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Power Losses and Power Factor Improvement of Factory Electrical Network Power Plants using Bank Capacitors

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Abstract**: *This paper presents power losses and power factor improvement of factory electrical network power plants using bank capacitors. In its operation, the electrical system always experiences losses and decreases in power factor. This condition is caused if the electrical loads are electric motors. A load of electric motors is inductive, which has a low power factor. This condition is often experienced in factories. Therefore in this study, capacitor banks are applied to reduce power losses and increase power factors. The results showed that the installation of capacitor banks with the right capacity was able to reduce losses and significantly increase the power factor of the system.***

Keywords : Power losses, power factor, factory electrical network, bank capacitor.

I. INTRODUCTION

As a developing country, the Indonesian people should carry out development in all fields [1]-[5]. One of them is development in the economic sector, which is being activated by the government to achieve national economic independence [6]-[9]. To achieve this goal, the government focuses on development in the industrial sector [10]-[13].

The development of industry in Indonesia, especially the electricity and oil and gas industries, has increased from year to year. This development is also supported by Indonesia's vast and varied natural resources. The role of industry is critical in realizing the optimal use of alternative natural resource energy [14]. Therefore, various kinds of production processes in the industrial area continue to develop [15]-[18].

Progress in the industry has a significant role in national development in all fields in order to improve the welfare of the community [19]. Progress in the industrial sector can also meet energy needs at home and abroad, strengthen the national economy, improve competitiveness, and improve the quality of human resources [20]-[24].

The most significant energy consumption in the world comes from petroleum.

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Petroleum can be the most consumed energy because it can provide enormous energy value. However, given the limited availability and economic value it has, various technologies and exploration and processing of petroleum continue to be developed [25]-[28]. As one of the oil-producing countries, experts are needed to empower this energy source appropriately because natural wealth is the necessary capital of the country's development towards the advancement and prosperity of the people of Indonesia [29]-[33].

PT Pertamina, as one of the leading SOEs in Indonesia, which is engaged in the oil and gas industry, of course, requires some experts to improve the quality and quantity of production.

PT Pertamina RU V Balikpapan, East Kalimantan, Indonesia, is one of six processing units owned by PT Pertamina with a processing capacity of 260 MBSD. To achieve the planned goals, PT Pertamina RU V Balikpapan requires facilities that can guarantee the quality and results that are following the desired quality and still maintain the continuity of the process of its activities.To operate industrial machinery at the refinery, the company cannot be separated from the need for electricity. PT Pertamina RU V Balikpapan has its power plant because the company's need for electricity does not depend on PLN. Electricity is supplied from a unit called the Power Plant. Power Plant 1 consists of 5 generators, and Power Plant II consists of 4 generators and 2 Diesel.

In the process of distributing electricity from the power plant to the load can not be separated from the risk of disruption. Therefore PT Pertamina RU V Balikpapan applies a double feeder system on each substation in order to increase the reliability of the electrical distribution system and can minimize the occurrence of disruptions in the motor work system and other electrical equipment. Therefore the writer wants to analyze the electricity distribution system by applying the double feeder system on a substation in PT Pertamina RU V Balikpapan.

This study aims to determine the level of reliability and application of the double feeder system in substation 80 on the power plant one distribution line towards the GM-201-01A motor load through substation 80 at PT Pertamina RU V Balikpapan. Another objective is to analyze the protection unit at the Motor Control Center GM-201-01A.

II. METHODOLOGY

The steps of this research are described as follows.

1. Preliminary Study

The preliminary study is the initial stage in the writing methodology. At this stage, a field study was carried out by observing directly the state of PT Pertamina RU V Balikpapan. Direct observation is carried out to know initial information about the environment and the industry situation.

The location chosen as the basis for research planning was carried out at PT. Pertamina RU V Jl. Yos Sudarso, Balikpapan, East Kalimantan, Indonesia.

2. Problem Identification and Formulation

After conducting a preliminary study, problems in the industrial area can be identified. Then the causes of the problem can be traced. In tracing the root cause of the problem, it is done through direct observation in the field, analyzing, ETAP simulation and interviewing the supervisors of the electrical industry.

In this study, the issue raised was the topic of the study of the reliability of the electric distribution system of the GM-201-01A motor as a crude booster pump at PT Pertamina Refinery Unit V Balikpapan. Therefore, in this research will analyze and understand the reliability of the electrical distribution system on the GM-201-01A motor that is distributed through two incoming feeders, namely incoming feeder A and incoming feeder B. The incoming feeder A is centered on power plant 1, and incoming feeder B centers on power plant 2. Here, the GM-201-01A motor electric distribution system work method will be presented with the application of a primary selective distribution pattern in minimizing the occurrence of disturbance in the GM-201-01A motor.

3. Literature Study

A literature study is conducted to find information about theories, methods, and concepts that are relevant to the problem. So with this information can be used as a reference in solving problems. Literature study conducted by searching for information and references in the form of textbooks, information from the internet, or other sources.

4. Data Collection

This data collection is done by direct observation in the industrial area, interviews with supervisors related to electrical and mechanical industry, and collecting data about motor data and protection relay data, and taking data from the power plant distribution diagram and the data generator at the power plant.

5. Data Processing

After the data is collected, the next step is data processing. Existing data are selected and sorted according to needs in the field. In data processing, determine the distribution path of power plant one towards substation 80 and GM-201-01A motorcycles as the topic of discussion and determine the theme of the research.

6. Data analysis

From the simulation, we will get a result that will be analyzed later. The data to be analyzed are data from the GM-201-01A motor power distribution system on substation 80 that uses a double incoming feeder system where the incoming feeder A is the regular power supply, and the incoming feeder B is the alternative power supply. The analysis obtained will be simulated using the ETAP application.

III. RESULTS AND DISCUSSION

A. Electrical Installation Data

Data collection was carried out at PT Pertamina RU V Balikpapan for two months starting on November 1, 2016, to December 30, 2016.

Data collection was carried out to determine the level of reliability of the power distribution system at power plant 1 to the GM-201-01A motor through substation 80 with the application of the double feeder system in overcoming disruption to electricity distribution.

Data collection was taken from maintenance area 1, and the data was taken in the direction according to the theme that is on the distribution path of power plant one towards substation 80.

This discussion will discuss distribution lines in Power Plant 1 to Substation 80. Power Plant 1 has five turbine generators, namely 5 L turbine generator, three turbine generator, turbine generator 6, turbine five insurance generator, and turbine generator 4. Each turbine generator is divided into three sections, while the distribution of 5L turbine generator and 3 turbine generator is combined into one section, namely section with 1 HT feeder.

Turbine generator 6 and generator 5 turbine are combined in one section with 3 HT feeders, while turbine generator 4 resides on 2 HT feeders. The power generated is a process of a Steam Power Plant owned by PT. PERTAMINA RU V Balikpapan. The energy used is steam, which first goes through the process. Steam is used to rotate turbines associated with motor generators so that motor-generators will produce electricity so that it can be used for existing loads such as 3-phase motors, water pumps, and several other electrical devices.

The total power generated at the Power Plant 1 generator is 9.6 MW, 6.6KV, 50 Hz, 0.8 pf. The power is to supply electricity to the Pertamina RU V refinery and is assisted with a small amount of power from Power Plant 2. On substation 80, it gets electricity from two incoming feeders, namely from the 1HT and 2HT busbars, where the 1HT busbar as normal conditions and 2HT as incoming backup in case of disturbance or rejuvenation at incoming from the 1HT busbar whereas the codee 5 turbine generator is currently stopped operating. In the three busbar sections in power plant 1, namely 1HT, 2HT and 3HT have 3 windings transformer (Three Windings Transformer) that serves as a protector in case of a short circuit (Over Load) caused by currents flowing from the Power Plant and as a link between Power Plant 1 and Power Plant 2. As we know, the busbar itself has a function as a conductor of copper-based electricity, where each busbar will provide a conductive network as well as a branch to connect each substation.

B. Analysis of Distribution Paths from Power Plant to Substation 80 (GM-201-01A)

The substation is a place to flow electricity from a power station to the grid or network.

Power flowing from Power Plant 1 to the substation will be received by the Circuit Breaker with a voltage of 6.6 kV or can be called an incoming feeder, which will then proceed to the busbar, the type of cable used from Power Plant 1 to the 80 substations is N2XSEKFGBY.

Substation 80 has two busbars. At the bus bar, the power is flowing at 6.6 kV. Then the power flows to the circuit breaker, and then the electric power will flow to the circuit breaker, which is distributed to the motor control center to be supplied to the load. Busbar is divided into two sections; that is because if there is interference in section 1, section 2 can help as a back-up; otherwise, it is the same or can be called an auto coupler.

The distribution system is divided based on rated voltage. Identification voltage distribution can be divided into 2, namely the primary voltage network system (medium voltage) and the secondary distribution system (low voltage)

1. Primary Voltage Network

The primary distribution system is used to channel electric power from power plant 1 distribution to substation 80 through medium cable ground media with medium voltage N2XSEKFGbY 3x (25-300) mm2 6/10 KV.

2. Secondary Voltage Networks Secondary Voltage Networks

The Secondary Voltage Network is used to channel electricity from power plant I to the GM-201-01A motor load.

One of the system patterns used is the primary selective pattern. This network of each transformer unit is served by two primary units to get healthy and alternative supply services.

The advantages of the primary selective system

• Reliability is further enhanced, especially on the first side, although service interruptions still occur.

• During maintenance, the system is not disrupted

For substation 80 gets supply from the 1HT busbar section with an alternative supply from the 2HT busbar section. On the system on substation 80, there are two incoming feeders, namely feeder A and feeder B. so that they can back up the feeder side that is experiencing interference. The support system uses a coupler.

One of the reliability of the primary selective distribution network at PT Pertamina RU V Balikpapan is to use the system coupler. Coupler itself is divided into manual coupler and auto coupler. The advantage of the auto coupler is the reliability of the distribution network. If an interruption occurs in one of the busbars, then with the Undervoltage relay setting that has been determined, the load on the interrupted flow can be backed up by other feeders with an auto coupler system without experiencing operational interruptions. The auto coupler is a circuit breaker (relay) connecting between incoming feeder A and incoming feeder B. If there is a troubleshoot on incoming feeder A, the incoming feeder B will back up the distribution line on incoming feeder A, by connecting the auto coupler that has been functioning automatically.

In this distribution line, the GM-201-01A motor on busbar A which functions as a Crude Booster Pump, receives the voltage from the incoming feeder. The voltage received is 6.6 kV, 3 phase, 50 Hz, 1000 A. Before and after being received at the incoming feeder, it first passes through the KCEG 142 relay to signal the circuit breaker if an overload or overload occurs. Among circuit breakers having differential relays working based on measurement of differences in current parameters, the working principle of this relay is to calculate the ratio of balanced current and balanced voltage schemes. The load is located on the CDU (Crude Distillation Unit) Plant. The type of cable used for distribution from the motor control center to the load is the Underground cable type N2XSEKFGbY (6 / 6KV, 3x240 cm). Figure 1 shows the electrical power plant 1 distribution path diagram towards substation 80 in ETAP software.

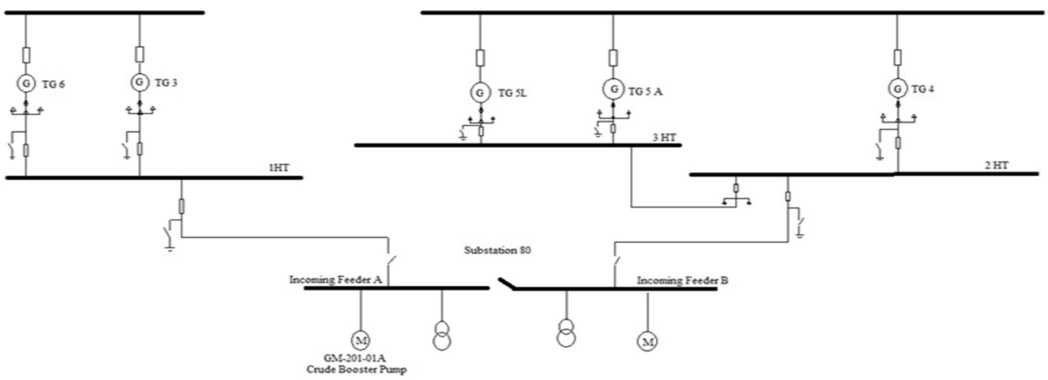

Figure 1. Power plant 1 distribution path diagram towards substation 80

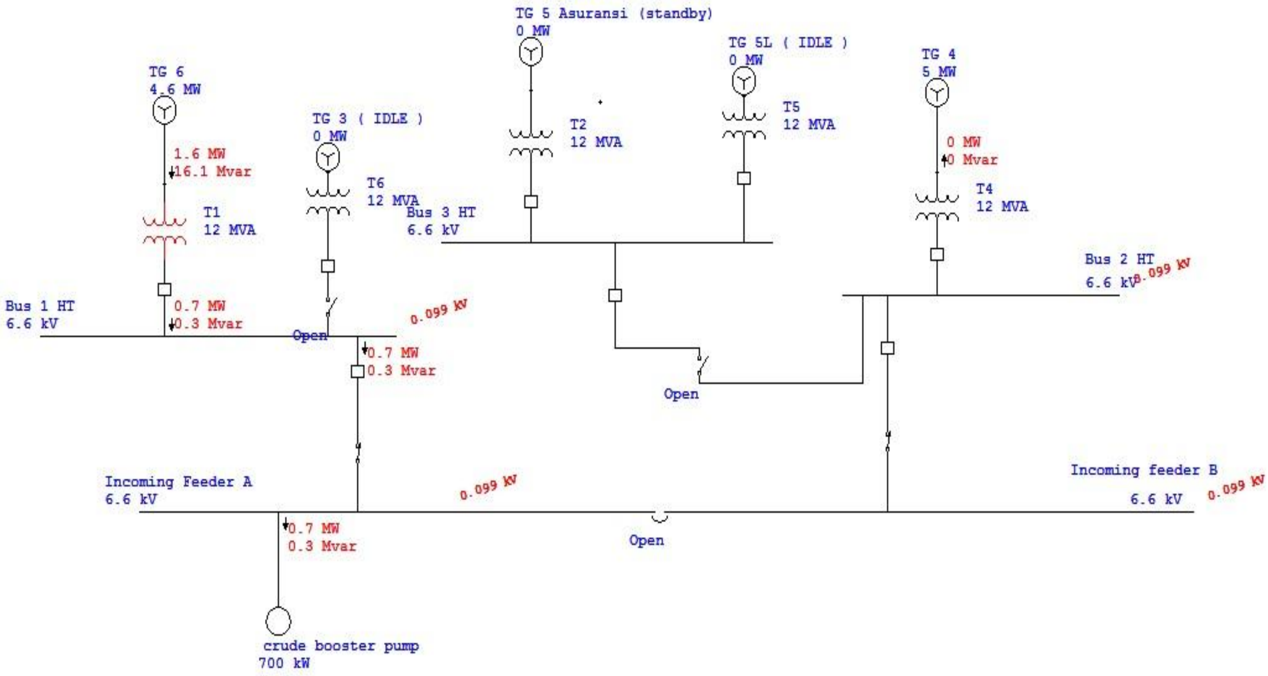

Figure 2. Simulation of the normal power supply condition from the incoming feeder A

LOAD FLOW REPORT

Bus		Voltage		Generation		Load		Load Flow					XFMR
ID	kV	% Mag.	Ang.	MW	Mvar	MW	Mvar	ID	MW	Mvar	Amp	% PF	% Tap
Bus1	6.600	1.500	-61.8	0	0	0	0	Bus4	-0.748	-0.311	4725.7	92.3	
								Bus7	0.748	0.311	4725.7	92.3	
Bus3	6.600	1.500	0.0	0	0	0	0	Bus6	0.000	0.000	0.0	0.0	
								Bus8	0.000	0.000	0.0	0.0	
*Bus4	6.600	29.942	0.0	1.597	16.096	0	0	Bus1	1.597	16.096	4725.7	9.9	
*Bus6	6.600	1.500	0.0	0	0	0	0	Bus3	0.000	0.000	0.0	0.0	
Bus7	6.600	1.500	-61.8	0	0	0.748	0.311	Bus1	-0.748	-0.311	4725.7	92.3	
Bus8	6.600	1.500	0.0	0	0	0	0	Bus3	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

SUMMARY OF TOTAL GENERATION, LOADING & DEMAND

	MW	Mvar	MVA	% PF
Source (Swing Buses):	1.028	8.997	9.056	-78.23 PF Leading
Source (Non-Swing Buses):	0.000	0.000	0.000	
Total Demand:	0.557	0.233	0.604	91.34 PF Lagging
Total Line Charging:	0.000	0.000		
Apparent Losses:	0.471	8.764		
System Mismatch:	0.000	0.000		

Number of Iterations: 15

Figure 3. Results report of simulation of the normal power supply condition from the incoming feeder A in ETAP software

Figure 2 shows the simulation of the normal power supply condition from the incoming feeder A, while Figure 3 shows the results report of simulation of the normal power supply condition from the incoming feeder A in ETAP software.

Under normal conditions, the GM-201-01A motor gets power supply from the incoming feeder A which is connected via the main bus ¬1 HT. on the main bus 1 HT, there are two generators, namely generator 6 and generator 3. In the actual field conditions, generator 3 is no longer operational. So the incoming feeder A is currently only supplied from generator 6 with 4.6 MW of power. In the implementation of the double feeder system, when there is a disruption in Incoming Feeder A, the power supply will be transferred to the Incoming feeder B.

Transfer of power supply from incoming feeder A to incoming feeder B is carried out. There is an interruption or maintenance period on incoming feeder A. Transfer of power from incoming feeder A to incoming feeder B uses an Undervoltage relay. When the incoming feeder A experiences a voltage drop, the coupler will automatically be connected to bus feeder A before the total shutdown condition.

From the simulation data of the two incoming feeder conditions, it can be seen that the input data of the incoming feeder power is the same. So the use of the double feeder system is reliable enough to overcome the disturbance conditions on the electric power supply to the GM-201-01A motor. Figure 4 shows the Control Systems on GM-201-01A Electric Motors.

Figure 4. Control Systems on GM-201-01A Electric Motors

In the 6.6 kV control motor operation with the type of Siemens AG motor can be analyzed as follows, the incoming current will be flowed to the fuse then the voltage will be reduced to 220 volts through a two winding transformer transformer after it passes through the relay (to trigger the contactor to work. Before the voltage Enter the contactor, the voltage will pass through a rotary switch where the switch functions as a switch to activate the voltage on the AC output.If the switch is not connected then the voltage from the AC source cannot flow.The switch consists of off, neutral and on.Thereafter, the switch the connected one will supply the output for the AC voltage, while for the DC output the voltage is supplied from the potential transformer, before becoming a DC voltage, the AC voltage will pass through the fuse and the rotary switch which then passes through the limited switch which functions as a synchronizer so that the voltage can flow. will pass rectifier to be changed first to DC current. After that, the DC current will be used as a voltage supply to the DC control, where the DC voltage used to activate the contactor is in the DC voltage circuit. Then in AC, the voltage will be flowed to the relay and flowed to the limited switch. After the limited switch is connected, the voltage will pass through the relay and go to the limited switch. After the limited switch is pressed, the voltage will pass through the rotary switch, which will be distributed to the contacts.

IV. CONCLUSIONS

This paper presents power losses and power factor improvement of factory electrical network power plants using bank capacitors. In its operation, the electrical system always experiences losses and decreases in power factor. This condition is caused if the electrical loads are electric motors. A load of electric motors is inductive, which has a low power factor. This condition is often experienced in factories. Therefore in this study, capacitor banks are applied to reduce power losses and increase power factors. The results showed that the installation of capacitor banks with the right capacity was able to reduce losses and significantly increase the power factor of the system.

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