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A Fast De Couple Method As Power Flow Optimization In Cooking Oil Processing Factory Based Matlab

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Article Info	ABSTRACT
Keywords: Power losses, Fast de couple, Matlab 7.0	Power losses that occur in transmission lines result in various impacts that arise, including a decrease in voltage on the transmission line, low power factor that occurs. To reduce the occurrence of power losses that occur in transmission lines, capacitors are installed. In installing capacitors, attention must be paid to the channels that use them, the location of the capacitor and the size of the capacitor used. This is done so that the placement of the capacitor can be optimal in reducing the power losses that occur.This analysis is applied using the fast de-coupling method on a 20 kV power system.with applicationMatlab 7.0, after analysisknowntotal P loss – loss = 76,025 kW, and Q loss = 216,077 kVAR. After optimization by adding a capacitor to bus 2, it was found that the power losses were smaller, namely total P loss – loss = 46,438 kW and Q loss = 125,307 kVAR,
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INTRODUCTION

In the distribution of electrical energy there are several problems faced including voltage drops, low power factors and power losses. The load on the distribution network can be a capacitive or inductive load, but in general it is an inductive load. If the inductive reactive load is higher, it will result in increasing the voltage drop, increasing power losses, lowering the power factor and reducing the power distribution capacity. To reduce the inductive reactive power load, a capacitive reactive power source is needed, one of which is a capacitor installed in parallel on the radial primary distribution feeder conductor.

MThe is a method of capacitor placement used greatly affects the performance and stability of the electric power system that occurs. The placement of shunt capacitors carried out in parallel and the appropriate kVAR size will provide reactive power compensation, increase voltage regulation, improve power factor, and reduce power losses. The capacitors used include determining the location and size optimal capacitor that can minimize the annual cost of power losses and capacitor usage costs. In addition, operating limits and power quality can be maintained within predetermined limits.

The method of determining the use of capacitors itself is quite a lot of types, including Fuzzy Logic, Simulated Annealing (SA), Tabu search (TS) and Genetic Algorithm (GA). Each of these methods has several advantages and disadvantages. In this study, the

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determination of optimal conditions for capacitor placement in the electric power system was carried out with a case study in the electric power system using the fastde couple method.

Theoretical Review

Power Flow

Power flow study is a study conducted to obtain information on the power flow and voltage of an electric power system under steady-state operating conditions. Power flow study also provides information on the transmission line load in the system, the voltage at each location for evaluating the regulation of power system performance and aims to determine the amount of real power, reactive power at various points in the power system that are in progress or expected for normal operation. In the study of power flow, loads and obstacles such as impedance, resistance and inductance must be described. The components of an electric power system generally consist of:

a. Power plant centers, in this case what is depicted is the generator.
b. Power transformers.
c. Transmission channels.
d. Static current synchronous capacitors.
e. Safety devices (circuit breakers and relays).
f. Loads consisting of dynamic loads and static loads.

Flow Optimization

The OPF method can determine the optimal operating conditions of an electrical network that is experiencing operational constraints. Which factors will be sought for the optimal point, will be formulated and solved using the appropriate optimization algorithm, such as the Fast de couple method. Examples of limitations that must be considered in this OPF method are such as power plant settings and large loads. We can solve the OPF problem from the minimum operating cost of the generator and the balance of the power flow. In the OPF variables can be adjusted to the generator output (MW) where the more specific variables consist of:

1. Generator voltage
2. Transformer tapping position
3. Setting switched capacitor
4. Current (Load shedding)

In the operation of the power system in steady state is the dependence between real power with the phase angle of the bus voltage and between reactive power with the magnitude of the bus voltage. In this condition, a small change in the voltage magnitude will not cause a significant change in real power [1]. While a small change in the phase angle of the voltage will not cause a significant change in reactive power. This can be proven in the approaches taken to express the relationship between P and δ and between Q and V. By using the polar coordinate form, the solution to the problem is obtained by assuming the elements of the sub matrices J2 and J3 in the Jacobi matrix are zero [1-2].

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ΔP	=	J1	0	Δδ
ΔQ		0	J4	ΔV

ΔP = J1Δδ =—Δδ (1)

ΔQ = J4Δ|V| = ,∂𝑃-∂𝛿.Δ|V| (2)

In the above equation, it can be seen that in the formation of active power, the determining factor is the voltage angle, so changes in the voltage magnitude do not affect the active power. The opposite condition is used in the reactive power formation equation, namely small changes in the phase angle will not cause significant changes in reactive power. Jacobi matrix elements:

For J1 :

,𝐻-𝑖𝑗.=,∂𝑃𝑖-∂𝛿𝑗.=−,,𝑉-𝑖.,𝑉-𝑗.,𝑉-𝑖𝑗..,sin-,,𝛿-𝑗.−,𝛿-𝑖.+,𝜃- 𝑖𝑗...=−,,𝑉-𝑖.,𝑉-𝑗.,𝑉-𝑖𝑗..,sin-,,𝛿-𝑗.−,𝛿-𝑖.+,𝜃-𝑖𝑗... .,𝐵-𝑖𝑗. (3)

,𝐻-𝑖𝑗.=,∂𝑃𝑖-∂𝛿𝑗.=−,,𝑉-𝑖.,𝑉-𝑗.,𝑉-𝑖𝑗..𝑠𝑖𝑛,𝜃-𝑖𝑗.+,,𝑗=1- 𝑗=𝑖.-𝑛 -,,𝑉-𝑖.,𝑉-𝑗.,𝑉-𝑖𝑗..,,𝛿-𝑗.−,𝛿-𝑖.+,𝜃-𝑖𝑗... =−,,𝑉-𝑖.. .,𝐵-𝑖𝑗.−,𝑄-𝑖. (4)

Where

Bij = Yij sin θij

Bij = Yij sin θij

Q1 = ,,𝑗=1-𝑗=𝑖.-𝑛-,ViVjVij.. sin (δj – δi + θij)
(5)

It can be seen from the equation above

For J2 : N_{ij}= 0 ; Nii = 0

For J3 : j_{ij}= 0 ; jii = 0

For J4 :

Lij = ,∂𝑄1-∂|𝑉𝐽|. = - |ViVjVij| sin (δj – δi + θij)

= - |ViVjVij| sin (δj – δi) . Bij(2.34)

Lij = ,∂𝑄1-∂|𝑉𝐽|. = - |ViVjVij| sinθij +,,𝑗=1-𝑗=𝑖.-𝑛-,ViVjVij.. (δj – δi + θij)

= ,∂𝑄𝑖-∂|𝑉𝑖|. = |ViViYij|sin θij + Qi

=,∂𝑄𝑖-∂|𝑉𝑖|. = - |Vi2| . Bii + Q_i (6)

Where

Bij = Yij sin θij

Bii = Yii sin θii

Qi =,,𝑗=1-𝑗=𝑖.-𝑛-,ViVjVij..sin(δj – δi + θij)

It can be seen from the equation above, in matrix form, the Jacobi matrix element symbols are corrected to:

ΔP	=	H	0	Δθ
ΔQ		0	L	ΔV

Or in iteration format we can write,

ΔPk = Hk . Δδk+1 (7)

ΔQk = Lk .$ΔV^{k+1}$ (8)

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This fast de couple method has the same convergence as the Newton Raphson method, the advantage of this method is the use of smaller computer memory because it ignores the sub matrices N and J (or J2 and J3).

Power flow using Matlab

Load flow studies are used to determine voltage, current, active power or reactive power at various points/buses on the electrical network under normal operating conditions (Stevenson, 1993). In addition to being used for planning the development of electrical systems in the future, it can also be used to evaluate the condition of existing electrical systems. This is used because the operational feasibility of a system depends on the effects caused by interconnections with other power systems, the addition of new loads, new generating stations, and new transmission network connections before all of them are installed/connected to the existing system.

With the existence of a MATLAB program, it is expected that the work/calculation in analyzing a load flow will be easy, fast, accurate, economical and save time. The purpose of this program is to check the voltages of each bus in the electrical network system, check the capacity of each bus whether it is large enough to distribute the desired power (Hutauruk TS, 1983), In addition, to help how to analyze a load flow quickly and easily so that it can save time which means this also increases work efficiency. In this case, by creating a simulation program for load flow analysis. The results of this study are expected to be used as an alternative policy in meeting the demands of the times in the computerization era, namely by creating a computer program for load flow analysis so that conveniences and time savings are obtained.

Shunt Capacitor

This shunt capacitor is connected or installed in parallel to the network or directly to the load, with the aim of improving the power factor, as a voltage regulator or to reduce power losses and voltage drops in the network. The shunt capacitor supplies reactive power orcurrent to neutralize the interphase output components of the current required by the inductive load. The voltage drop on a short transmission line with a lagging power factor can be calculated as follows:

$$VD = RI_r + XI_x \quad (9)$$

Where :

VD: Voltage Drop
R :Resistance
X : Reactance
Ir : Power component of current
Ix : Reactive components

$$VD = R I_r + X I_X - X I_C \quad (10)$$

Where : Ic = reactive component of the leading current.

The difference between the voltage drop calculated based on equations (9) and (10) is the voltage increase when the capacitor is installed, which can be shown as follows:

$$VR = X I_C \quad (11)$$

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METHODOLOGY

In this thesis research, the research material is the creation of an application program with a programming language using Matlab to solve the problem of optimizing power flow and improving the voltage profile in a 20 kV electric power system in a cooking oil processing plant. In electric power, a cooking oil processing plant requires a lot of power, where in the plant (molding) making cooking oil containers (jerry cans) requires a power of around 513.2 kW / 220.4 kVAR, this is because in this plant there are many machines with high power. So it requires a lot of power. And for the cooking oil filling (packaging) plant, it requires a power of 227.2 kW / 90.4 kVAR. This is because the machines in this plant have less power than in the molding plant.

In the research conducted at the cooking oil processing factory, there is a method that is useful for compiling the steps taken during the research and how to complete the research so that the results of the research are obtained. Before using the fast de couple method as a solution to optimize the power flow of a 20 kV electric power system in a cooking oil processing plant using Matlab, there are several steps that must be taken, namely, analysis and simulation of the power flow in the electric power system in a cooking oil processing plant is carried out with a large installed load with the generator's capacity. The simulation is carried out using Matlab to obtain the power flow using the fast de couple method.

The data used in this study is 3 bus data, where the required data contains data from the cooking oil processing plant as the object of research, where the cooking oil processing plant uses a 3 bus electric power system, which has 1 generator and two plants as buses that use loads. The following is the electric power system data in the cooking oil processing plant.

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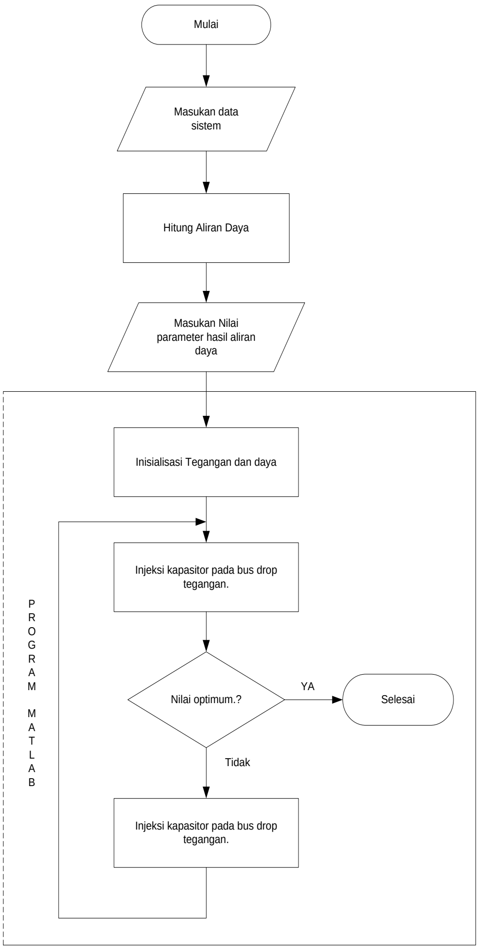

Figure 1. Research flow diagram

Table 1. Generation and load data for 3 bus system

BUS DATA Cooking oil processing plant						
NO BUS	LOAD		GENERATOR			
	kW	kVAR	kW	kVAR	Qmin	Qmax
1	0	0	0	0	0	0
2	513	220	40	0	-40	50
3	227	90.4	0	0	0	0

And to analyze the power flow of the electric power system in the cooking oil processing factory that will be used in this research, it can be seen in the image below.

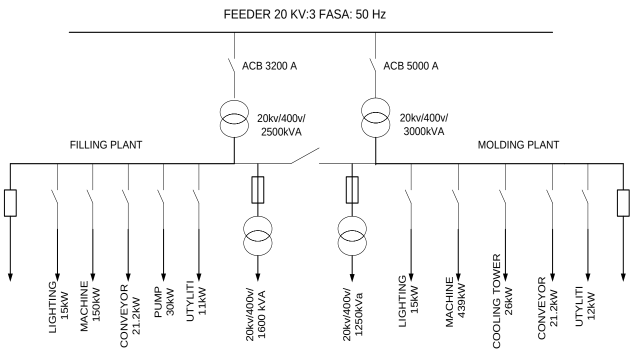

Figure 2. Electrical power system in a cooking oil processing plant

The image below shows a series of transmission system models in a cooking oil processing plant, where there are transformer generators, transmissions, and loads, where later the appropriate capacitors will be installed on the buses that experience a voltage drop. And will improve the voltage profile in the transmission system in the cooking oil processing plant.

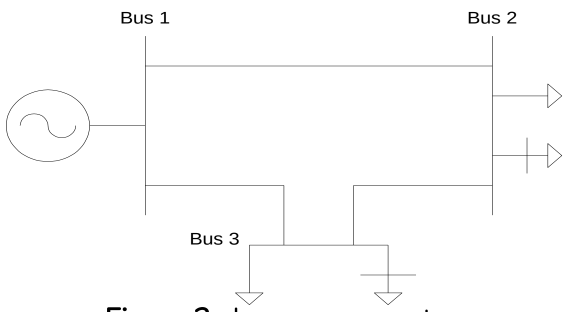

Figure 3. bus power system

In selecting a bus as a location for capacitor placement, many parameters can be used as considerations, for example power loss indices (PLI) or power loss index. In this simulation program, the bus can be determined independently but should refer to the power loss index. The selection of candidate buses depends on the objectives to be achieved. The value of the power loss index (PLI) can be formulated in the following mathematical equation:

$$PLI_{n} = \frac{X(n) - Y}{Z - Y} \quad (12)$$

Where

PLI = power loss index
X = reduction of active power losses
Y = minimum active power loss reduction
Z = maximum active power loss reduction
n = bus number

Before determining the value of the power loss index, it is necessary to first calculate the reduction in active power losses. The reduction in active power losses is obtained from the difference between the amount of active power losses in the initial condition and the amount of active power losses after reactive power compensation. The selection of bus candidates is done using the Matlab program. The method used is the fast de couple method using the Power toolbox in Matlab 7.8 (R2009a). Matlab here has voltage and PLI inputs, while the output is CSI (Capacitor suitability index). PLI has a range between 0 and 1, for the voltage used it has a range between 0.9 and 1.1 pu, while the output (CSI) has a range between 0 and 1.

RESULT

Voltage Drop

After conducting a simulation using the matlab program with the fast de couple method on the electric power system in the cooking oil processing plant, the interim results were obtained by entering data on the power system in the cooking oil processing plant, where bus 2 experienced a voltage drop, with a voltage of 0.803 pu. This proves that the voltage on bus 2 is not yet in accordance with the SPLN voltage V = + 5% to -10% of the nominal voltage. While for bus 1 (1.50) and bus 3 (0.963) are still said to be in a stable voltage according to the provisions of the SPLN voltage V = + 5% to -10% of the nominal voltage. The following is a table of interim results of the electric power system in the cooking oil processing plant using the Matlab program.

Table 3. Temporary results of the electric power system in the cooking oil processing plant

		Burden		Generator	
Bus	V (pu)	kW	kVAR	kW	kVAR
1	1,050	0.000	0.000	776,451	526,935
2	0.803	5.132	2.204	40,000	0.000
3	0.963	2.272	9,040	0.000	0.000
Total		7,404	3.108	816,451	526,935

The figure below shows the voltage profile of the electrical power system in the cooking oil processing plant. Where bus-2 experiences a voltage drop, the voltage profile will be improved by adding a suitable capacitor to bus 2.

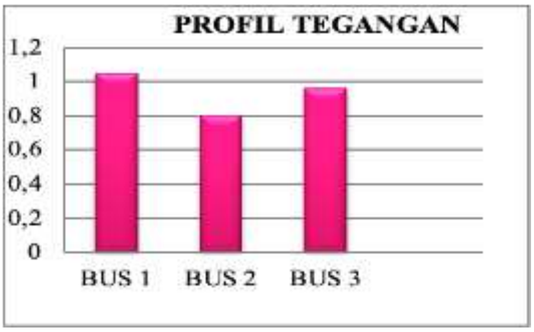

Figure 4. Voltage profile in cooking oil processing plant

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Based on the author's research conducted at the Cooking Oil Processing Plant, there are several data that the author has recorded. Then tested through computational methods using the Matlab program. The results of this study are the results of the Matlab program execution for the problem of power optimization in the Cooking Oil Processing Plant. The trial was carried out by entering parameters from data taken from the Cooking Oil Processing Plant so that the minimum value of power losses was obtained after the capacitor was installed on the bus that experienced a voltage drop. The analysis and programs that have been developed will be tested on the IEEE 3 bus 3 channel 20 kV network system in a cooking oil processing plant.

Flow Program.

The research results were obtained after the IEEE 3-bus, 3-channel 20 kV network system data was entered into the power flow solution program and then entered into the power optimization program using the MATLAB program with the specified iterations, then making changes to the parameters used.

To select the appropriate coefficient, changes are made to one of the parameters with the other parameters remaining constant. After obtaining the appropriate parameters for a particular coefficient, the value is considered the most appropriate. After that, it is also done for the other parameter coefficients using the selected parameters as the next reference.

Table 4. shows the research results in the form of the results of the influence of voltage changes and power losses after installing capacitors on bus 2.

No	Channel		P loss before Optimization		P Loss after optimization	
	From the Bus	To the Bus	(kW)	(kVAR)	(kW)	(kVAR)
1	1	2	55,152	160,555	32,250	91,026
2	1	3	11,830	33,115	8,921	24,735
3	2	3	7.247	19,191	3.913	8.264

The results of this test were obtained from the 8th iteration, where before the capacitor was installed on the bus that experienced a voltage drop, the power losses incurred were quite large (160,555kVAR), and after optimization by installing capacitors on buses that experience voltage drops, the reactive power losses are reduced to (91,026 kVAR). Meanwhile, the test results on the voltage magnitude per unit (pu) and the results of the voltage angle (degrees) before and after optimization are shown in table 5 below.

Table 5. Results of magnitude stress (pu) and angular stress before and after optimization.

No Bus	Before Optimization		After Optimization	
	Magnitude Voltage(pu)	Angular Stress(°)	Magnitude Voltage(pu)	Angular Stress(°)
1	1,050	0.000	1,050	0.000
2	0.803	-13.209	1.001	-13,644
3	0.963	-4.724	0.994	-4.943

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The results of this test are intended to obtain the optimal capacitor value to improve the voltage according to the specified limits. In this test, the voltage limits are adjusted to the PUIL 1987 standard, namely the tolerable voltage limit in the distribution system is 5% so that Vmin = 0.95 pu and Vmax = 1.05 pu.

From the results of the Power Flow analysis, it can be seen that the voltage conditions on bus 2 before optimization were still experiencing a voltage decrease of 0.803 pu, this proves that the voltage on bus 2 is not yet within the voltage limit that can be tolerated in the electric power distribution system, whereas after optimization was carried out by injecting a capacitor of 350 kVAR, the voltage change on bus 2 increased and changed to1.001pu and this voltage can be tolerated with the voltage limits in the electric power distribution system as stipulated in the 1987 PUIL standard.

And the results of the comparison of the results before and after this optimization are shown in Figure 4.1, where the figure below shows the comparison curve of changes in the voltage profile before and after optimization where the voltage conditions are still within the voltage limits, namely +5% to -10% of the nominal voltage of 1 pu in the power flow of the electric power system in the cooking oil processing plant.

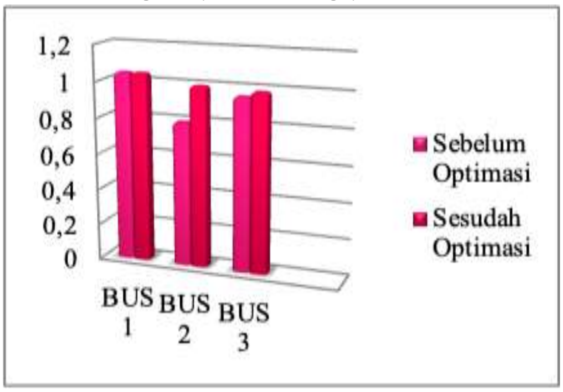

Figure 5. Comparison curve before and after optimization of power flow in a cooking oil processing plant.

Discussion of Research Results

The research results that have been presented above are not free from the discussion of the research results, this shows that the research results do not mean that they do not have a discussion or method used to obtain the research results. So the discussion of this research will explain the way to find a solution to the results of the power flow optimization analysis research in a cooking oil processing plant with the fast de couple method, using matlab.

Where from the data the input written in the program is in the form of generation and loading on the bus. And after all the input is run using the Fast de couple method in the Matlab program, the results of the voltage in pu, the results of the power flow, and the results of the voltage losses are obtained. After obtaining these results, the placement of the capacitor can be determined to optimize the voltage on the bus that is experiencing a voltage drop. The following are the results of installing the capacitor on bus 2 shown in Figure 6 below

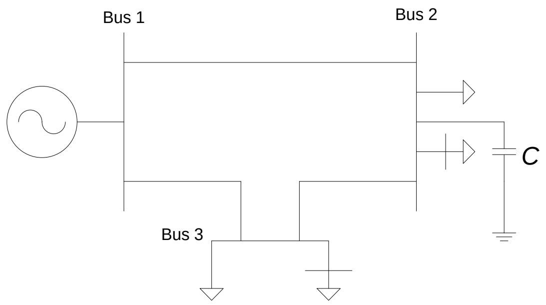

Figure 6. results of installing capacitors on bus 2.

Determining the size of the capacitor for optimization

In the cooking oil processing plant itself, the capacitor installed to optimize the voltage that has decreased is on bus 2, a capacitor of 350 Kvar is installed. The reason for choosing a capacitor with that nominal value is because of the need to improve the voltage on bus 2 and successfully reduce power losses flowing in the electric power system in the cooking oil processing plant. The following table shows the results of installing capacitors on bus 2.

Table 6. Results before installing the capacitor on bus 2

	Before Optimization		Total P Loss Before Optimization	
No Bus	Injection (kVAR)	Magnitude Voltage(pu)	kW	kVAR
1	0	1,050		
2	0	0.803	76,025	216,077
3	0	0.963		

Table 7. Results after installing capacitors on bus 2

	After Optimization		Total P Loss After Optimization	
No Bus	Injection (kVAR)	Magnitude Voltage(pu)	kW	kVAR
1	0	1,050		
2	350	1.001	46,438	125,307
3	0	0.994		

The results of power flow optimization in the cooking oil processing plant using the Matlab program, provide quite good results. Both in terms of reducing the losses of active power generated, as well as the voltage profile and reactive power generation. The bus voltage profile achieved is generally quite good and remains within the system tolerance limits. Capacitor injection in buses that experience a voltage drop allows a significant reduction in power losses to be achieved. With the change in active power generated on each generating bus, it can be seen that the entire voltage value on each bus also changes. The changes obtained in terms of quantity are very significant. As an illustration, it can be seen that bus 2 experiences a voltage drop, whereas previously the magnitude voltage (pu) on bus 2 was0.803 pu, after injecting a capacitor of 350 kVAR, the voltage optimization that occurs on bus 2 becomes 1.001 pu.

Meanwhile, the losses of active power and reactive power flowing are reduced after optimization, where initially the total losses of active power and reactive power were

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76,025 kW and 216,077 kVAR. After optimization on bus 2, the total losses of active power and reactive power became 46,438 kW and 125,307 kVAR, as shown in the table below.

Table 8. Effect of voltage changes and power losses after optimization.

No Bus	Before Optimization	After Optimization	Total P Loss Before Optimization		Total P Loss After Optimization	
	Magnitude Voltage(pu)	Magnitude Voltage(pu)	kW	kVAR	kW	kVAR
2	0.803	1.001	76,025	216,077	46,438	126,307

While the computation time produced after optimization on bus 2 is very influential at the time of optimization. This can be seen from the comparison of the two images below where the computation time before and after optimization computation using the Matlab program device.

CONCLUSION

Based on the analysis and data, it was concluded that there are two important aspects in using programming methods to produce a solution to the channel power optimization problem in a cooking oil processing plant. MATLAB can solve power optimization problems that occur in cooking oil processing plants and can improve voltage profiles. To get the optimum final value depending on the parameters and number of iterations because not all parameter values produce optimum values, the fast de couple method is a fast step to find a power flow system solution in search of functions and objectives that will be optimized in the factory. cooking oil processing. The test results were obtained from the 8th iteration, whereThe losses of active power and reactive power flowing are reduced after optimization, where initially the total losses of active power and reactive power were 76,025 kW and 216,077 kVAR. After optimization on bus 2, the total losses of active power and reactive power became 46,438 kW and 125,307 kVAR, The voltage condition on bus 2 before optimization was carried out still experienced a voltage decrease of 0.803 pu, after optimization was carried out by injecting a capacitor of 350 kVAR, the voltage change on bus 2 increased and changed to1.001pu and this voltage can be tolerated with the voltage limits in the electric power distribution system as stipulated in the 1987 PUIL standard.

REFERENCES

[1] Meliandri Ed, Et Al 2012, Journal “Optimal Power Flow Analysis In Bali Electrical System” Electrical Technology Vol. 1 No 11.
[2] Muammar Zainuddin, Et Al., 2014 Journal “Optimization Of Photovoltaic Distributed Generations (Pvdg) Injection Using Genetic Algorithm Method” L Eeccis Vol. 8, No. 2.
[3] Ken Kevin Samosir, Et Al., 2014 "Comparison Of The Fast De Couple Method And The Gauss Siedel Method In The Solution Of The Power Flow Of The 20 Kv Distribution System Using Etap Power Station And Matlab" (Application At Pt.Pln Persero, Medan Branch),Singuda Ensikomm Vol. 7 No. 2

[4] Unggul Dzackiy Et Al., 2012, Journal "Optimization Of Capacitor Placement Using Fuzzy Logic And Genetic Algorithm In Electric Power Distribution System", Department Of Electrical Engineering, Faculty Of Engineering, Diponegoro University.
[5] Heru Dibyo Laksono, 2010, Journal "Optimization Of Capacitor Placement In Electric Power System Using Genetic Algorithm" (Case Study Of Pt. Pln Sumbar-Riau System), Issn: 0854 – 8471, No.34 Vol.1 Year Xvii
[6] Efrita Arfah Z, Et Al. 2013, Journal "Optimal Power Flow (Opf) Of Java Bali 500 Kv Power Plant Using Particle Swarmoptimization (Pso) Template Algorithm," National Seminar On Applied Science And Technology, Isbn: 978-602-98569-1-0, Surabaya.
[7] Cekmas Cekdin, , 2005, Book "Theory And Examples Of Questions Using The Matlab Programming Language", Andi Offset Publisher, Yogyakarta.
[8] Cekmas Cekdin, 2013, Book "Electric Power Transmission", Publisher Andi Offset, Yogyakarta.
[9] Hilal, Hamzah. 2006. "Electric Power System Analysis Ii." Center For Teaching Material Developmentumb. Mercu Buana University.
[10]Hadi, Sadaat. 2002. " *Power System Analysis".*John Wiley And Sons, Inc. : New York.
[11] 2006 Check-In Check-Out,Book" *"Electric Power System Example Questions And Solutions Using Matlab"*Publisher Andi Offset, *Yogyakarta*
[12] Muhamad Rizki Fauzi Et Al., 2014 Journal "Slack Bus Arrangement In Optimizing Power Flow In The Case Of Ieee 30 Bus Using The Newton-Raphson Newton Raphson Method In Matlab 7.0 Application"
Electrichsan, Vol. 1, No. 1.
[13] Sulistiyono 2010, Journal *"Comparison Of Gauss-Seidel Method, Newton Raphson Method And Fast Decoupled Method In Power Flow Solution" Diponegoro University, Semarang*