

Gas Power Plant Operation Simulator using LabVIEW in Energy Conversion Laboratory of Jakarta State Polytechnic

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Keyword: Simulator, Gas Power Plant, LabVIEW

Abstract: Gas Power Plant (GPP) is a power plant that uses power produced by the combustion of fuel and high-pressure air to turn a turbine that has been coupled with a generator to produce electrical energy. In this research a GPP simulator software was created and validated using experimental data sets, therefore operators can operate GPP safely and produce the desired output. This software simulator consists of virtual instruments that include gas energy sources, combustion chamber, cooling system, generators, measuring devices and controllers. The controller settings will affect the turbine performance. This simulator software was made by using Datalogging and Supervisory Control (DSC) facilities from LabVIEW. It can be use to understand the operation and behavior of gas turbines.

1 INTRODUCTION

One of the many power plants in the world specifically in Indonesia is the GPP. Gas Power Plant is a power plant that uses power produced by the combustion of fuel and high-pressure air to turn a turbine that has been coupled with a generator to produce electrical energy. Energy recovery from natural gas distribution network is a strategy for sustainable energy in the urban area (Hooman Golchoobiana, 2019).

The operation of a power plant requires more human resources to be developed for the safe operation of the power plant. Workforce training uses hardware need a lot of money and can cause work accidents and equipment damage if not done carefully.

To increase the effectiveness of the work of a company is need for proper planning on operational (Novi Gusnita, 2017). Users employing manual system can cause considerable problems as well as production disruption, leading to some serious drawbacks (Erwin N.D, 2017).

Several studies have been carried out by making turbine gas model simulations to determine the performance of turbine gas using math modeling (Henrique GJ, 2017), the air conditioning system will affect the performance of turbine gas (Ejiroghene KO et al. 2016), turbine monitoring

parameters on thermal power usage using MATLAB (M. Surekha, 2015), controlling boilers and fans using LabVIEW (P. Hari Krishnan, 2014), several identification methods for the laboratory model of a thermal plant (P. Tapak M. Huba, 2016), LabVIEW can be use to adjusting, monitoring and controlling (Arun.P.R, 2014), to design, simulate and optimize controller, acquire data, present numerical display and store environment and electrical parameter (Chokri B. A., 2015) and (Amit Kumar Rohit, 2017). LabVIEW allow to control the object, carrying out the visualization of the process control and analysis of measurement data (Piotr Perz, 2017), control, and image processing (Chen Shi, 2019), design, simulate and optimize two-position controller (Tomáš Uričaa, 2017), and make Virtual Lab (Poorna chandra B R,2014)

From all this research will be developed by making a simulator on Gas Power Plant.

Operation of power plant must be satisfactory before going into actual operation. The operation of the power plant must be carried out properly according to the SOP before the actual operation.

Energy Conversion Laboratory, Department of Mechanical Engineering, Jakarta State Polytechnic has Gas Power Plant produce by Cussons, which is used for student, technician and lecturer practice and research. The operation of this Gas Power Plant requires quite a lot of gas fuel so it requires high costs. In addition, the operation of Gas Power Plant

requires sufficient knowledge to be carried out safely and the results are as expected. Therefore it is necessary to make a Gas Power Plant simulator that is used to train the skills to operate a virtual power plant in accordance with the Standard Operating Procedure (SOP). In this research Gas Power Plant simulator software will look like Gas Power Plant in Energy Conversion Laboratory of Jakarta State Polytechnic. The software is made with Datalogging and Supervisory Control facilities integrated with LabVIEW. LabVIEW with a graphical programming syntax that makes it simple to visualize, create, and code engineering systems

It is expected that with this simulator software, students, lecturers and technicians can conduct training in the operation of gas turbines more easily and can understand how to operate Gas Power Plant correctly and safely.

The fundamental thermodynamic cycle of gas turbine engines is the Brayton Cycle. Figure 1 shows, a gas turbine cycle. High pressure air from compressor mixed gas fuel in combustion chamber produces high temperature gas which is used to turn the turbine. The turbine connected to the compressor and generator by a rotating shaft. The shaft transmits the power necessary to drive the compressor and generator. It is important to recognize that the gas turbine has a dual usage: It designates to drives the compressor and the load. The turbine connected to the generator by the simplest plant is the open turbine gas cycle as shown in figure 1.

1. Air at room pressure and temperature is compressed to a high pressure in the compressor
2. Fuel is added in the combustion chamber where combustion takes place resulting in high-temperature combusted gases
3. The hot gases expand in the turbine back to the atmospheric pressure producing mechanical power

Main equation are :

1. Air compressor outlet temperature (T_2):

$$T_2 = (r_p)^{\frac{k-1}{k}} \times T_1 \quad (1)$$

T_1 = Ambient temperature

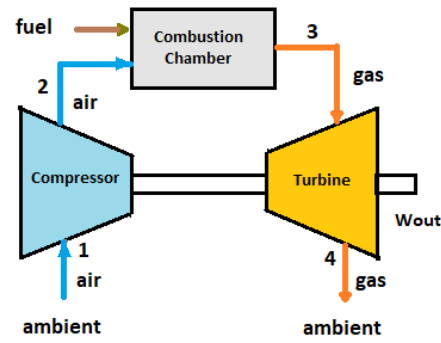


Figure 1: Gas Turbine Cycle

$r_p = 2$ = Compressor specification, depend on compressor size

k = Heat capacity ratio = 1,4

2. Compressor outlet pressure (P_2) :

$$P_2 = r_p \times P_1 \quad (2)$$

P_1 = Gas fuel pressure

3. Compressor power input (W_c) :

$$W_c = \dot{m}_a C_p (T_2 - T_1) \quad (3)$$

\dot{m}_u = Air flow

C_p = Heat capacity at pressure constant

4. The thermal energy produced by the combustion chamber (q) is:

$$q = HH_V \times \dot{m}_f \quad (4)$$

HH_V = 50000kJ/kg for LPG fuel

\dot{m}_f = Fuel Flow

5. The combustor outlet temperature (T_3) :

$$T_3 = \frac{q}{\dot{m}_u C_p} + T_2 \quad (5)$$

6. The turbine power inlet temperature (T_4) :

$$T_4 = T_3 - \frac{W_c}{\dot{m}_u C_p} \quad (6)$$

7. The turbine power inlet pressure (P_4) :

$$P_4 = \left(\frac{T_4}{T_3}\right) \times P_3 \quad (7)$$

P_3 = The combustion chamber pressure

8. The turbine power outlet temperature (T_5) :

$$T_5 = \left(\frac{P_1}{P_4}\right) \times T_4 \quad (8)$$

9. The turbine power (W_{tp}) is:

$$W_{tp} = \dot{m}_u C_p (T_4 - T_5) \quad (9)$$

10. The thermal efficiency of the plant (η_t) is:

$$\eta_t = \frac{W_{PT}}{q} \quad (10)$$

2 MATERIAL AND METHOD

The method used is to observe the work of the Gas Power Plant at the Energy Conversion Laboratory of Jakarta State Polytechnic, collect measurement data, create the gas power plant layout and create the gas power plant program based on the layout that was created. The program was made using Datalogging and Supervisory Control (DSC) facilities from LabVIEW software. At this stage the Front Panel and Block Diagram design is carried out in accordance with the work process of the gas power plant in the Energy Conversion Laboratory of Jakarta State Politechnic. This software simulator consists of virtual instruments that include gas energy sources, combustion chamber, cooling system, generators, measuring devices and controllers. The controller settings will affect the turbine performance.

The simulator is operated based on the SOP of Gas Power Plant in the Energy Conversion Laboratory of Jakarta State Politechnic. This SOP is listed on the simulator screen to make it easy for users to operate this simulator.

All data from the simulator was stored in an Excel table using the spreadsheet write facility from LabVIEW.

3 RESULT AND DISCUSSION

Figure 2 shows front panel of GPP simulator. The operation of GPP simulator starting by regulating the gas fuel, turn on the oil pump as a cooler, turn on the compressor to produce high pressure air, then igniting the ignition to carry out the fuel combustion process. The result of combustion in the form of high temperature gas will rotate the turbine. The generator that coupled with the turbine will rotate hence produces electricity.

Figure 3 shows block diagram of GPP simulator.

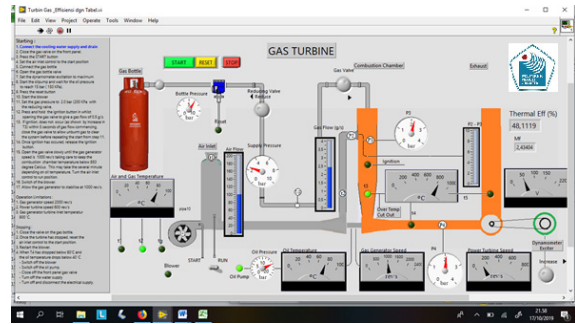


Figure 2: Gas Power Plant Simulator Front Panel

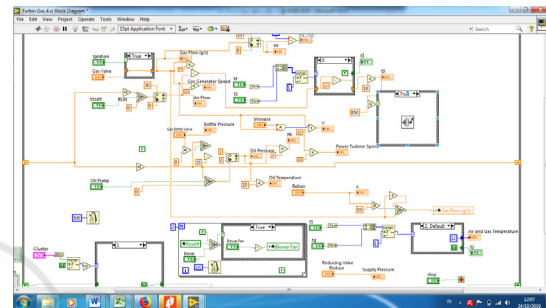


Figure 3: Gas Power Plant Simulator Block Diagram

4 CONCLUSION

The GPP simulator shows the interaction between the energy source, combustion process, gas turbine, virtual instrument and control. The Gas Power Plant simulator software was created and validated using experimental data sets, to produce the desired output. This software simulator consists of virtual instruments that include gas energy sources, combustion chamber, cooling system, generators, measuring devices and controllers. The controller settings will affect the turbine performance.

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