

The Efficiency of Fuel Consumption using the Power Factor Improving of Thermal. Power Plant: New Approach for CO2 Emission Reduction

by Syarifuddin Nojeng

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The Efficiency of Fuel Consumption using the Power Factor Improving of Thermal Power Plant: New Approach for CO₂ Emission Reduction

Syamsir¹, Syarifuddin Nojeng¹, Andi Syarifuddin¹

¹Electrical Engineering Department, University Muslim of Indonesia, Makassar, Indonesia

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Address for Correspondence: Syamsir, Syarifuddin Nojeng, Electrical Engineering Department, University Muslim of Indonesia, Makassar, Indonesia.

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Abstract

Impact of the thermal power plant for CO₂ emissions was a crucial problem in the global warming. Therefore, the CO₂ reduction commitments continued effort through a various methods and technologies to improve the efficiency of thermal power plant. By using the method of load flow analysis, showed improvement in the quality of the power factor of electric power system has been verified to improving the power plant output. Proposed have showing relationship between power factor improvement to the reduction of CO₂ emissions from thermal power. From the results obtained by using the IEEE 30 bus test system modified proved that there was of the CO₂ emissions reduction especially on the rate of the power factor > 0.97 (lagging).

Keywords: power factor improving, CO₂ emission, thermal power plant.

Introduction

Recently, thermal power plant in the world as the electricity power source have been contribute to overall emissions [1]. By reference from reported in [1,2] that the thermal plant fuel coal, oil and gas are the major contributors of CO₂ emitter of greenhouse. Case studies for other sectors for example; transport, industrial processes, etc., power plant have contributes 21.3% of the causes of increase CO₂ world. The International Energy Agency, report estimates that 70% of the greenhouse gases are produced within the cities [3]. Reported in [4], China, India, Indonesia contributed as much as 38%, respectively, 51%, 21% and 33% in CO₂ emission from electric power generation

sector. The CO₂ emissions in 2020 are estimated to achieve 236 million ton of CO₂ [5].

The growth of world energy consumption continuously increase, therefore number of thermal power installation also growing. The production of electricity from thermal energy in the European Union has reached 54% of the power plant total in year 2005. Include Indonesia with electricity demand growth by average is 7% annually require electricity supply mainly comes from thermal power plant.

In [2], Java and Bali power system, through the baseline scenario estimate of accelerating of projects generating 20,000 MW, there will be the addition of a conventional coal power plant by 27,000 MW. Total production is equivalent to the production of 72.8% of the total

production in 2020 (Coal, Oil, Geothermal, hydro power).

Efforts to reduce CO₂ emissions through the development of technology and policy of the emission reduction [6]. In ref. [7] reported a future energy storage that consider model by adjust variable-speed pumped hydro storage (AS-PHS). Two cases has been studied; with and without AS PHS showing that considering AS PHS resulted in a significant reduction in gas generation, total system operating cost and CO₂ emissions of power plant. In this case, an article in the Protocol Kyoto set the "carbon market" which gives compensation to power plant operators in determining the selling price of electricity. Kyoto Protocol (1997) that have been ratified by almost all countries have become the reference of CO₂ emission reduction of greenhouse gas producer (GHS).

Concept design to reduce GHS propose using the of offshore platform supply vessel system based on hybrid diesel generator and fuel cell power plant [8]. In ref.[9] introduce a develop new technology to capture and store CO₂ currently emitted by fixed sources such as turbines, heaters and boilers. Ref.[10] reported that near-zero-carbon-emission for power plant can be use of the renewable energy storage medium. While, by power plant integration in an oil refinery can be to reduce CO₂ emissions using Oxy-combustion [11]. In this proposal describes the impact of the power distribution system efficiency improvements of coal-fired thermal electricity to load centers through improved power factor. Load power factor of less than 0.9 will affect the power loss in the channel [12].

The paper organized as follow, In section II contains a problem description about power flow analysis and fuel characteristic of thermal power plant. For section III is a describe impact the power factor to output power plant (generator). To application proposed will be

found in section IV and the discuss. Finally, for section V is contains conclusion.

PROBLEM DECRPTION

To improving the efficiency of the transmission line can be obtained by using the improved power factor at the load, using: reactive power compensation,

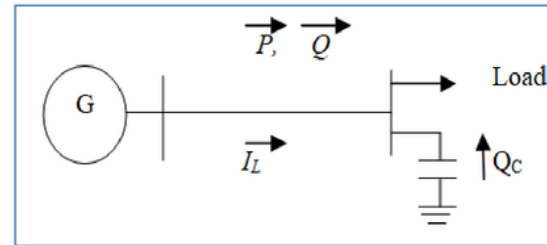


Fig. 1: Single line diagram with capacitor compensation.

For that load flow studies should be done to determine the amount of power loss and power output on the power system. The equation relationship between line current and node voltage on the electric power grid point can be expressed as follows:

Where $[Y]$ = Admittance

$[V]$ = Voltage matrix

$[I]$ = Line current

$$I = \sum_{j=1}^n Y_{ij} \cdot V_j \quad (i=1, 2, 2, 3, \dots, n) \quad (1)$$

$$I = \frac{P_i - jQ_i}{V_i} \quad (i=1, 2, \dots, n) \quad (2)$$

Where P and Q are active and reactive power injection at Node, so:

$$I = \frac{P_i - jQ_i}{V_i} = \sum_{j=1}^n V_j \cdot \hat{V}_j \quad (i=1, 2, \dots, n) \quad (3)$$

Loss of power after power factor improvement is expressed as follows:

$$P_L + jQ' = \sum_{i=1}^{NB} \sum_{j=1}^{NB} Z_{ij} \left(|I_j|^2 \cos \phi_j' + j |I_j|^2 \sin \phi_j' \right) - \left(|I_i|^2 \sin \phi_i - j |I_i|^2 \sin \phi_i' \right) \quad (4)$$

So the output power at the plant can be expressed as

$$P_{Gi} = P_{Di} + P_{Li} \quad (5)$$

Where: are a power demand (load) and the power loss in line at the i-th transaction.

To determine requirement each power plant fuels (Thermal power plant) can be obtained based on the characteristics of Input - Output fuel. Input-output characteristics illustrate the relationship between the input and output of fuel produced by the power plant (MW) as shown in figure 1.

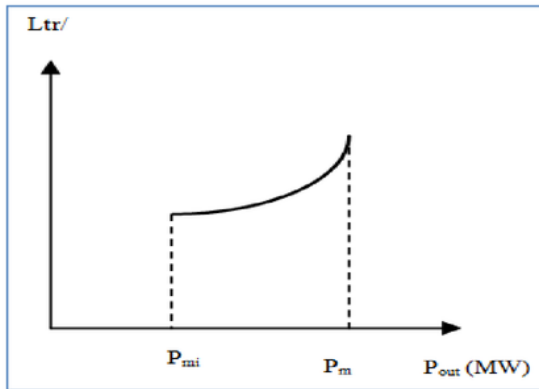


Fig. 2: Input-output fuel consumption characteristic of thermal power plant

In the thermal power plant, input-output characteristics can be obtained through an approach based on second order polynomial functions are:

$$H_i = \alpha_i + \beta_i P_{ii} + \gamma_i P_{ii}^2 \quad (6)$$

Where:

H_i = Fuel consumption of thermal power plant - i (liter/hour)

$\alpha_i, \beta_i, \gamma_i$ = Output of power plant - i (MW)

P_{ii} = Input-output parameter unit termal - i.

III. Propose method

The output power each generator on each bus is a function of the impedance and current of each transmission line. Flow line can be increased if there is a change in power load at bus i-th. Changes in the active power or reactive power will lead to changes in power loss on the line.

By defining the power factor or is the ratio of active power and apparent power, we can expressed equation of active power delivering as :

$$P_i = V_i I_i x \cos \phi_i^{act} \quad (7)$$

So that the delivery of any thermal power plant can be expressed as a function that depends on the power factor. According to equation (7) above, then:

$$P_{out, \cos \phi_{act}} = P_i f(\cos \phi_i^{act}) \quad (8)$$

To obtain the input-output characteristics of thermal power plant taking into account the

actual power factor, the equation (7) substituted into a (8), to obtain:

$$H_{i,\cos\phi_{act}} = \alpha_i + \beta_i P_{ti,\phi_{act}} + \gamma_i P_{ti,\cos\phi_{act}}^2 \quad (9)$$

To determine of CO2 emission for thermal power plant based on power factor using:

$$Emmission_GHG,\cos\phi_{act} = F_{consump,\cos\phi_{act}} * E_{GHG,fuel} \quad (10)$$

Table 1: Emmision factor recommended IPPC [13]

Source	Emmision factor
US. Dept. Energy	0.69
Japan Energy and Economic	0.68
China Energy Reseach Institut of National Development and Reform Commission	0.67

IV. Case Study and Result

A. The 30 Bus IEEE test system

As an illustration of the verification method proposed, the proposal has been tested on 30 bus IEEE test system. Scenario at bus 7, 12 and 21 are inductive load with a power factor will be improved by the injection of reactive power. And for the slack bus is a thermal power plant (steam / gas) by fuel MFO (Marine Fuel Oil).

Power factor is tolerated from 0.84 (in accordance with the initial conditions IEEE 30 bus system) to the maximum power factor ($\cos\phi = 1$). Due to a leading power factor will result in power loss greater than $\cos\phi = 1$ (unity).

Based on the picture, it is obtained that the power loss is reduced if the power factor increasing

- Determine the input equation out fuel power plant:
- Assumptions: Bus#1 consists of 4x100 MW generator with fuel MFO (Thermal power plant).
- Fuel consumption of each generator are:
 1. Output 100 MW = 0.20 ltr/h
 2. Output 80 MW = 0.23 ltr/h
 3. Output 60 MW = 0.25 ltr/h
 4. Output 50 MW = 0.27 ltr/h

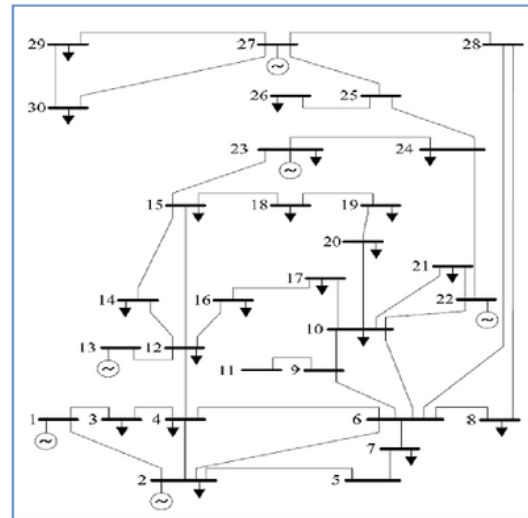


Fig 3: Single line diagram the 30 bus IEEE test systems

B. The Result

In Figure [4], showing the power losses maximum according to scenario initial conditions by 19.917 MW and output power at G1 (slackbus) is 262.316 MW. With the improvement of power factor (load) hence, the biggest loss is based on scenario; L # 12 by the power factor 0.95, by amount 19.902 MW and the output of G1 is 263.302 MW. While for

scenario with all loads (L7; L12 and 21) have a power factor 1 (unity) then the power losses is 19.614 and the G1 output is 263.013 MW.

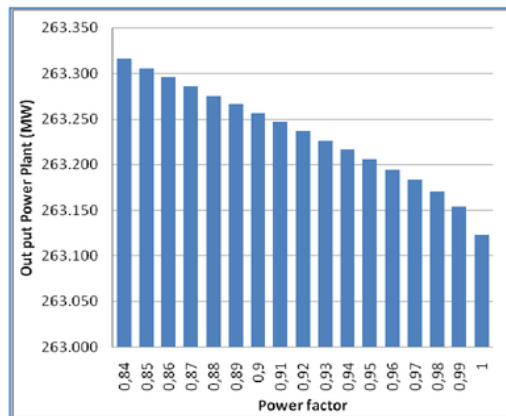


Fig. 4: Impact of output power plant to the load power factor

Figure 4 shows that a change on power factor will cause a change in output power at bus 1 (slack: bus). Power factor is tolerated from 0.84 (in accordance with the initial conditions IEEE 30 bus system) to power factor ($\cos \phi = 1$). The higher the power factor at bus # 21 hence, will decrease the power output at Bus 1.

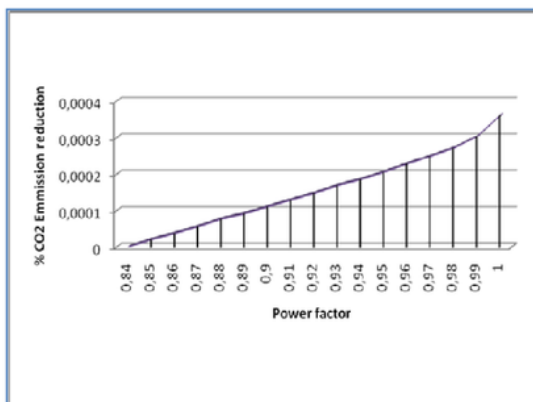


Fig. 5: CO2 emission reduction based on power factor

Based on Figure [5] shows a reduction of CO2 emissions produced by the power plant at bus # 1 (slack bus) as a result of the improvement of

the power factor. In this graph also illustrate the relationship increased CO2 similar to the characteristics input-output of power plant fuel. At $\cos \phi$ values between 0.97 to 1, then the reduction in CO2 emissions was relatively higher than at $\cos \phi < 0.97$

Conclusion

The proposal shows that the improvement in power factor will improve the efficiency of power distribution systems. Based on testing on IEEE 30 bus system by assuming thermal power plant at slack bus at bus # 1, shows that the improvement of power factor will be able to reduce CO2 emissions. This is related due to decrease of fuel consumption of thermal power plant. This proposal also shows reduction of CO2 emissions that significant with $\cos \phi$ between 0.97 to 1. while for $\cos \phi < 0.97$, showing a stable trend.

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References

1. Soeren Lindner, et.al, CO2 emissions from China's power sector at the provincial level: Consumption versus production perspectives, Renewable and Sustainable Energy Reviews, Volume 19, March 2013, pp.164–172.
2. Hai qin et al., Theoretical Analysis and Reaseach on CO2 Emmission of Thermal Power Plant, E-Product E Service and E-Entertainment (ICEEE), 2010.

3. Mahendra Sethi, Location of greenhouse gases (GHG) emissions from thermal power plants in India along the urban-rural continuum, *Journal of Cleaner Production*, Volume 103, 15 September 2015, pp. 586-600
4. RUPTL 2009-2020, <http://www.pln.co.id>
5. Shiwei Yu, Carbon emission coefficient measurement of the coal-to-power energy chain in China, *Applied Energy*, 2014.
6. Ning Zhang, The effect of size-control policy on unified energy and carbon efficiency for Chinese fossil fuel power plants, *Energy Policy*, Volume 70, July 2014, pp. 193–200.
7. Haneen Aburub, A study of EPA GHG emissions standards for existing power plants in WECC region, *Clemson University Power Systems Conference (PSC)*, pp.1-6,2016.
8. Maria C. Díaz-de-Baldasano, Conceptual design of offshore platform supply vessel based on hybrid diesel generator-fuel cell power plant
9. *Applied Energy*, Volume 116, 1 March 2014, pp. 91-100
10. Knut Aasen, Development of a hydrogen membrane reformer based CO₂ emission free gas fired power plant, *Greenhouse Gas Control Technologies 7*, Volume I, 2005, pp. 83-91
11. S Gai, et.al, Process simulation of a near-zero-carbon-emission power plant using CO₂ as the renewable energy storage medium, *International Journal of Greenhouse Gas Control*, Volume 47, April 2016, pp. 240–249.
12. Ana,et.al, Oxy-combustion power plant integration in an oil refinery to reduce CO₂ emissions, *International Journal of Greenhouse Gas Control*, Volume 45, February 2016, pp. 118–129.
13. C.J.Wu, et.al, Power Factor Definition and Effect on Revenue of Electric Arc Furnace Load. 2002.Proceedings *Powercon 2002*, pp. 93-97.
14. IPPC Guidelines for National Greenhouse Gas Inventories: Reference Manual, revised 1996

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