International Research Journal of Advanced Engineering and Science
ISSN (Online): 2455-9024

Optimization of Stepping Capacitor Bank Rotary Method as a Power Factor Improvement of 3 Phase Based Load Micro PFR60-415

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Abstract— *Inductive load with low power factor causes the load current to get bigger so that it needs to improve the power factor. The use of inductive loads such as induction motors and transformers can cause overuse of reactive power, and has an impact on increasing PLN fines that must be paid if the power factor < 0.85. Repair of the power factor in inductive load can be done by installing the capacitor according to the required value with a 3-phase load target. Power factor repair uses the Micro PFR60-415 power factor regulator tool as a stepping regulator for each bank capacitor installed. The use of micro PFR60-415 power factors is expected to make maximum power factor improvements and in accordance with the desired improvement targets. The results achieved in this study are Optimization of Stepping Capacitor Bank Rotary Method as An Improvement of Micro-Based 3 Phase Load Power Factor PFR60-415. Where automation itself is used for bank capacitor assembly activities and operated by Micro PFR by rotary method or sequentially automatically to find the best cosphi value of each compensation stepping repair power factor at a 3-phase load. With the application of this research, it is expected that the value of KVARh can be minimized. In the implementation and testing of the tool has worked well to correct the power factor above the minimum limit of the specified cosphi set, which is > 0.85, so that the power factor improvement is successful.*

Keywords— *Power factor, Reactive Power, Rotary Method, Stepping Capacitor.*

I. INTRODUCTION

The problem that often occurs in industry is the installation of large electrical power but not in accordance with the amount of power used when the industry is running [1]. This happens because of the emergence of 3-phase electrical reactive power which causes the power factor to be damaged and bad [2], [3]. Reactive power is the power generated from various electrical equipment that produces magnetic induction and produces harmonic power [4], [5]. Reactive power is also known as power loss or power loss. Increased kVar or reactive power causes electricity bills or costs to swell and be expensive. One of the efforts made to overcome this problem is the installation of a device, namely a capacitor bank. The main function of a capacitor bank is to balance the inductive charge. While the electrical equipment that is often used usually has inductive characteristics, so to balance the characteristics of the load, a capacitor bank is installed which acts as a capacitive load. The operation of the capacitor bank is to use stepping or steps automatically to find the best cosphi value in each installed capacitor. Cosphi limit > 0.85 - 1 is the sought power factor and if < 0.85 then there are still voltage losses and will cause swelling of electricity bills if not repaired immediately.

In this case the rotary method is used to activate the stepping capacitor bank to suit the load requirements and the use of capacitors can be effective and efficient [6]. The rotary method is to find the cosphi value on the capacitor sequentially automatically at each step or step. Rotary stepping programming using a tool that is a power factor regulator Micro PFR60-415.

II. METHOD

A. Mikro PFR60-415

To assemble a power factor improvement tool using a capacitor bank, you definitely need a tool called Power Factor (PF) controllers. As the name suggests, this tool is useful to set the PF state in the network to match the PF that desired.

The number of steps in the PF Controller varies from 4 steps, 6 steps, 8 steps, 12 steps and 14 steps depending on the manufacturer. On The design of this tool uses the Micro Power Factor type PFR60-415 with 6 steps for activating the capacitor bank.

Fig. 1. Mikro PFR60-415

B. Non-Polar Capacitor

In improving the power factor for a 3-phase load that is covering small industries, it is enough to use a capacitor bank non-polar capacitor. This bank capacitor is a collection of several capacitors connected in series or parallel one each other to store electrical energy. Storage that generated is then used to neutralize or fix power factor and increase the number of total stored energy.

Here are the steps in setting or making non-polar capacitors 3 phase capacitor bank:

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1. Prepare a non-polar capacitor with a size that has been specified for example 50uF with a voltage specification of 400-450 VAC. The combined delta circuit must be of one size and voltage.
2. Combining the three capacitors with size and the voltage is the same in delta/series on one side of the pole, so that from 6 pole terminals to 3 phase cable outputs towards the trainers.
3. After the capacitor has been installed, to get rid of the remnants the voltage on the capacitor needs to be installed chalk resistor with a size of 15Watt 15kΩ connected in series to each pole of the capacitor.
4. After all circuits and components of the capacitor bank installed, then just connect the circuit to the contactor.

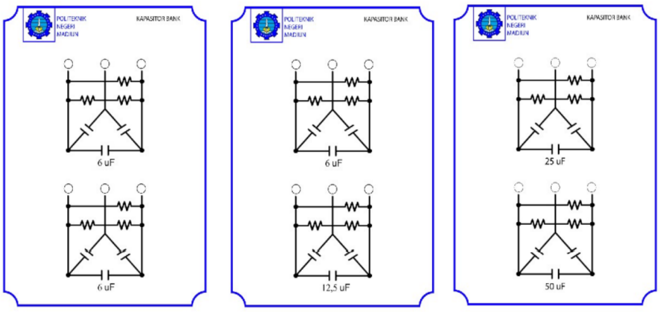

Fig. 2. Non-polar Capacitor

Research Scheme

This testing stage is based on the research scheme in Figure 3. The source of electrical energy from this study is from the PLN electricity source. Research scheme diagram of this tool as follows:

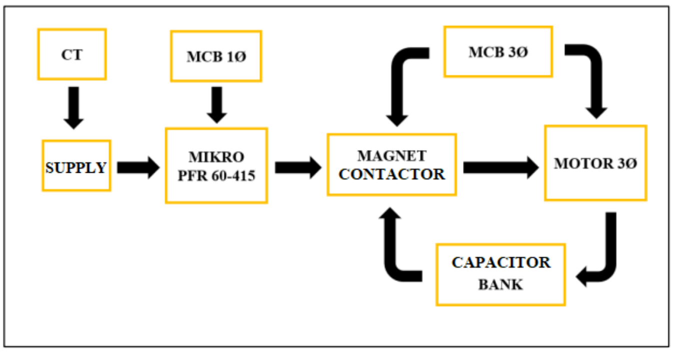

Fig. 3. Research Scheme

The explanation of the work diagram above is as follows:

1. PLN 220 V, used as a source of power factor tools Micro PFR60-415 and control circuit as well as power on capacitor bank.
2. CT, Current Transformer is used as current meter which enters the capacitor bank device circuit.
3. 1 Phase MCB is used as an automatic safety on control circuit and especially the incoming current on Power Regulatory Factors.
4. 3-Phase MCB is used as the same automatic safety like a single phase MCB. But for this 3 phase MCB is used protection for power circuits and induction motors.
5. Magnetic Contactor (MC) is used as an automatic switch which works on the basis of electromagnetic induction. Besides that, on the contactor there are also NO and NC switch components and there is a copper coil. When the coil copper (coil) is given alternating electric current then the switch it will connect or change its state automatically automatic.
6. Bank Capacitor, used as load balanced inductive because the capacitor is capacitive so the load balanced or aligned (resistive).
7. Power Factor is used to keep the PF condition at network to match the desired PF. On tool at least the PF measurement results will be displayed network, entered step. PF also set stepping capacitor according to the installed load.
8. 3-Phase Induction Motor as power factor improvement target 3 phase load.
9. Indicator light is used to make it easier for users know which steps are working.

III. Results and Analysis

Inductive Load Measurement

Measurement target uses four 3-phase induction motors, each 1 HP two motors and 2 HP two motors, namely with no compensation load or no load. Measurements are made on site Electrical Engineering Laboratory or workshop of Campus 1 the State Polytechnic of Madiun.

After measuring the inductive load using a power analyzer, we get some good results later will be used as a reference to determine the size capacitor capacity for 3 phase load power factor improvement. The results of the Power Factor (PF) are Cosphi motors that appears on the power analyzer. The measurement results there are 16 variations 3 phase no load motors and 4 variations of full load 3 phase motors containing initial cosphi and currents that appear as follows:

TABLE 1. Initial Measurement of Full Load Electric Motor

Load	Cosphi Value	Current (A)
Motor 1 (1 HP)	0,851	3,0
Motor 2 (1 HP)	0,854	3,3
Motor 3 (2 HP)	0,865	3,7
Motor 4 (2 HP)	0,862	3,7

TABLE 2. Initial Measurement Results No-load electric motor

No	Motor 1	Motor 2	Motor 3	Motor 4	Cosphi	Current (A)
1	ON	OFF	OFF	OFF	0,12	1,5
2	OFF	ON	OFF	OFF	0,16	1,5
3	OFF	OFF	ON	OFF	0,23	1,4
4	OFF	OFF	OFF	ON	0,12	3,3

Bank Capacitor Capacity Calculation

After measuring the inductive load on the motor, 3 phase induction and cosphi power factor (PF) has been found, the next step is to calculate the capacity capacitor bank (QC).

This method requires data from PLN receipts for one month period (eg 1 year). Then the calculation data is taken from paying the highest kvarh fine. Other data that required is the amount of usage time.

$$Qc = \cos\varphi \text{ begin} - \cos\varphi \text{ end} \times P$$
$$= (\cos^{-1} \text{ begin} - \cos^{-1} \text{ end}) \times P$$
$$= (\tan \text{ begin} - \tan \text{ end}) \times P$$

TABLE 3. KVAR Results of Electric Motors without Load

No	Cos φ begin	ACos	TAN	Cos φ end	ACos	TAN	KVAR Result
1	0,12	1,451	8,273	0,95	0,318	0,329	0,965
2	0,16	1,410	6,169	0,95	0,318	0,329	0,946
3	0,23	1,339	4,231	0,95	0,318	0,329	0,848
4	0,12	1,451	8,273	0,95	0,318	0,329	2,123

TABLE 4. Test Results Rotary Stepping No Load

Motor (1 HP)	Motor (1 HP)	Motor (2 HP)	Motor (2 HP)	Cosphi begin	Cosphi end	working steps
ON	OFF	OFF	OFF	0,12	0,98	1
OFF	ON	OFF	OFF	0,16	0,96	1
OFF	OFF	ON	OFF	0,23	0,94	1 – 2
OFF	OFF	OFF	ON	0,12	0,96	1 – 2

IV. CONCLUSION

The conclusion of this research is:

1. Determination of the initial Cosphi value obtained through load measurement using Power Analyzer and final Cosphi via target calculation of power factor improvement using Micro PFR.
2. Determination of the size and number of stepping capacitors calculated using the boolean algebra formula that has been described in final project material, in order to obtain 6 steps of power factor improvement rotary method.
3. Precise and efficient repair for 3 motor power factor malfunction phase of no load or full load conditions, namely using a capacitor bank which is applied in the trainer capacitor bank. Trainer capacitor bank has been successfully designed and works according to power expectation factor with the rotary method.

ACKNOWLEDGMENT

The authors would like to thank the State Polytechnic of Madiun through excellent research in 2022 so that the authors get financial support in this research.

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