PERFORMANCE TEST OF GAS TURBINE PART OF THE COMBINED CYCLE

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Abstract
Tulisan ini menampilkan beberapa hasil pengujian parameter turbin gas dari pembangkit listrik tenaga gas dan uap (PLTGU) "Tanjung Priok Gas Fired Power Plant Extension Project (740 MW)". Dari pengujian ini dapat disimpulkan bahwa untuk power turbin gas 184 MW, konsumsi bahan bakar adalah 51.6 m^3/h dengan komposisi gas buang adalah CO2 adalah 0.4 % volume, SO2 adalah1.1 ppm, NOx adalah 1.4 ppm dimana harga ini masih dalam batas-batas yang dipersyaratkan secara teknis. Getaran tertinggi terjadi pada bantalan no 2 yakni sebesar 56 um pada arah x dan 54 um pada arah y.

Kata kunci : turbin gas, daya, generator, gas buang, vibrasi

1. INTRODUCTION

The gas turbine is the most versatile item of turbo machinery today. It can be used in several different modes in critical industries such as power generation, oil and gas, process plants, aviation, as well domestic and smaller related industries. A gas turbine essentially brings together air that it compresses in its compressor module, and fuel, that are then ignited. Resulting gases are expanded through a turbine. That turbine's shaft continues to rotate and drive the compressor which is on the same shaft, and operation continues. A separate starter unit is used to provide the first rotor motion, until the turbine's rotation is up to design speed and can keep the entire unit running. The compressor module, combustor module and turbine module connected by one or more shafts are collectively called the gas generator.

The Tanjung Priok Gas Fired Combined Cycle power plant project consisting of two modern gas turbines and generators in combination with one steam turbine. The power plant delivers 740 MW of electricity to the national grid.

This paper discusses some results of the performance test for gas turbine part of combined cycle that were carried out to verify the guarantee parameters under the specified condition in accordance the procedure.

2. MATERIALS AND METHODS

The objective of this study is to evaluate the performance test of the gas turbine part of Tanjung Priok Gas Fired Power Plant Extension Project (740 MW) based on the ASME Standard.

2.1. Discription Of Tpgfppep System

Figure 1 shows the Tanjung Priok Gas Fired Power Plant Extension Project (TPGFPPEP). This plant is a Gas Fired Combined Cycle Power Plant consisting of two modern gas turbines and generators in combination with one steam turbine. The power plant delivers 740 MW of electricity to the national grid.

This system was designed for the dual fuel system either fuel oil or fuel gas. The fuel oil is supplied from the existing HSD fuel oil unloading station at terminal point to the HSD fuel oil receiving tank and then sent to fuel oil treatment system. Treated HSD fuel oil is fed to existing HSD Fuel Oil Storage tank. One 100 % GT main fuel oil pump pressurizes the fuel oil to desired pressure of gas turbine system. The high pressure fuel oil is passed through the flow meter and filtered by a filter to remove fine particles before the fuel is delivered to the gas turbine (2).

The fuel gas system is intended to remove the solid and liquid droplets to the designed levels from the fuel gas. This is done by fuel gas treatment system. The treated gas is led to gas turbine via fuel gas compressor which

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compresses the fuel gas to pressure levels as required for the gas turbine operation (2).

Figure 1. Tanjung Priok Gas Fired Power Plant Extension Project

2.2. Performance Test And Measuring Procedure

2.2.1. Standard

The performance test was carried out basically based on the ISO 2314 -1989. Also the following standards were used in the performance test:

a. ASME MFC-4M -1986 R 2003 for Measurement of Gas Flow by turbine meters.

b. AGA report No 8 -2003 for compressibility factors of natural gas and other related hydrocarbon gases.

c. ISO 6976 – 1995 for Natural Calculation of calorific values, density and Wobbe index from compressibility.

2.2.2. Test Condition

In order to carry out the performance test, the following condition should be satisfied :

a. Prior to performance test, necessary cleaning of air inlet filter and gas turbine compressor.

b. Gas turbine should be operating at state conditions.

c. All drain valves, bypass valves and isolation valves should be closed.

d. All parameters should be maintained as close as possible to the Base Reference Conditions.

e. Gas turbine shall be operated at base load with the exhaust gas temperature control mode.

2.2.3. Measuring

The major measured parameters for the performance test are indicated below and all measuring items for calculation are shown in table.1. Measurement interval are :

a. Data measured by stationary instrument and temporary instruments, which signals are sent to DCS, will be logged at every one (1) minute.

b. Integral generator power output will be measured and printed at every five(5) minutes.

c. Auxiliary power consumption will be measured one time through the test period.

d. Fuel sample will be taken before, during and on completion the test.

2.3.4. Correction Method From Test Condition to Rated Condition

The measured performance under the test conditions shall be corrected to the base reference condition specified in reference 1 using respective curves.

The gas turbine gross power output under Base Reference Condition is calculated as follow :

$$PGT = \frac{PGTM}{K1xK2xK3xK4xK5xK6xK7xK8} \quad \text{.....(1)}$$

where :

- PGT = corrected gas turbine gross power output under the base reference condition (kW).
- PGTM = measured gas turbine gross power output at generator terminal (kW).
- K1 = power output correction factor for ambient temperature.
- K2 = power output correction factor for barometric pressure.
- K3 = power output correction factor for relative humidity.
- K4 = power output correction factor for gas turbine generator frequency.
- K5 = power output correction factor for fuel characteristic.

Diterima 25 Juni 2012; terima dalam revisi 10 Juli 2012; layak cetak 3 Agustus 2012

- K6 = power output correction factor for gas turbine exhaust duct pressure.
- K7 = power output correction factor for gas turbine generator power factor
- K8 = power output correction factor for degradation.

3. RESULTS AND DISCUSSION

Table 2 shows some of the results of power test performance for gas turbine of a combined cycle power plant. It could be seen that for gas turbine power output is 98 MW, the fuel consumption is 26.2 m^3/h and for 184 MW the fuel consumption is 51.6 m^3/h.

Figure 2 shows the vibration and bearing temperature diagram for gas turbine power output and gas turbine speed are 98 MW and 3000 rpm respectively. From this diagram it could seen that the highest bearing vibrations are 56 um and 54 um in x and y direction respectively, this occurred at thrust bearing no 2. The vibration of bearing no 1 and no 3 in x direction are 38 um and 31 um respectively. The bearing vibration of bearing no 4 and no 5 are relatively small. From the figure 2 it could be also seen that the highest drain temperature is 64.7 ^oC and the highest metal temperature is 84,3 ^oC.

From figure 3 it could be seen a blade path temperature variation and exhaust temperature diagram. The minimum blade path temperature is 481 ^oC at path no 9 and maximum temperature occurred at path no 15 is 497 ^oC . The average temperature of blade and exhaust gas temperature are 490 ^oC and 491 ^oC respectively.

Figure 4 shows the exhaust gas flow through the stack. The composition of exhaust gas are : CO is 19.7 ppm, CO2 is 0.4 % volume, SO2 is 1.1 ppm, NOx is 1.4 ppm. These results are within the limits of requirement technical specification

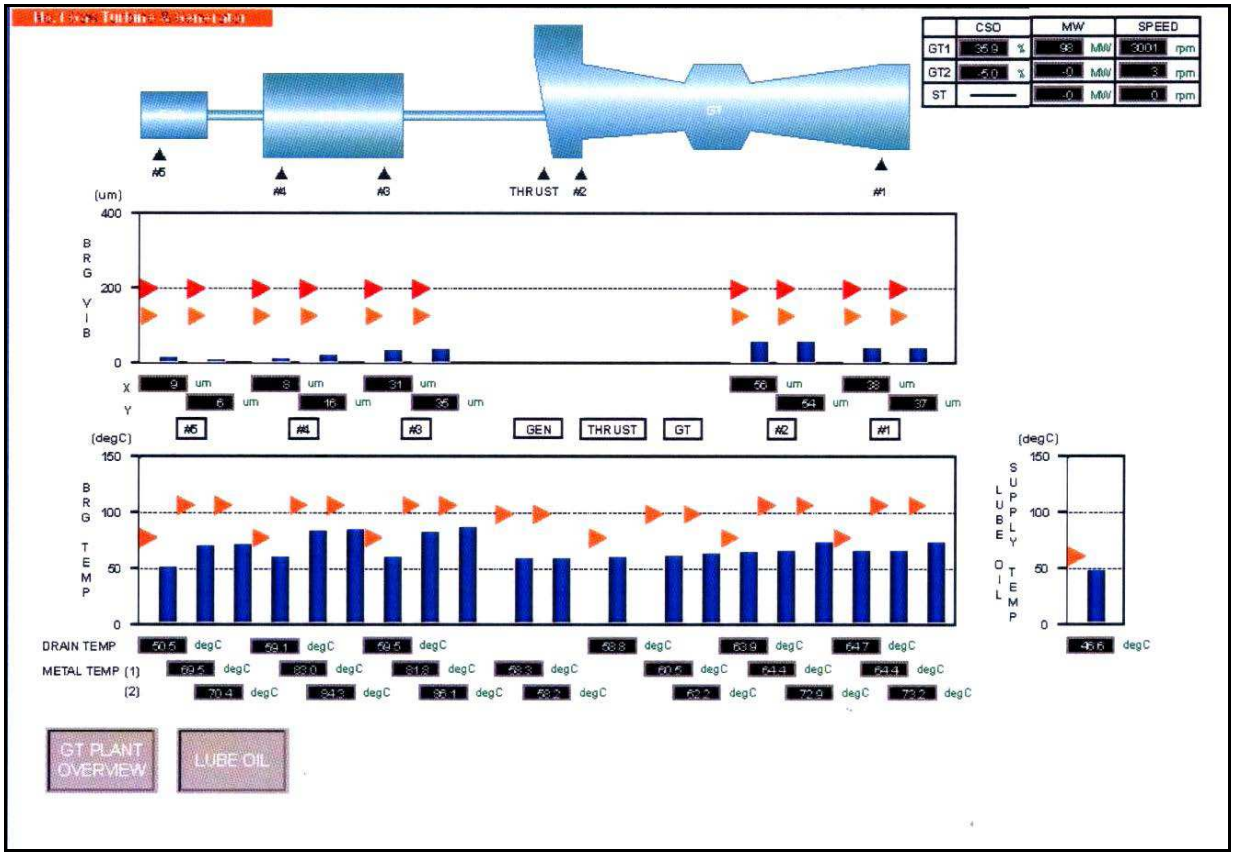

Figure 2. . Vibration and bearing temperature diagram

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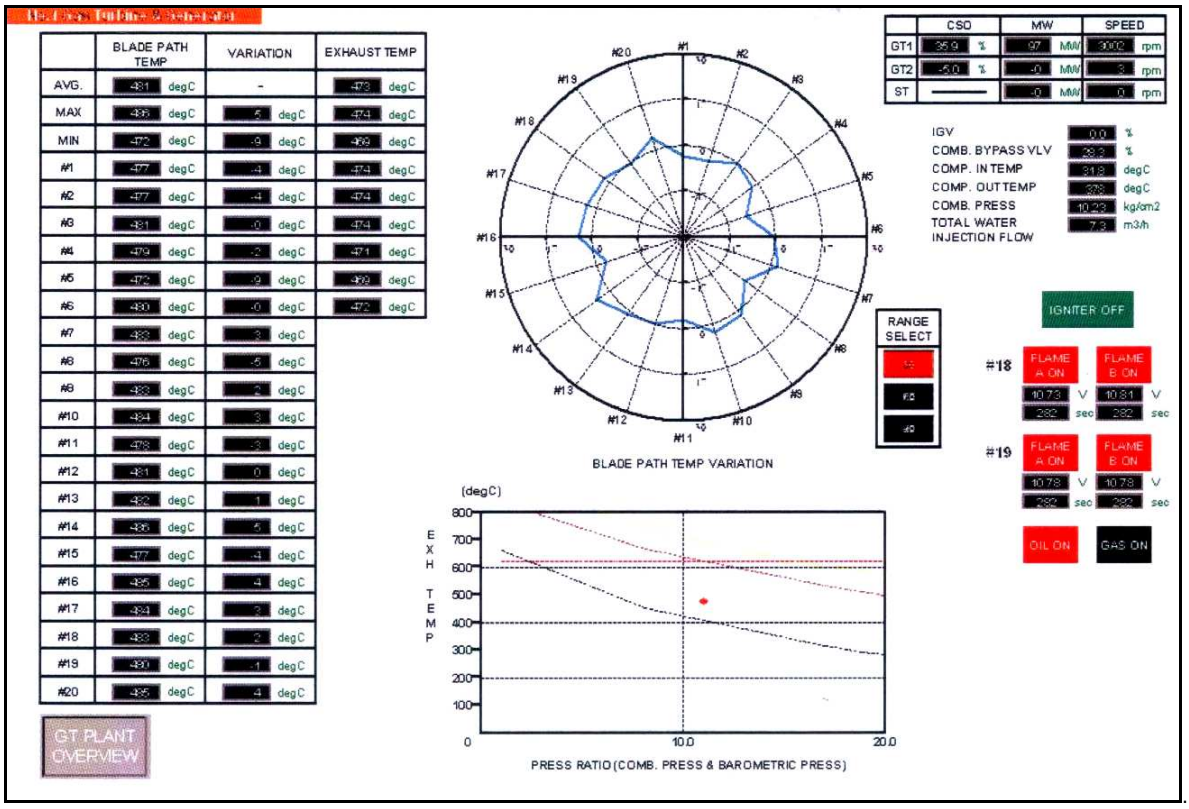

Figure 3. Blade path and exhaust temperature diagram

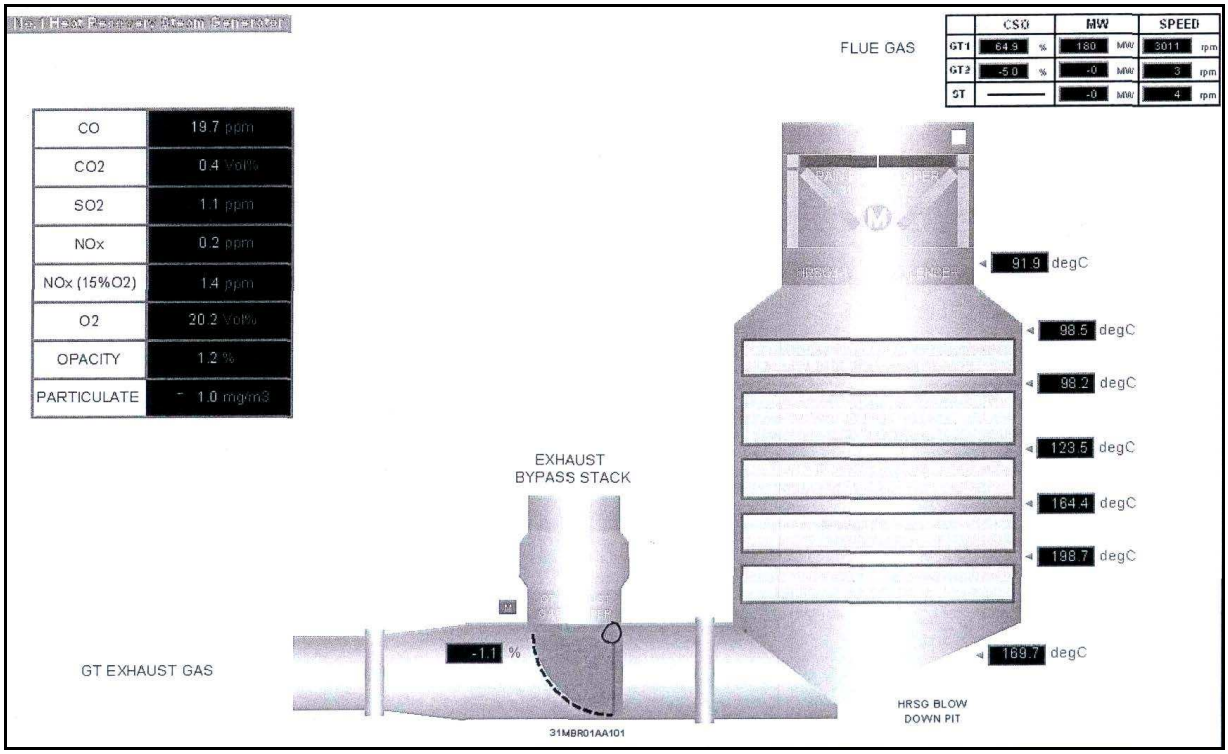

Figure 4. . Exhaust gas flow of gas turbine

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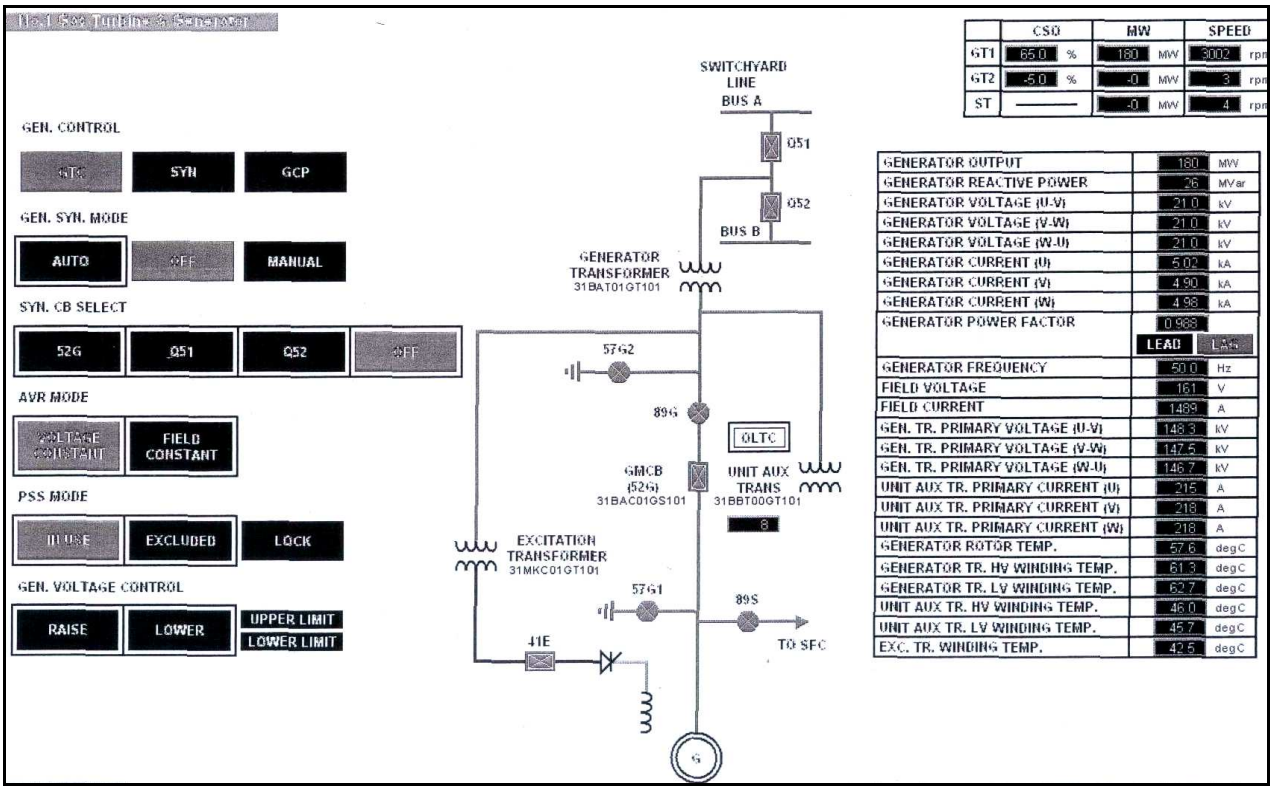

Figure 5. Gas turbine generator performance

The gas turbine generator performance is given in figure 5. The generator output is 180 MW, the generator reactive power is 26 MVar, the generator voltage U-V, VW and WU are 21 kV respectively. From this figure it may be also seen that the generator current U, V and W are 5.02 KA, 4.90 kA and 4.98 kA respectively.

4. CONCLUSION

From the above discussion it could be concluded that :

a. The performance test of gas turbine parameter shows that for power output 184 MW, the fuel consumption is 51.6 m^3/h.
b. For gas turbine power output about 180 MW the exhaust gas compositions are CO is 19.7 ppm, CO2 is 0.4 % volume, SO2 is 1.1 ppm, NOx is 1.4 ppm. These results are within the limits of requirement technical specification.
c. The highest bearing vibrations are 56 um and 54 um in x and y direction respectively, this occurred at thrust bearing no 2.
d. The average temperature of blade and exhaust gas temperature are 490 ^oC and 491 ^oC respectively.

REFFERENCE

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Diterima 25 Juni 2012; terima dalam revisi 10 Juli 2012; layak cetak 3 Agustus 2012