GAS TURBINE-STEAM TURBINE POWER PLANT

The air standard cycle for a gas turbine power plant is the Brayton cycle which, like Rankine cycle, also consists of two reversible adiabatics and two reversible

isobars, but unlike Rankine cycle the working fluid does not undergo phase change.

A gas turbine plant can be either open or closed. Simple, open gas turbine plant is shown in Fig. 3.6.

Since the product of combustion is the working fluid which produces power by doing work on the blades of the gas turbine, it is an internal combustion plant. However, unlike the reciprocating internal combustion engine, the gas turbine is a steady flow device and the blades are always subjected to the highest gas temperature.

To limit the maximum gas temperature
to about 1200 K at inlet to the turbine consistent with the materialized, a high air-fuel ratio is used.

The disadvantages of a gas turbine power plant in a utility system are the following:

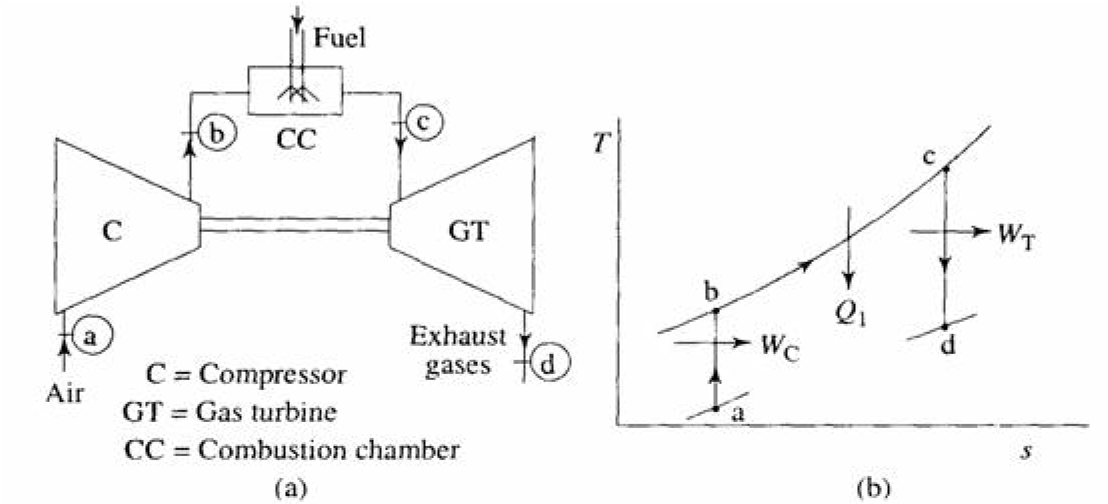

Fig. 3.6 Open cycle gas turbine plant

1. Large compressor work input, since the power required to drive the com pressor is
considerably higher than that required by a pump for the same pressure ris e. The compressor thus consumes a large part of the work produced by the turbine.

2. Large exhaust loss, since the exhaust gas temperature is quite high and also the mass
flow rate of gas is large due to high air —fuel ratio used.

3. Machine inefficiencies, since with the decrease in compressor efficiency (i the work
input to the compressor increases and with the decrease in turbine efficiency (the work
output from the turbine decreases. At certain values of i and 17 a situation may arise
when the compressor consumes more power than what the turbine develop s. So, the machine efficiencies of the compressor and the turbine have to be high enough to yield justifiable net work output.

4. Low cycle efficiency, due to the large exhaust loss, large compressor wor k and
machine inefficiencies.

5. Costly fuel, since the cost of kerosene and other fuels used is much higher than that of
coal. Its availability is also not always guaranteed.

Due to the above factors, the cost of power generated by a stationary gas turbine plant for
a utility system is high. However, a gas turbine plant offers certain advantages also, as given below:

1. Less installation cost

2. Less installation time

3. Quick starting and stopping

4. Fast response to load changes

So, a gas turbine plant is often used as a peaking unit for certain hours of the day when
the energy demand is high. A large steam plant designed to meet peak loa ds would operate at an uneconomical load factor during most of the year.

Thermodynamics of Brayton-Rankine Combined Cycle Plant

Let us consider two cyclic power plants coupled in series, the topping plant operating on Brayton cycle and the bottoming one operating on Rankine cy cle
(Fig. 3.7).

Helium gas may be the working fluid in the topping plant and water in the bottoming plant. As shown in Section 3.4.1, the overall efficiency of the combined plant is given by Eq. (3.6)

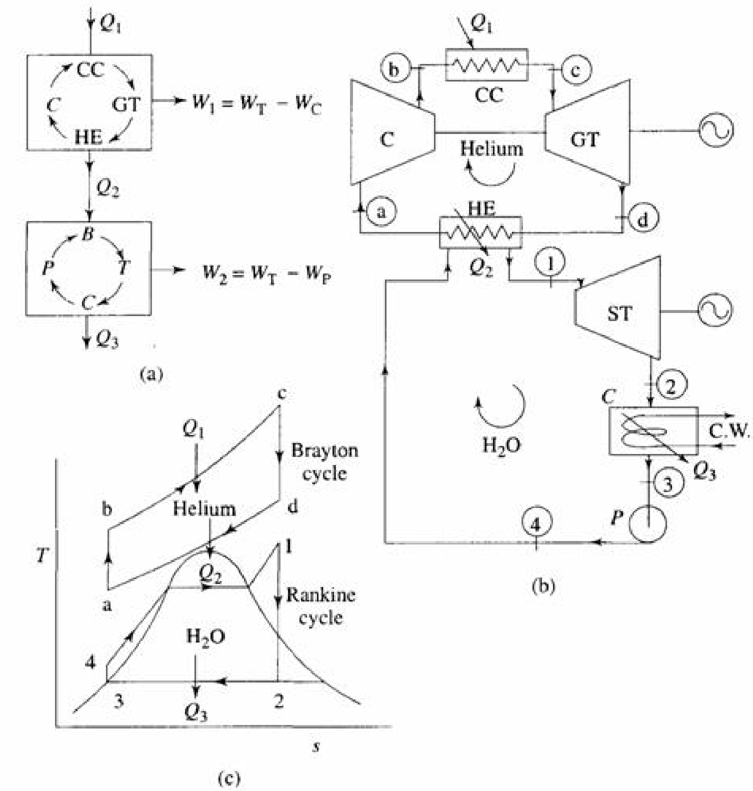

Fig. 3.7 Brayton/Rankine combined cycle plant

$$\eta = \eta_1 + \eta_2 - \eta_1 \eta_2$$

where η_1 and η_2 are the thermal efficiencies of the Brayton cycle and the Rankine cycle, respectively,

neglecting the pump
work.As inlet temperatures to gas turbine keep increasing (due to the use o f better
material and blade cooling), the importance of supplementary firing diminish es further. However, supplementary firing may provide increased operating and fuel flexibilities in CC plants, which may fall into the following two categories.

1. Combined cycle plants with limited supplementary firing

Supplementary firing raises the temperature of the exhaust gas to 800 to 900 ° C.

Relatively high flue gas temperature raises the condition of steam (84 bar, 525 ° C), thereby improving the efficiency of the steam cycle.

Source : http://mediatoget.blogspot.in/2011/10/gas-turbine-steam-turbine-power-plant.html