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OVERCOMING OVERLOAD OF DISTRIBUTION TRANSFORMERS WITH THE UPRATING METHOD AT THE SM01 TIE LINE SINABANG ULP SINABANG

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ABSTRACT

This study discusses the overcoming overload problem in the distribution transformer that occurred at the SM01 Tie Line Sinabang ULP Sinabang Feeder. Transformer overload can lead to decreased electrical system performance, equipment damage, and potential power outages. The method used in this study is uprating, which is increasing the capacity of the transformer to meet the increasing load needs. The study begins with the analysis of historical load data and the identification of the factors that cause overload. Furthermore, simulations were carried out to evaluate the performance of the transformer under different load conditions. The uprating method is applied by taking into account the applicable technical specifications and operational standards. The simulation results show that increasing the capacity of the transformer can reduce the frequency of overload events and improve the reliability of the power supply. From the results of the study, it was concluded that the uprating method was effective in handling the problem of overload of distribution transformers at SM01 Feeder. Recommendations for the implementation of uprating and periodic monitoring of transformer conditions are also prepared to ensure operational continuity and safety of the electricity distribution system.

Keywords : overload transformer, uprating, electricity distribution,

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1. INTRODUCTION

Along with the rapid population growth every year (Hamdani et al., 2019; Tharo et al., 2019a; Tharo & Hamdani, 2020). Electricity demand has also increased significantly. With the increasing population and the need for electrical energy needed, the larger the electricity supply distributed to customers. So the load on the transformer is also increasing, even to the point of exceeding the predetermined load percentage (Tharo et al., 2019b, 2023a, 2023b; Wibowo et al., 2017).

At PT. PLN (Persero) ULP Sinabang has distribution substations that are experiencing overload problems. Overload is a common disturbance in distribution transformers, but if left in this state, it can have an impact on damage to electrical equipment if there is current flowing (Tharo et al., 2022; Wibawa et al., 2022). If there is a disturbance, the current flowing will exceed the capacity of an electrical equipment and the safety system that has been installed beforehand (Tarigan et al., 2022; Wibowo et al., 2017b). Therefore, to maintain reliability in the distribution of electrical energy, it is necessary to pay attention to the load on the transformer to maintain the efficiency of electrical power and avoid damage to the electricity distribution system. Following the provisions of the SPLN (State Electricity Company Standard) for the percentage of transformer load not exceeding 80% of the transformer capacity and its nominal current (In). Overloading the transformer will affect the performance of the transformer because the overload causes heat which will cause the transformer to be disturbed, the heat caused by the overload will also affect the life of the transformer which will work in poor conditions.

Based on the measurement results, the amount of load of the SMM034-00 distribution substation transformer at the SM01 Tie Line Sinabang feeder at peak load was obtained as a percentage of load of 95.01% with a transformer capacity of 50 KVA, therefore the transformer has exceeded the maximum limit of transformer load that has been determined by SPLN 50:1997, which is 80% of the transformer capacity. This will affect the reliability of the distribution of a transformer and result in a high

consumption of transformer damage. Therefore, it is necessary to make efforts to optimize the work of a transformer by using the transformer uprating method, so that the transformer at the SMM034-00 substation does not have overload problems and the work efficiency of the transformer at the SMM034-00 substation can be more optimal.

2. RESEARCH METHOD

The type of research in this final project is quantitative. Quantitative is the collection of data based on deep measurements and the results of those measurements are solved in mathematical form. The data source was taken from the data of the transformer substation with the transformer code SMM034-00 at the SM01 Tie Line Sinabang feeder PT. PLN (Persero) ULP Sinabang. The data needed is the type and brand of transformer, current and voltage data. In this study, the author analyzed the calculation of the load and the percentage of load on the transformer after uprating. The research data was collected from the SMM034-00 transformer substation at the SM01 Tie Line Sinabang PT. PLN (Persero) ULP Sinabang. The research was conducted in Sinabang, East Simeulue, Simeulue Regency.

The Data Collection Method is done in the following stages:

1. Literature Studies
   Literature study is a collection of references from books, previous research and journals related or that can support the theory of completing research on Distribution Transformer Overload Mitigation with the Uprating Method at SM01 Tie Line Feeder Sinabang.
2. Transformer substation data monitoring
   The source of voltage and load current data on the transformer to be uprated is taken from the internal data of the transformer substation on Google Sheet USD 007 PT. PLN (Persero) ULP Sinabang.
3. Field observation
   In completing the research, the author also took data on transformer substations by means of direct observation in the field and took system data that was directly related to the author's research.
4. General information data of PT. PLN (Persero) ULP Sinabang
   Other supporting data needed in this study are Single Line Diagram (SLD) of the Sinabang ULP distribution network and transformer nameplate data.

In the process of this research, there are procedures that are passed in stages, including the following:

1. Collecting voltage and load current data at transformer substations
2. Perform calculations of load and percentage of transformer load before uprating
3. Measure the voltage and load current at the transformer substation after uprating
4. Perform load calculations and transformer load percentages after uprating
5. Conducting a comparative analysis of the percentage of load after transformer uprating

3. RESULTS AND DISCUSSION

3.1. Results

1. Single Line Diagram

In the image below is a Single Line Diagram of 20K Distribution System of PT. PLN (Persero) ULP Sinabang Feeder SM01 - Tie Line Sinabang. The part given by the red circle is the SMM034-00 substation in Suak Buluh Village, Simeulue Regency which is the object of the research.

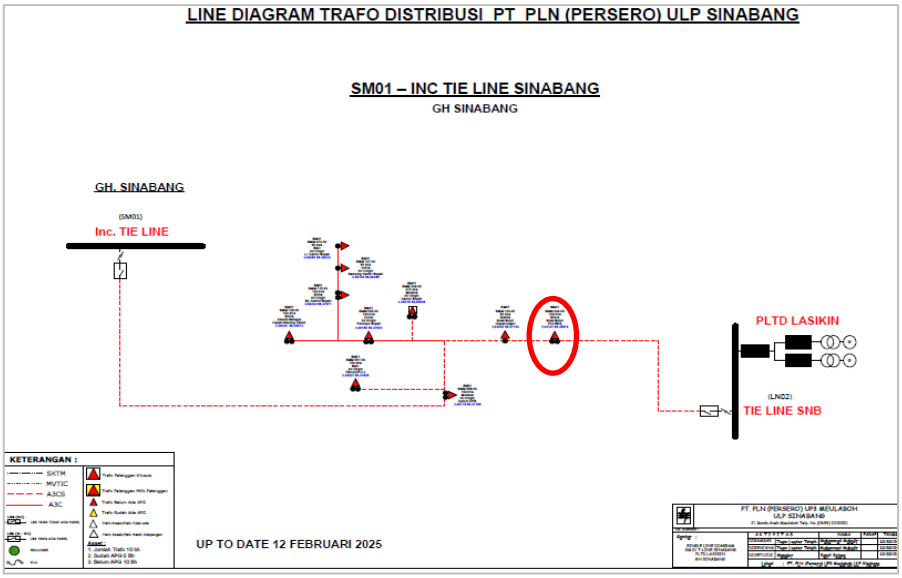

Figure 1. Single Line Diagram ULP Sinabang

2. Transformer data and substation measurement results at peak load

The following is the *name plate of* the transformer before uprating with a capacity of 50 kVA.

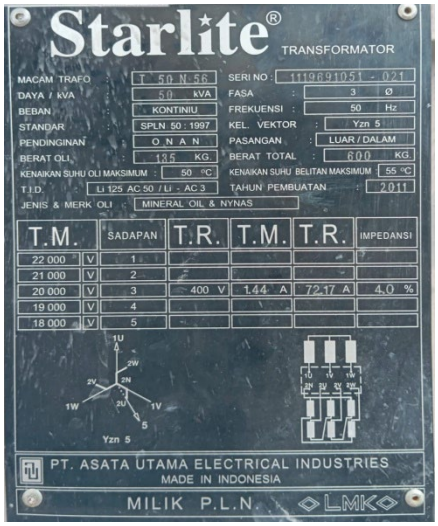

Figure 2. Transformer name plate before uprating

To conduct the analysis of the SMM034-00 substation, data are needed as inputs, including current and voltage measurement data in each substation department before uprating.

Table 1. Current Measurement Results

CURRENT MEASUREMENT				
DEPARTMENT	**R (A)**	**S (A)**	**T (A)**	**N(A)**
A	55	27	46	30
B	37	24	23	21
TOTAL	92	51	69	

Table 2. Voltage Measurement Results

VOLTAGE MEASUREMENT					
PHASA – PHASA			**PHASA – NEUTRAL**		
SAR	R-T	S-T	R-N (V)	S-N (V)	T-N (V)
397	394	392	224	223	225

4.2. Transformer Load Calculation Analysis Before Uprating

1. Transformer Load Conditions

The SMM034-00 substation has a transformer capacity of 50 kVA. In order to find out the magnitude of the nominal current/full load current, it is as follows:

I fl = $\frac{Kapasitas\ transformator}{V\ x\ \sqrt{3}}$

I fl = $\frac{50000}{400\ x\ \sqrt{3}}$

I fl = 72.16 A

Then to calculate the average current of the load of the transformer, you can use the formula:

$_{\text{AVERAGED}} = \frac{IR+IS+IT}{3}$

$_{\text{AVERAGED}} = \frac{\mathbf{92+51+69}}{\mathbf{3}}$

AVERAGE = 70.66 A

The calculation of the transformer load on each phase can be determined by using the following formula:

Sr = VRN x total IR

Sr = 224 x 92

Sr = 20,608 VA

Sr = 20,608 KVA

Ss = VSN x IS total

Ss = 223 x 51

Ss = 11,373 VA

Ss = 11,373 KVA

St = VTN x Total IT

St = 225 x 69

St = 15.525 VA

St = 15,525 KVA

The calculation of the total load of the SMM034-00 transformer can be found by adding up all the majors per phasa.

STOTAL = SR + SS + ST

STOTAL = 20,608 + 11,373 + 15,525

STOTAL = 47,506 KVA

Calculation of the load percentage of the transformer

After obtaining the total load value of the SMM034-00 transformer, the result of the percentage (%) of loading before uprating can be calculated using the following formula:

% load = x 100%$\frac{\boldsymbol{S\ total\ beban}}{\boldsymbol{S\ transformator}}$

% load = x 100%$\frac{\mathbf{47,506}}{\mathbf{50}}$

% load = 95.01%

The results of the calculation of the load percentage at the SMM034-00 substation show that the substation has experienced overload with a total transformer load percentage reaching 95.01% and has exceeded the standard set by SPLN 50:1997, which is the maximum limit of 80% of the transformer capacity.

2. Determination of the right replacement transformer capacity for uprating

Based on the analysis of the results of the load calculation and the percentage of load on the SMM034-00 transformer, the rating / capacity of the replacement transformer used for uprating work can be determined with the following equation:

Distribution Transformer Rating = $\frac{kVA\ beban}{0{,}8}$

Distribution Transformer Rating = $\frac{47{,}506}{0{,}8}$

Distribution Transformer Rating = 59.38 KVA

The calculation result of the rating / capacity of the replacement transformer for the uprating work is 59.38 KVA. Based on the results of the calculation adjusting to the category of transformer capacity

available in the electrical industry, the appropriate replacement transformer rating is a 100 KVA transformer.

Table 3. Current on the primary and secondary sides

No	$\frac{Daya\ (KVA)}{Fasa}$	Ip (A)	Is (A)	80% x Is (A)
1.	$\frac{25}{1}$	1.25	54.1	43.28
2.	$\frac{50}{1}$	2.5	108.23	86.58
3.	$\frac{64}{1}$	3.2	138.53	110.82
4.	$\frac{25}{3}$	0.72	36.08	28.86
5.	$\frac{50}{1}$	1.44	72.17	57.74
6.	$\frac{100}{3}$	2.89	144.34	115.47
7.	$\frac{160}{3}$	4.62	230.94	184.75
8.	$\frac{200}{3}$	5.77	288.67	230.94
9.	$\frac{250}{3}$	7.22	360.84	288.67
10.	$\frac{315}{3}$	9.09	454.66	363.73
11.	$\frac{400}{3}$	11.54	577.35	461.88
12.	$\frac{630}{3}$	18.20	910.40	728.32

Figure 3. Transformer name plate after Uprating

4.3. Analysis of Transformer Load Calculation After Uprating

1. Substation Current and Voltage Measurement Results at Peak Load

The following are the results of current and voltage measurements of the SMM034-00 substation that has been uprated by transformers that are overloaded.

Table 4. Current Measurement Results After Uprating

CURRENT MEASUREMENT				
DEPARTMENT	**R (A)**	**S (A)**	**T (A)**	**N (A)**
A	45	28	34	29
B	39	28	34	26
TOTAL	84	56	68	

Table 5. Voltage Measurement Results After Uprating

VOLTAGE MEASUREMENT					
PHASA – PHASA			**PHASA – NEUTRAL**		
SAR	R-T	S-T	R-N (V)	S-N (V)	T-N (V)
395	398	396	221	222	224

2. Transformer Load Conditions

Substation SMM034-00 when transformer overload has been overcome with the uprating method, this transformer has a transformer capacity of 100 kVA, to calculate the amount of nominal current/full load current is as follows:

I fl = $\frac{Kapasitas\ transformator}{V\ x\ \sqrt{3}}$

I fl = $\frac{100000}{400\ x\ \sqrt{3}}$

I fl = 144,337 A

Then calculating the average current on the SMM034-00 substation can use the following formula

AVERAGED = $\frac{IR+IS+IT}{3}$

AVERAGED = $\frac{\mathbf{84+56+68}}{\mathbf{3}}$

AVERAGE = 69.33 A

The calculation of the transformer load on each phase can be determined by using the following formula:

Sr = VRN x total IR

Sr = 221 x 84

Sr = 18,564 VA

Sr = 18,564 KVA

Ss = VSN x IS total

Ss = 222 x 56

Ss = 12.432 VA

Ss = 12,432 KVA

St = VTN x Total IT

St = 224 x 68

St = 15.232 VA

St = 15,232 KVA

The calculation of the total load of the SMM034-00 transformer can be found by adding up all the majors per phasa.

STOTAL = SR + SS + ST

STOTAL = 18,564 + 12,432 + 15,232

STOTAL = 46,228 KVA

Calculation of the load percentage of the transformer

After obtaining the total load value of the SMM034-00 transformer, the result of the percentage (%) of load after uprating can be calculated using the following formula:

% load = x 100%$\frac{\boldsymbol{S\ total\ beban}}{\boldsymbol{S\ transformator}}$

% load = x 100%$\frac{\mathbf{48,228}}{\mathbf{100}}$

% load = 48.23 %

The results of the calculation of the percentage of load on the SMM034-00 substation show that the substation has returned to normal or has not experienced overload with a total percentage of 48.228%

of transformer loading. The value of the load percentage is in accordance with the optimal load characteristics of the transformer which is limited to a maximum of 80% and a minimum of 40% measured from current.

4.4. Comparison of Loading Percentages Before and After Uprating

Based on data on transformer load measurement before and after transformer uprating at substation SMM034-00 PT. PLN (Persero) ULP Sinabang was obtained from the results of the calculation of transformer load per phase before the transformer uprating, namely at phasa R of 20,608 kVA, phasa S of 11,373 kVA and phasa T of 15,525 kVA with a percentage of transformer power load of 95.01% where the amount of this charge has exceeded PLN's standard limit of 80% of the transformer capacity. From the results of the analysis, it can be concluded that the transformer is in a state of overload and must be handled using the transformer uprating method at the SMM034-00 distribution substation.

Below is a table of transformer charging results before transformer uprating at the SMM034-00 distribution substation. It can be seen from the table below, namely:

Table 6. Results of Calculation of Loading Percentage Before Uprating

Department	**Current (A)**				**Transformer Load Percentage**
	R	S	T	N	
A	55	27	46	30	95,01 %
B	37	24	23	22	
Power (kVA)	20,608	11,373	15,525		
Total Power (kVA)	47,506				

After calculating the load of the transformer after uprating the transformer, the results of the calculation of transformer load per phasa were obtained, namely at phasa R of 18,564 kVA, phasa S of 12,432 kVA and phasa T of 15,232 kVA with a percentage of transformer power load of 48.23% where the amount of load after uprating the transformer was concluded that the transformer was in a normal state / not overloaded anymore because of the percentage of load below 80%.

Table 7. Calculation Results of Load Percentage After Uprating

Department	**Current (A)**				**Transformer Load Percentage**
	R	S	T	N	
A	45	28	34	29	48,23%
B	39	28	34	26	
Power (kVA)	18,564	12,432	15,232		
Total Power (kVA)	46,228				

4. CONCLUSION

The results of the research and analysis that have been carried out, several conclusions can be drawn, namely:

1. The total load of the SMM034-00 transformer before uprating with a capacity of 50 kVA is 47,506 kVA with a transformer load percentage of 95.01%, where the transformer is in an overload condition so that it needs to be handled using the transformer uprating method.
2. The total load of the SMM034-00 transformer after uprating with 100 kVA is 46.228 kVA with a transformer load percentage of 48.23%, where the transformer is already in a normal and safe state and does not experience overload.
3. The application of the transformer uprating method is very effective to maintain the reliability of electrical energy distribution and avoid damage to the SMM034-00 50kVA transformer due to increased heat temperature from continuous overload.

The suggestions from this study are as follows:

1. In order to measure the current and voltage of the transformer regularly in order to find out the amount of load and the percentage of load on the transformer
2. Handle it immediately if there is a transformer that is overloaded.

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