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ENGINE 5 FUEL RATIO OPTIMIZATION WITH LOAD FEEDBACK CORRECTION USING VAMPSET SOFTWARE TO REDUCE SPECIFIC GAS CONSUMPTION (SGC) AT PT PLN NUSANTARA POWER ARUN GENERATION UNIT

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ABSTRACT

Fuel Ratio *Optimization* with 3% Load Feedback *Correction* to Reduce *Specific Gas Consumption* (SGC) at PLTMG Arun is a test in the field of power plants that focuses on optimizing the SGC Engine of PLTMG by looking for a fuel *mixture* composition that produces optimal efficiency of the generating engine and is safe for the reliability of the plant. In 2023, the SGC target is 8600 BTU/kWh. The highest SGC value of one of the engines in 2023 is in Engine 5 of 9327.27 BTU/kWh with an average exhaust gas temperature of 528°C, while the lowest SGC value in Engine 10 is 8,481 BTU/kWh with an average exhaust gas temperature of 532°C. The difference in exhaust gas temperature shows that there is an unused potential for heat energy in engine 5, causing a significant difference in SGC. This test aims to optimize the combustion point using a structured method calculation reference, maintain the engine exhaust gas temperature in accordance with *the commissioning limits*, lower the SGC and increase efficiency, then it will be obtained as a reference as the basis for changes from the AFR. For AFR tuning from the initial condition, i.e. *load feedback* = *load output generator,* it will then be converted to *load feedback* < *load output generator*. The method used is to use the *load feedback correction method* by modifying the analog value scale *of the output of the Power Monitoring Unit (*PMU) from the initial condition of 4-20 mA = 0-12000 kW to the modified condition of 4-20 mA = (0-(12000+x%) kW, where this condition adjusts from the allowable combustion results according to the *lean burn* diagram from the manufacturer. From the implementation in October 2023, the SGC value decreased from the previous 9327.27 BTU/kWh to 9177.87 BTU/kWh. In addition, there was an increase in plant efficiency from 36.54% to 37.14, an increase in EAF from 98.34% to 98.91%, a decrease in EFOR from 1.37% to 0.09% and a decrease in GPHR from 2350,473 Kcal/KWh to 2312,673 Kcal/KWh.

Kata kunci: Engine, *fuel ratio*, *specific gas consumption*, *commissioning*, *load feedback*, efisiensi, *exhaust gas temperature.*

INTRODUCTION

The Arun Gas Engine Power Plant (PLTMG), which is located in Meuria Paloh Village, Muara Satu District, Lhokseumawe City, Aceh, is an asset of PT. PLN Nusantara Power and operated by PT PLN Nusantara Power. Located on the former land of PT Arun, this plant began operating at full capacity in January 2016 with a capacity of 184 MW, which with which helped significantly reduce the electricity deficit in the Aceh system, where the deficit figure is 27 MW that must be supplied from North Sumatra.

The location of the Arun PLTMG construction is located in the area of PT. Arun NGL, Lhokseumawe City, with an area of 4 hectares. The plant will use 19 units of Wärtsilä gas engines type W 20V34SG class 9.73 MW with *a gross output* of 184 MW.

The total available power plants in Aceh are supplying 550 MW with Aceh's peak load requirement of 577 MW, of which PLTMG Arun contributes 184 MW which is equivalent to 31.8% of Aceh's electricity needs. PLTMG Arun operates using LNG fuel from PT. Tangguh and PT. Badak LNG which is then stored and flowed using the regasification facility of PT. PAG with an average gas absorption per day of 20 MMSCFD.

Specific Gas Consumption (SGC) is one of the performance contract targets that shows the level of fuel efficiency in generating engines with energy units per kWh generated. If the SGC is higher, it indicates the use of more fuel to produce electrical energy so that it can increase the cost of materials

burn. In semester 1 of 2023, the realization of SGC in Engine 5 is 9328 BTU/KWh while the SGC performance contract target in 2023 is 8600 BTU/kWh.

Fuel consumption is affected by the ratio of fuel consumption to air consumption (*AFR, air fuel ratio).* To set this ratio, it is carried out by the manufacturer's technicians at the time *of the overhaul* using the WecsplorerUT software. So far, the unit has not been given access to tune independently. The impact of *AFR tuning* can affect the SGC on the unit. *The last AFR tuning* in 2019 after the implementation of *16000 hours* of preventive maintenance.

Based on these conditions, we took the initiative to make additional efforts to optimize the SGC of the plant in addition to routine and periodic maintenance actions, namely by creating a structured calculation analysis method to see the combustion point which aims to improve engine efficiency, in this case SGC, which will then be adjusted at the combustion point using the load feedback *correction method* in the engine automation control system.

METHOD

This test was carried out on Engine 5 which is located in Engine hall 1 block A1 with the engine specifications shown in table 1.

Tabel 1 *Main technical* data Engine

Main Techinical Data	
E20V34SG ENGINE	*Power Plant dan Compressor Drive Engines*
Cylinder Bore	340 mm
Piston Stroke	400 mm
Speed	750 RPM
Mean Effective Pressure	22 Bar
Piston Speed	10 m/s
Output/Cylinder	500 Kw
Natural Gas Methane Number	55-90
Lower Heating Value	Min 28 Mj/NM3

Specification of Gas Fuel

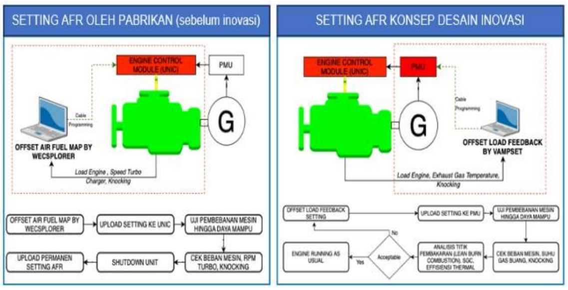
The following is shown a table of gas fuel specifications that will be carried out in this study.

Table 2 Fuel composition

Gas Composition	
Methane	99,8317 mol %
Ethane	0,0000 mol %
I-Butane	0,0000 mol %
N-Butane	0,0000 mol %
I-Pentane	0,0000 mol %
N-Pentane	0,0000 mol %
Nitrogen	0,1683mol %
CO2	0,0000 mol %
Hexane Plus	0,0000 mol %

Testing

The figure below explains the process of programming *(mapping) the air fuel ratio* to the engine load using the WECSPlorerUT software which is directly connected to UNIC but has limited access by the wartssila manufacturer. Meanwhile, in the test concept, programming is carried out with VAMPSET software which has open access to offset *load feedback* PMU connected to UNIC to affect the mapping of the air fuel ratio to the engine load.



RESULT AND DISCUSSION

The identification of problems related to SFC Engine 5 that was not achieved was found where it was found that the engine exhaust gas temperature parameter at the optimal load had a lower value with an average exhaust gas temperature of 528°C, than during the initial commissioning condition with an average of 531°C. The engine 5 exhaust gas temperature comparison is shown in figure 1.

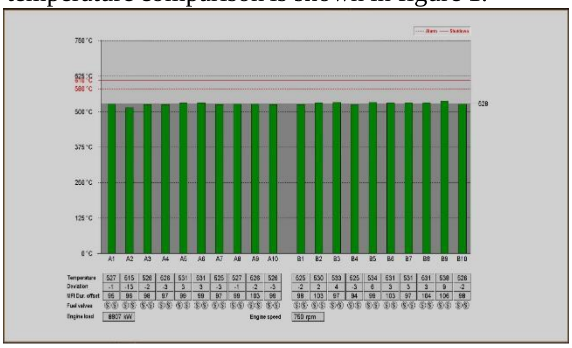


Figure 1. *Exhaust gas temperature* koreksi *load feedback* 0%

The above condition is the basis for the focus of data collection on each Engine 5 cylinder at Bank A and Bank B, this condition can be seen in figure 2

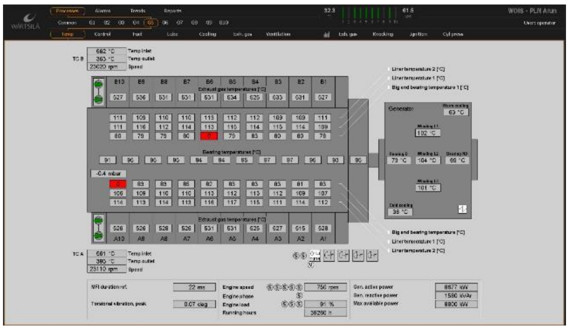


Figure 2. Parameters of bank A and bank B correction *load feedback* 0%

This condition is assumed to show that there is still energy that has not been burned with a very high difference between the exhaust gas temperature alarm point and the current operating conditions so that there is still the potential to make *load feedback* corrections on the Engine 5 to increase the combustion ratio to be better by correcting *the load feedback* by modifying the *power monitoring unit* output analog value scale (PMU) from the initial condition of 4- 20 mA = 0-12000 kW to the modified condition of 4-20 mA = 0-(12000 +x%) kW. Load feedback correction test simulations were carried out at several correction points, namely 1%, 3% and 5% load feedback corrections. From this implementation, the *exhaust gas temperature* parameters on Engine 5 are obtained as follows:

- 0% load feedback *correction* with an average exhaust *gas temperature* of 528oC (Figure in attachment 3 Point 1)
- Correction *of 1% load feedback* with an average exhaust *gas temperature* of 532oC (Figure in Appendix 3 Point 2)
- Load *feedback* correction of 3% with an average exhaust *gas temperature* of 535oC (Figure in Appendix 3 Point 3)
- Load *feedback* correction of 5% with an average exhaust *gas temperature* of 536oC (Figure in Appendix 3 Point 4)

From the simulation above, it shows with the implementation of correction *load feedback* 1%, 3% and 5% can cause combustion in the combustion chamber to be more optimal, which is shown by an increase in *exhaust gas temperature* on Engine 5. From the calculation results, the efficiency achievement in Engine 5 is obtained as follow

- 0% load feedback *correction* with efficiency realization of 36.54%
- Load *feedback* correction of 1% with the realization of efficiency of 36.62%
- Load *feedback* correction of 3% with the realization of efficiency of 37.14%
- Load *feedback* correction of 5% with the realization of efficiency of 37.66%

The above results show that the best efficiency is obtained at a 5% *load feedback* correction with an efficiency of 37.66%, but for long-term operation there is an increase in *temperature* in *cylinder* A10 and cylinder B6 which touches the *exhaust gas temperature* alarm point at 580 ºC while the engine *trip* tip occurs at *a temperature* of 610 ºC and almost touched the *knocking point* in the combustion chamber. This condition is shown in figure 3.

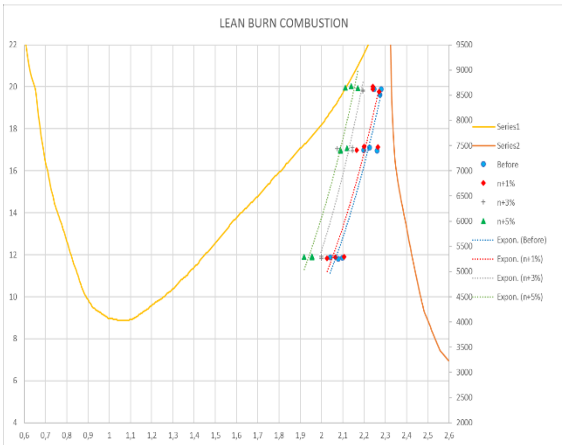


Figure 3. *Lean burn combustion*

From these conditions for long-term operation it is ideal at a *3%* load feedback *correction with air fuel* optimum point ratio (λ, BMEP) from the Engine #5 test with the result from the initial condition (2.27, 19.79 bar) to (2.19, 19.79 bar), as shown in Figure 3.

CONCLUSIONS

1. The 3% load feedback *correction* is the safest and most reliable point with a combustion ratio (λ, BMEP) of (2.19, 19.79 bar) from the initial condition (2.27, 19.79 bar).
2. The achievement of equivalent *availability factor* (EAF) performance of the implementation of 3% load feedback correction with positive polarization obtained a result of 98.91% better than the existing condition with an ealization of 98.34%.
3. The achievement of the *equivalent forced outage rate* (EFOR) performance of the implementation of 3% load feedback correction with negative polarization obtained results of 0.09% better than the existing conditions with ealization of 1.37%.
4. The achievement of *specific fuel consumption* (SFC) for the implementation *of load feedback* correction with negative polarization obtained the following results:
   - 0% load feedback *correction* of 9327.27 Btu/KWh

- 1% load feedback *correction* of 9305.99 Btu/KWh
- 3% load feedback *correction* of 9177.87 Btu/KWh
- 5% load feedback *correction* of 9049.74 Btu/KWh

5. The achievement of *the gross plant heat rate* (GPHR) of the implementation of load *feedback* correction with negative polarization obtained the following results:
   - 0% load feedback *correction* of 2350.473 KCal/KWh
   - 1% load feedback *correction* of 2345.032 KCal/KWh
   - 3% load feedback *correction* of 2312.673 KCal/KWh
   - 5% load feedback *correction* of 2280.314 KCal/KWh
6. The achievement *of thermal efficiency* in the implementation of load feedback correction with positive polarization obtained the following results:
   - 0% load feedback *correction* of 36.54%
   - 1% load feedback *correction* of 36.62%
   - 3% load feedback *correction* of 37.14%
   - 5% load feedback *correction* of 37.66%

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