Simulation of Cycles Gas Turbine Power Plant in Aspen HYSYS

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Introduction

Global warming has become a great concern of our modern society. CO2 is considered as the main cause of global warming, and more than 40% of the CO2 emissions stem from the power industry (IEA, 2017). Owing to the lower, cleaner emissions and higher thermal efficiencies of Gas Turbine Power Plant.

Gas turbine power plant still use. Gas turbine has lot of disadvantages for example in Nigeria produced only 64.3% of its nameplate capacity from 2001 to 2010 (Oyedepo, 2014). The part-load operation arises from several reasons. First, the power demand is hardly steady and rarely equals the design capacity. Second, many countries mandate power plants to maintain spinning reserves (surplus capacity) to guard against unforeseen peaks in demands. Third, a power plant may often be overdesigned to buffer against demand uncertainties. As expected, the thermal efficiency of a power plant decreases as the operation drifts away from the design condition. Therefore, there are strong incentives for improving the plant performance during part-load operations (Liu, 2019).

In this work, I present simulation of Aspen Hysys of Gas Turbine simulation that make my self understand the principle of Gas Turbine Power Plan in many cycle, open loop, closed loop, and open loop with regeneration in different of mass flow fuel.

Simulation in Aspen HYSYS

Component :

a. Natural Gas

- Methane (CH_4)
- Ethane (C_2H_6)
- Propane (C_3H_8)
- N-Butane (C_4H_{10})
- N-Pentane (C_5H_{12})

b. Air
- Oxygen (O_2)
- Nitrogen (N_2)

c. Product Reaction
- Carbone Dioxide (CO_2)
- Water (H_2O)

Fluid Packages :

Peng-robinson

Reaction :

Using Conversion Reaction in Complete Reaction with Co (%) = 100 in these reaction

a. Methane Combustion

$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$

b. Ethane Combustion

$C_2H_6 + 3.5O_2 \longrightarrow 2CO_2 + 3H_2O$

c. Propane Combustion

$C_3H_8 + 5O_2 \longrightarrow 3CO_2 + 4H_2O$

d. N-Butane Combustion

$2C_4H_{10} + 13O_2 \longrightarrow 8CO_2 + 10H_2O$

e. N-Pentane Combustion

C5H12 + 8O2 $\longrightarrow$ 5CO2 + 6H2O

Base Data :

a. Air for Turbine

T = 30^{o}C

P = 1 atm

F = 73,2 kg/s

Composition :

N_2 = 0.79

O_2 = 0.21

b. Natural Gas to Combustion Chamber

T = 30^{o}C

P = 10 atm

$F = 6000$ kg/h

Composition :

$CH_4 = 0.88$

$C_2H_6 = 0.05$

$C_3H_8 = 0.02$

$C_4H_{10} = 0.006$

$CO_2 = 0.044$

c. Type Gas Turbine : Titan 250

Two Shaft

Efficiency = 0.85

- Compressor :

Pressure ratio : 24:1

Efficiency = 0.85

Simulation

Closed Loop

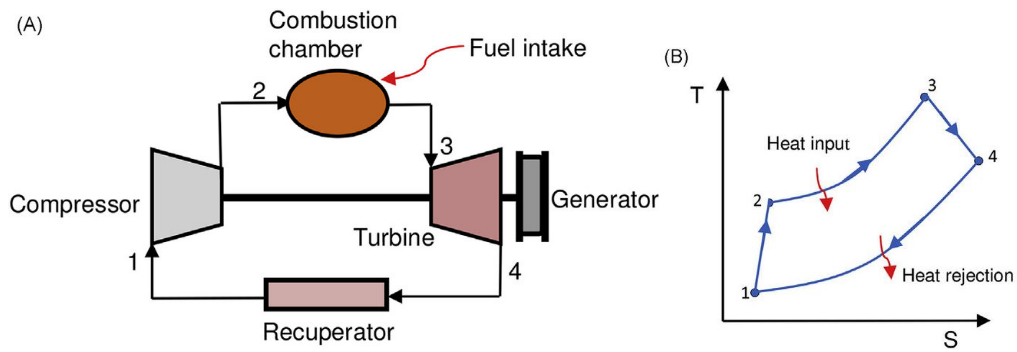

Figure 1. Simple Closed Circuit Diagram Gas Turbine Plant

Open Loop

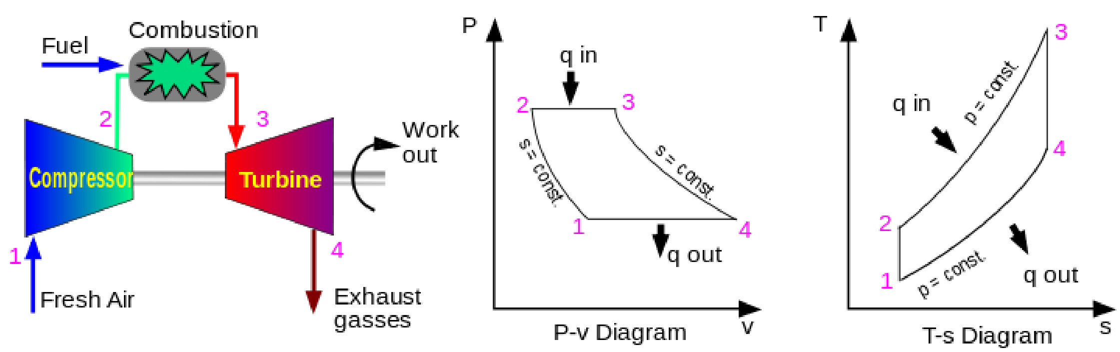

Figure 2. Simple Open Circuit Diagram Gas Turbine Plant

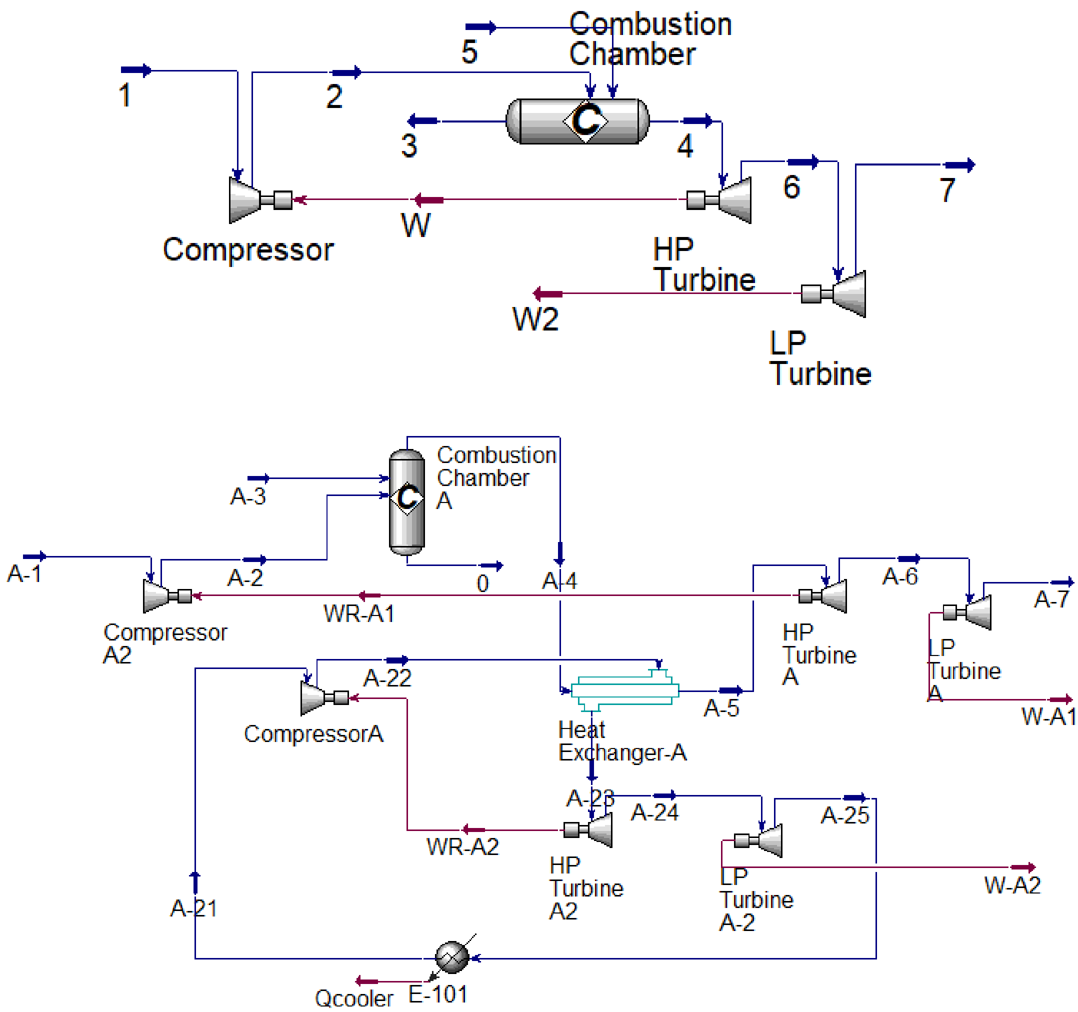

Figure 3. Simple Open Circuit (Up) and Closed Circuit (Down) Gas Turbine Plant

Optimization in Open Loop Gas Turbine Power Generation

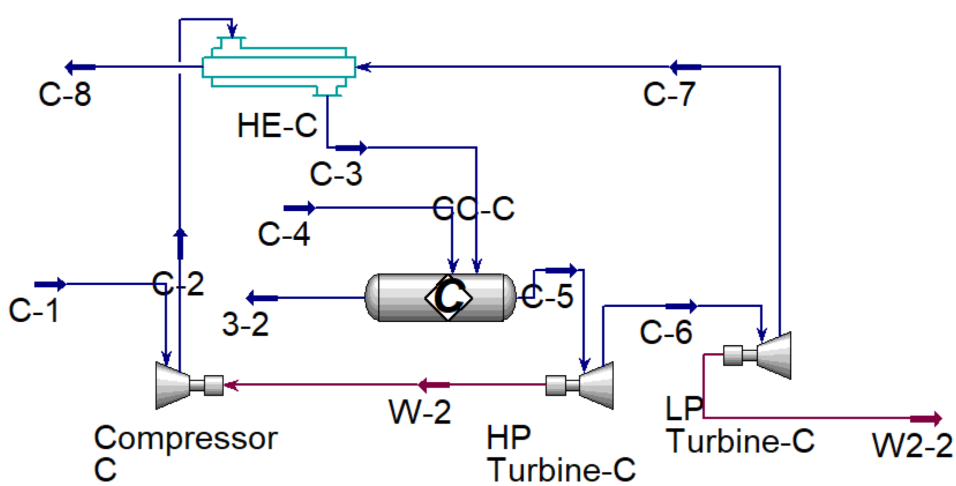

Figure 4. Open Circuit Gas Turbine with Regeneration (Heat Exchanger)

Result and Discussion

Comparison of Generated Power

Cycle	Power (kW)
Open Loop	28,900
Closed Loop	12,720 + 9,715 = 22,435
Open Loop with Regeneration	29,880

Open loop in gas turbine power generation is more effective than closed loop. Addition of regeneration before turbine increase power generation until 3.39%.

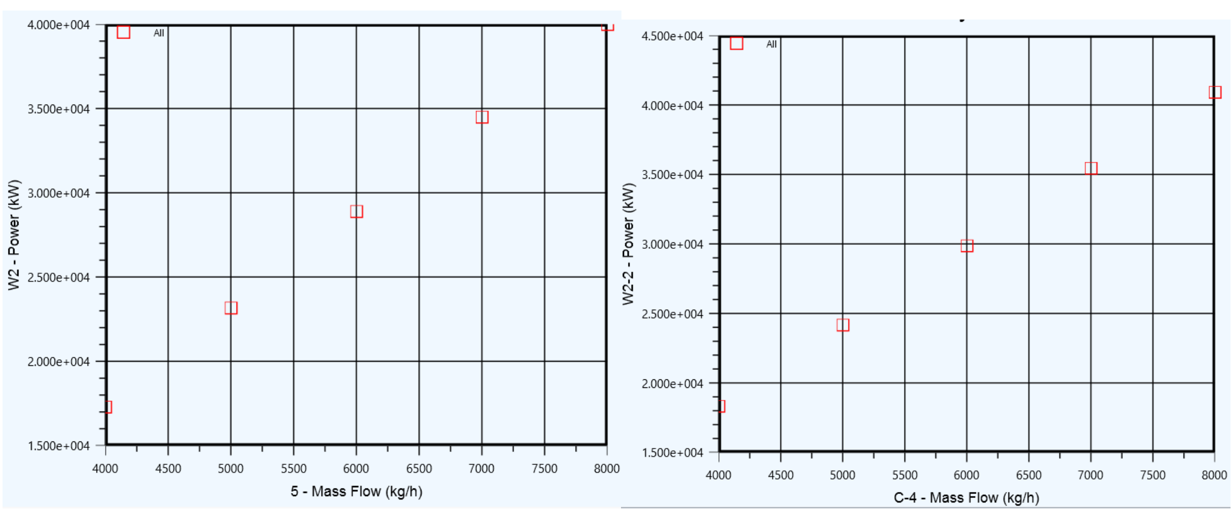

Figure 2. Performance of Gas Turbine with Open Loop (Left) and Open Loop with Regeneration (Right)

Increasing mass flow of Fuel in Combustion Chamber can increase the power generation. Basically, the diference of power that generated is closed. In Open Loop with Regeneration there is Heat Exchanger, that we can set the output of gas that enter in combustion chamber until dT around 10^{o}C (Rules of Thumbs) and make the power generated until 4.461 x 10^4 kW with 8000 kg/h Fuel. Increase of power generated with heat exchanger until 11.53%

Conclussion

Simple open loop is more efficient than closed loop for power generation in gas turbine simulation. Adding regeneration with heat exchanger before entering combustion chamber can increase power generation 3.39% in 6000 kg/h fuel. The value can increase by increasing the fuel with relaxing the temperature of Heat Exchanger until 11.53% in 6000 kg/h fuel.

References

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