Analysis of The Quality of Electrical Power and Its Impact on PT Pamin Medan Factory Operations

Arnold Noverson Laia, Rahmaniar, Haris Gunawan

Abstract

PT. Pacific Medan Industri (PAMIN), which is located in the modern industrial area of Medan which was established in 1998, is one of the companies engaged in the food sector that produces palmoil-based products such as palm oil, shortening, margarine, cooking oil, special fats, PET bottles including metal printing (printing), cans (cans) and jerry cans for packaging. The problem at PT PAMIN is poor power quality caused by the load on the transformer. The solution is to reduce the use of excess loads, so that the transformer can be more optimal and maximum efficiency. The purpose of this study is to determine the quality of electrical power in PAMIN and analyze the problems of electrical power quality that occur in PAMIN. The results of the active power analysis were obtained at 86,768 kVA. The results of the load analysis were obtained as I average = 91.657 A, IR = 1.08, IS = 1.004, IT = 0.906.

Keywords: Pamin, Transformer, Electric Energy

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Introduction

Electrical energy is a very important need in the electricity distribution system for the present and the future, in the distribution of the electric power system cannot be separated from the existence of disturbances [1]. Since the last few years, the use of electrical energy has been very rapid, this is due to the increasing growth of society and also the development of quite high development [2]. The quality of electrical power is an important thing to pay attention to in the industrial and household world. Good electrical energy quality in the industry will not only produce maximum products, but good electrical energy quality can also make electrical equipment in the industry more durable [3]. Electrical power loss, commonly called shrinkage or losses, is the loss of electrical energy due to technical and non-technical problems. Technical problems are generally caused by the quality of electrical conductivity [4]. Distribution network conditions that are not optimal will result in less effective services, including due to voltage drops [5]. Current or voltage will contain harmonics, which can then be the cause of poor power quality in the system. Power quality is largely influenced by nonlinear load types, load imbalance and harmonic wave distortion that exceeds the standard. The parameters of electrical energy power quality are power and harmonic factors.

The power factor is the ratio between active power and pseudo-power. The factors that affect the quality of electrical energy are voltage, current and power factor (COS PHI). A power triangle is a triangle that describes the mathematical relationship between different types of power, namely active power (Watt), reactive power (Var) and pseudo-power (VA) [6]. Electrical power is generated by an energy source and then the load connected will absorb electrical power. Harmonic distortion will adversely affect the power factor [7]. Harmonica results in the occurrence of current and voltage wave distortion. Harmonics occur due to the presence of a nonlinear load, where a high-frequency wave will be formed which is a multiple of its fundamental frequency [8]. However, this type of three-phase non-linear equipment produces harmonic currents on the three-phase power grid, causing damage to household and industrial equipment [9].

THD is one of the parameters that states the quality of an electrical signal to be used compared to a pure sinusoidal signal [10]. A small THD value can be obtained by setting the value of the triangular wave frequency to high. However, the required hardware specifications are becoming higher [11]. A capacitor bank is a collection of several capacitor units that are connected in series or parallel to obtain a certain capacity [12]. The installation of a bank capacitor in accordance with the conditions of the electrical system greatly affects the reliability and effectiveness of the installation of a bank capacitor with consideration of the cost of installing a bank capacitor [13]. The placement of a bank capacitor on the distribution network is the main solution to overcome this problem, but to optimize the installation to have a significant influence on the voltage level in the network requires quite complicated calculations, especially [14]. To determine the effect of the installation of the capacitor bank on the power factor reviewed from the percentage of power efficiency in the reefer plug [15]. One of the functions of the use of a bank capacitor is as a tool to increase the power factor. The high power factor is highly desirable so that the induction motor operates more efficiently and keeps costs lower for all systems [16]. The power factor allowed by the PLN standard is >0.85. The use of a bank capacitor cannot be separated from the presence of damage disturbances. Damage that occurs to the capacitor bank includes the capacitor exploding, the capacitor catching fire and the capacitor fuse breaking [17]. The capacitor bank cannot compensate for the pf and results in the incurring of kVARh usage costs [18].

To convert the active power value (KW) to the apparent power value (KVA), you can use equation

1. It can be seen below:

$$1\ KVA = 1000\ W \times \cos\theta \qquad (1)$$

To find the average current, you can use equation 2:

$$I_{Rata-rata} = \frac{IR+IS+IT}{3} \qquad (2)$$

Research Methodology

Data Collection

Data collection has an important role in the preparation of mini-research in the context of scientific research. This method is used to gain an in-depth understanding of the phenomenon being studied through descriptive, interpretive, and contextual data collection and analysis [19]. Data collection techniques with observation and interviews that then produce documentation [20]. Some of the guidelines in this writing are given in the following steps:

1. Observation
   With this observation technique, data collection is carried out by directly reviewing the research site to obtain the information needed for research needs.
2. InterviewTo get good data, interviews were conducted by researchers with related parties.

Research Flow Diagram

Figure 1 explains that this research started from a literature study where the researcher collected reference sources from journals. After collecting reference sources, the next stage is data collection. The data obtained is transformer data. After data collection, the next stage is results and discussion. In which the researcher analyzes the transformer data and then makes a discussion. After analyzing the data and making a discussion, the next stage is for the researcher to make conclusions from the results of the analysis on the transformer.

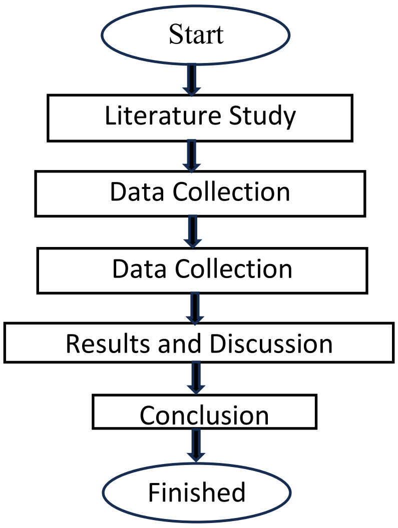

Figure 1. Research Flow Diagram

Results

Electrical Power Analysis Results

The electrical power measured in this study is active power, reactive power and power factor in each phase (R, S and T) with morning (09.00 – 10.00 WIB) and afternoon (14.00-15.00 WIB).

Active Power Analysis Results

The active power measurement in this study was used to see how

much power was used in the main panel of transformer A and transformer B, the following is a table of active power data obtained during the research:

Tabel 1. Average Active Power on Transformer Master Panel A

No	Phasa	Active Power (kW)	
		Morning	Afternoon
1	R	22,71	22,902
2	S	21,131	24,902
3	T	18,89	21,611

The electrical power in Table 1 above is the average active power used per day in the main panel of transformer A for 2 weeks in the morning and evening, while the data is per day. The average active power above is used as a comparison of whether the power used exceeds the source power provided by PLN. In general, the active power in the three phases increased in the afternoon because the peak load was in the afternoon, the largest active power consumption was found in the S phase in the afternoon reaching 24.902 kW and the lowest active power consumption was found in the T phase in the morning, which was 28.89 kW. It can be seen in the morning in phase R, the average power used is 22.71 kW which is the highest active power consumption in the morning, followed by the T phase of 21.131 kW and the lowest active power of all time, namely in the T phase with a consumption of 18.89 kW. In the afternoon the average power usage increases and becomes the peak load at this time, this is due to the large number of factory employees in PAMIN during the day and almost all rooms are used at that time. The average power used in phase R is worth 22,902 kW, phase S is around 24,902 kW and is the highest active power of all time and in phase T reaches 21,611 kW. Because the peak load is in the afternoon and this is used as a reference to compare with the source provided by PLN, the total active power used at the peak load is 69,415 kW. To convert active power to pseudo-power, you can use equation 1, namely:

1 kVA = 1000 W x Cos ϑ
1 kVA = 1000 W x 0.8
1 kVA = 800 W (0.8 kW)
0.8 KW = 1 kVA
1 kW = 1.25 kVA
69.415 x 1.25 = 86.768 kVA

So, the use of active power with a value of 69,415 kW is equivalent to 86,768 kVA, when compared to the source provided by PLN, then the use of active power in PAMIN does not exceed the source provided, where the source provided by PLN is 200 kVA.

Tabel 2. Average Active Power on Transformer Master Panel B

No	Phasa	Active Power (kW)	
		Morning	Sore
1	R	1,0072	0,5164
2	S	1,337	0,912
3	T	0,687	0,565

The electrical power in Table 2 above is the average active power used per day in the main panel of transformer B for 2 weeks in the morning and evening, while the data per day. The average active power above is used as a comparison of whether the power used exceeds the source power provided by PLN. In general, the active power consumption in the three phases decreased in the afternoon, the largest active power consumption was found in the S phase in the morning reaching 1.337 kW and the lowest active power consumption was found in the R phase in the afternoon which was 0.5164 Kw. It can be seen in the morning in the R phase, the average power used was 1.0072 kW. phase S with a value of 1.337 kW where in this phase is the highest active power of all time, phase T is 0.687 kW. In theafternoon, the average power usage decreases, this is due to the decrease in employees at the PAMIN factory in the afternoon. The average power used in phase R is 0.5164 kW, phase S is 0.912 kW and in phase T reaches 0.565 kW which is the lowest average active power of all time. Because the peak load is in the morning and this is used as a reference to compare with the source provided by PLN, the amount of active power used at the peak load is 3.0312 kW or through calculations such as the main panel of transformer A above, 3.789 kVA is obtained, when compared to the source provided by PLN, the use of active power in transformer B in PAMIN is very little used considering that in this transformer the power is only used for office space and toilets, while the source provided by PLN is 100 kVA.

Reactive Power Analysis Results

Reactive power measurement is also needed in this study, where reactive power is measured in 2 different times, namely morning and evening for 2 weeks, following the average reactive power during the research process:

Tabel 3. Average Reactive Power on Transformer Master Panel A

No	Phasa	Reactive Power (kVARH)	
		Morning	Sore
1	R	1,6193	1,6183
2	S	1,5715	1,654
3	T	2,0045	2,028

The reactive power data in Table 3 above is the measured average power contained in each phase on the main panel of transformer A, this reactive power is the power used for the generation of magnetic fields in some electronic equipment, while for reactive power data. In general, it can be seen that the greatest use of reactive power is found in the afternoon in the T phase, while the lowest is found in the S phase in the morning. It can be seen that the use of reactive power in the morning in phase R reaches 1.6193 kVAR, in phase S reaches 1.5715 kVAR and in phase T reaches 2.0045 kVAR where in phase T is the highest use of reactive power in the morning. Then in the afternoon the R phase consumed a reactive power of 1.6183 kVAR, there was a slight decrease in the use of reactive power of 1.654 kVAR in the S phase and in the T phase it increased again to 2.028 kVAR which in this phase became the highest reactive power of all time. For small consumers or households, the existence of this reactive power is not too much of a problem because PLN does not take into account in determining electricity bills. PLN requires that the power factor must be more than 0.85. If the value of the power factors is less, the reactive power will be measured and calculated in determining the amount of the bill, because the large flow of reactive power causes the PLN's equipment to not work efficiently and cannot be used optimally. Therefore, to see whether the use of reactive power is normal or not, it can be seen from the value of the power factor on the main panel of transformer A, if the value of the power factor is still within safe limits or according to the standard, then the use of reactive power can be said to be normal, but if the value of the power factor is less than the set standard, then the use of reactive power is too large, can be seen on the main panel of transformer A, the value of the power factor is in accordance with the set standard which means that the reactive power consumption can be said to be normal.

Tabel 4. Average Reactive Power on Transformer Master Panel B

No	Phasa	Reactive Power (kVARH)	
		Morning	Sore
1	R	0,915	0,815
2	S	0,1779	0,3784
3	T	0,505	0,455

The reactive power data in Table 4 above is the average of the measured reactive power contained in each phase on the transformer master panel B, this reactive power is the power used for the generation of magnetic fields in some electronic equipment, while for reactive power data. In general, it can be seen that the greatest use of reactive power is found in the morning in the R phase, while the lowest is found in the S phase in the morning. It can be seen that the use of reactive power in the morning in phase R reaches 0.915 kVAR where in phase R is the highest reactive power use of all time, in phase S it drops back down to 0.1779 kVAR and in phase T reaches 0.505. In the afternoon, phase R consumed reactive power of 0.815 kVAR, then there was a slight decrease in the use of reactive power of 0.3784 kVAR in phase S and in phase T it increased again to 0.455 kVAR. For small consumers or households, the existence of this reactive power is not too much of a problem because PLN does not take into account in determining electricity bills. PLN requires that the power factor must be more than 0.85.

Load Analysis Results

In the load analysis in this study, the data taken is the average load flow data on each master panel which is measured and then processed using the load imbalance equation. The data displayed is the average current load in each master panel for 2 weeks in each phase, but for data per day. Here is the average current load over 2 weeks:

Tabel 5. . Average Current on Transformer Master Panel A

No	Phasa	Reactive Power (kVARH)	
		Morning	Sore
1	R	99,823	100,331
2	S	92,101	109,883
3	T	83,048	94,999

After the average load current on the transformer master panel A is collected as in Table 5 above, then the data will be processed with equation 2 to find the average current in each phase, for example the author will process the data in the morning:

$$I_{Average} = \frac{IR+IS+IT}{3}$$

$$= \frac{99,823+92,101+83,048}{3}$$

$$= 91,657 \text{ A}$$

$$a = \frac{IR}{I\ average}$$

$$= \frac{99,823}{91,657}$$

$$= 1,08$$

$$b = \frac{IS}{I\ average}$$

$$= \frac{92,101}{91,657}$$

$$= 1,004$$

$$c = \frac{IT}{I\ average}$$

$$= \frac{83,048}{91,657}$$

$$= 0,906$$

Discussion

The electrical power quality in the main panel of transformer A has poor conditions, where there are several problems that occur and do not meet the standards set by several national and international electrical installation regulations (SPLN, PUIL 2011, IEEE and IEC). The quality of electrical power in the main panel of transformer B has a poor condition, where there are several problems that occur and do not meet the standards set by several national and international electrical installation regulations (SPLN, PUIL 2011, IEEE and IEC). 2. The low power factor value in the R and T phases is with a value of 0.74, where the value is far from the standard set by PLN, the standard set by PLN is in the value range of 0.85–1. The cause of low power factor values is the use of large reactive power or the use of inductive loads.

Conclusion

The measurement of the amount of electrical power quality at the PAMIN factory was carried out for 2 weeks during working hours with 2 times, namely morning (09.00 – 10.00 WIB) and afternoon (14.00 – 15.00 WIB) The measuring tool used in data collection is the Power Clamp Meter with the brand Lutron PC 6011SD. The results of the active power analysis were obtained at 86,768 kVA. The results of the load analysis were obtained as I average = 91.657 A, IR = 1.08, IS = 1.004, IT = 0.906.

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