted transformer.

As previously explained, this applied research is only in the form of energizing distribution transformers from step-down to step-up by utilizing existing step-down distribution transformers rather than buying new step-up transformers. Likewise, the transformer operation in this context is only carried out without load, where the analysis of the operation model of the step-up distribution transformer energize shows that the no-load losses in the transformer occur due to the magnetizing current required to energize the transformer core. In principle, these losses are constant and occur 24 hours a day, 365 days a year, regardless of the load.

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No-load losses in a step-up distribution transformer due to magnetizing current occur when the magnetizing current is required to produce flux in the transformer core, namely as follows:

- magnetizing current: the current required to produce flux in the transformer core.
- core loss: current required to compensate for hysteresis and eddy current losses.

Transformer losses are important performance parameters to indicate the efficiency of the transformer, and whether the transformer performance meets the requirements. Transformer losses are divided into load losses and no-load losses. Load losses are related to the coil, while no-load losses are generated in the core. No-load losses in transformers can be caused by several factors, such as inaccurate voltage levels, and negative sequence supply voltages. Eddy current losses can be minimized by using a thicker iron core. Distribution transformers must be measured periodically to determine their performance. The efficiency of transformer use is when the transformer has a load of 60% - 80%. Distribution transformers that experience loads exceeding 80% of the transformer capacity can affect the life of the distribution transformer, the level and quality of service to consumers, and have the potential for major disruptions. The following is a measurement of the current variable when the transformer is given voltage.

Figure 8. Current measurement on phase R

Figure 9. Current measurement on S phase

Figure 10. Current measurement on S phase

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Figure 11. Current measurement on neutral

Figure 12. Current measurement at grounding

The data obtained are the results of direct measurements during the transformer model operation trial in Figure 8 to 12. For the voltage given constant for each phase, the voltage given for the neutral phase is 220 volts and the voltage between phases is given at 380 volts. This voltage is given on the secondary side of the transformer, in accordance with the previous hypothesis that the transformer will output a voltage from the primary side of around 20 kV. The following is a recapitulation of the current measurement results.

This output voltage energizes the transformer and cubicle so that all systems are energized. To ensure the presence of voltage and losses, current measurements are carried out as above. Current indicates unused power or loss during the energizing process. This model does not use any load at all, only a 3-phase source, transformer, and cubicle.

The loss that occurs in this model lies in the transformer. The transformer requires a closed circuit on its primary side to create induction. This induction will be forwarded to its secondary side to change the voltage. So that the current that is measured is the current from the primary side of the transformer circuit to create induction.

This current is clearly not related to the load and this will only be fictitious power that cannot be utilized. This condition is a loss even though it only provides voltage on the primary side. The point of view in this analysis is that the primary side is initially the secondary side of the transformer and the secondary side is the primary side. Therefore, this study aims to reverse the polarization of the transformer

Then the following is the performance curve of the transformer energizing model for the voltage and current variables without load as follows in Table 2, Figure 13 and Figure 14.

Table 2. Recapitulation of Measurement Results Without Variable Current Load

Variable	Phase		
	R	S	T
Voltage	220/380V	220/380V	220/380V
Current	5.53 A	5.06 A	5.82 A

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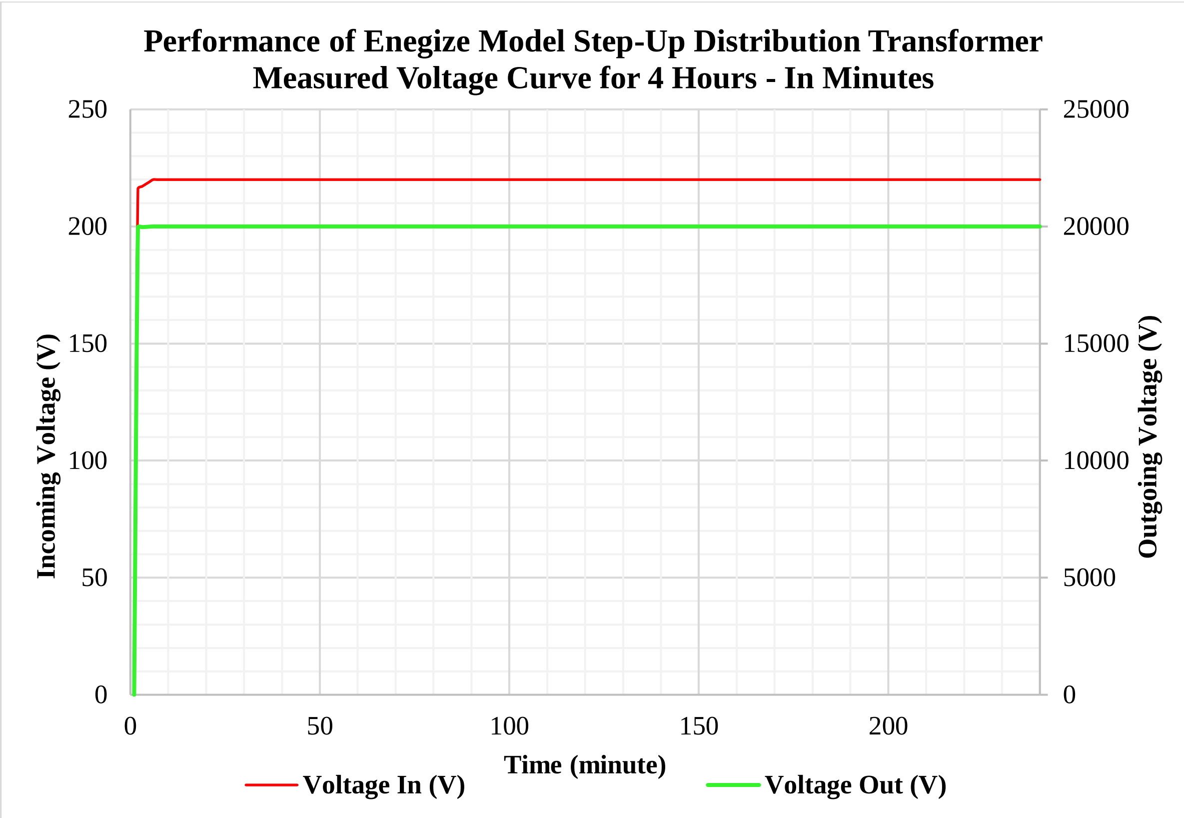

Figure 13. Performance curve of transformer energize model for variable voltage

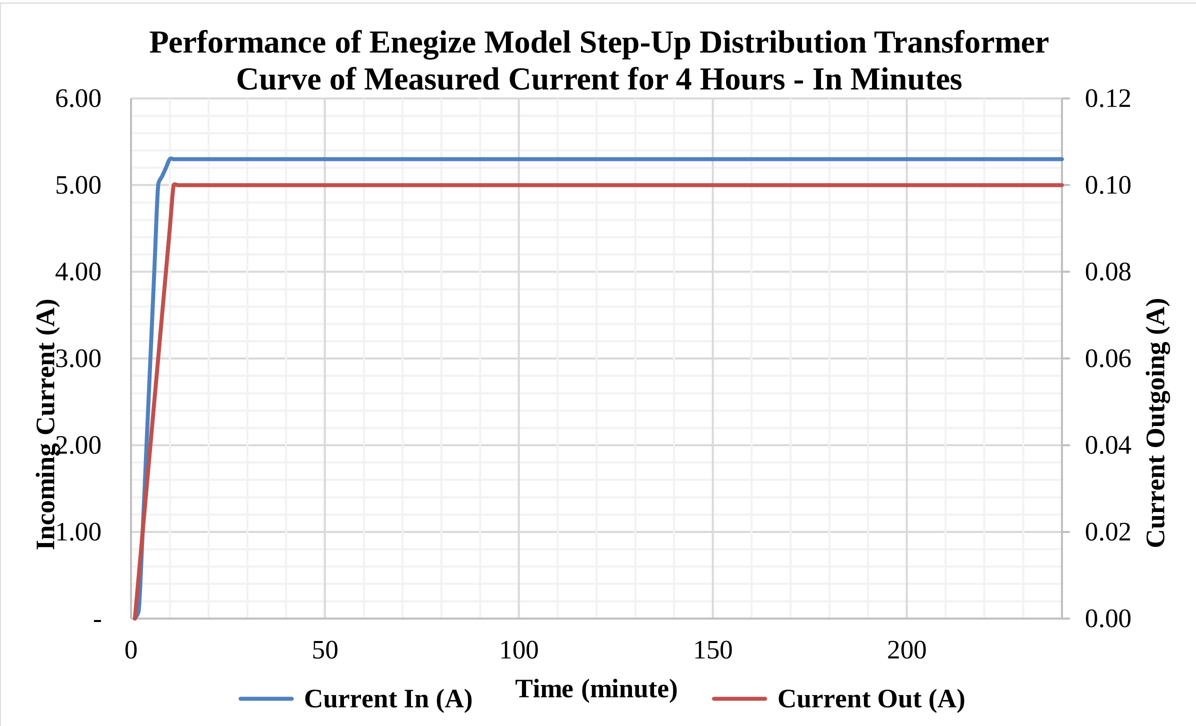

Figure 14. Performance curve of transformer energize model for variable current

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To help the analysis, a simulation is also carried out that resembles the energize model, in the display Figure 15 and Figure 16. This simulation provides a source of inter-phase voltage of 380 volts, then goes to a transformer with a capacity of 25 kVA. In the model after the transformer output goes to the cubicle, but in the simulation the cubicle becomes only a circuit breaker and separator. The results of the simulation show the same output voltage, therefore this simulation uses an ideal transformer so that there is no loss from the transformer and no current flows as shown in the Load Flow Report.

LOAD FLOW REPORT

Bus		Voltage		Generatio		Load		Load Flow					XFM R
ID	kV	% Mag.	Ang.	MW	Mvar	MW	Mvar	ID	MW	Mvar	Amp	%PF	%Tap
Bus1	20.000	100.000	0.0	0	0	0	0	Bus3	0.000	0.000	0.0	0.0	
* Bus3	0.400	95.000	0.0	0	0	0	0	Bus1	0.000	0.000	0.0	0.0	

* Indicates a voltage regulated bus (voltage controlled or swing type machine connected to it)
# Indicates a bus with a load mismatch of more than 0.1 MVA

Figure 15. Results of the Energize Model simulation

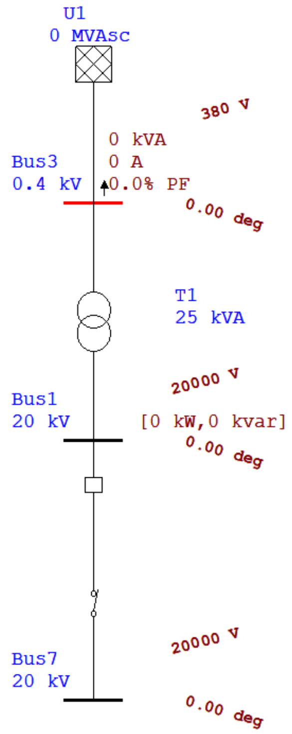

Figure 16. Simulation circuit of transformer energize model

4. CONCLUSION

Based on the results of the discussion on Energizing Distribution Transformer 1 at the Electrical Engineering Workshop of the Samarinda State Polytechnic, several conclusions can be drawn, namely:

1. The energizing model of distribution transformer 1 located at the Electrical Engineering Workshop of the Samarinda State Polytechnic is in the stage of changing low voltage 220/380 volts, 3 phases, 50 Hz to medium voltage 20 kV, 3 phases, 50 Hz and there are losses during the induction process / during the energizing process which is indicated by the current flowing on the input side of phase R 5.53 A, phase S 5.06 A, phase T 5.82 A, neutral 16.83 A and grounding 0.06 A

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2. The equipment module resulting from energizing distribution transformer 1 located at the Electrical Engineering Workshop of the Samarinda State Polytechnic which can be used as an object of lecturer research in the context of technological development and innovation in the electricity industry according to its specifications and required standards which include aspects of safety, operational efficiency, and maintenance of distribution transformers.
3. Distribution transformer 1 energized equipment module located in the Electrical Engineering Workshop of Samarinda State Polytechnic which can be used as an object for learning practicums and competency tests.

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