Gas Turbines

- A gas turbine is a machine delivering mechanical power or thrust. It does this using a gaseous working fluid. The mechanical power generated can be used by, for example, an industrial device.
- The outgoing gaseous fluid can be used to generate thrust. In the gas turbine, there is a continuous flow of the working fluid.

Efficiency is 20 to 30% whereas that of steam power plant is 38 To 48%

Major Applications of Gas Turbine

1. Aviation(self contained, light weight don't require cooling
2. Power Generation
3. Oil and Gas industry(cheaper supply of fuel and low installation cost)
4. Marine propulsion

1

Gas Turbine

Hot gases move through a multistage gas turbine.

Like in steam turbine, the gas turbine also has stationary and moving blades.

The stationary blades

- ✓ guide the moving gases to the rotor blades
- ✓ adjust its velocity.

The shaft of the turbine is coupled to a generator.

2

Working principle :

- Air is compressed(squeezed) to high pressure by a compressor.
- Then fuel and compressed air are mixed in a combustion chamber and ignited.
- Hot gases are given off, which spin the turbine wheels.
- Gas turbines burn fuels such as oil, natural gas and pulverized(powdered) coal.
- Gas turbines have three main parts:

i) Air compressor

ii) Combustion chamber

iii) Turbine

3

Advantages of Gas turbine power plants.

- Storage of fuel requires less area and handling is easy.
- The cost of maintenance is less.
- It is simple in construction. There is no need for boiler, condenser and other accessories as in the case of steam power plants.
- Cheaper fuel such as kerosene , paraffin, benzene and powdered coal can be used which are cheaper than petrol and diesel.
- Gas turbine plants can be used in water scarcity areas.
- Less pollution and less water is required.

4

Disadvantages of gas turbine power plant

1. 66% of the power developed is used to drive the compressor. Therefore the gas turbine unit has a low thermal efficiency.
2. The running speed of gas turbine is in the range of (40,000 to 100,000 rpm) and the operating temperature is as high as 1100 – 1260^{0}C. For this reason special metals and alloys have to be used for the various parts of the turbine.
3. High frequency noise from the compressor is objectionable.

5

Performance Terms

- **Pressure Ratio-** Ratio of the cycle's highest pressure to its lowest pressure.
- **Work Ratio**: Ratio of network output to the total work developed in the turbine.
- **Air Ratio**: kg of air entering the compressor inlet per unit of cycle net output, Kg/kWh
- **Compression efficiency**: Ratio of work needed for ideal air compressor through a given pressure range to work actually used by the compressor.
- **Engine Efficiency**: It is the ratio of the work actually developed by the turbine expanding hot power gas through a given pressure range to that would be yeilded for ideal expansion conditions
- **Machine Efficiency**: Collective term of engine efficiency and compressor efficiency of turbine and compressor.
- **Combustion Efficiency**: It is the ratio of heat actually released by 1 g of the fuel to heat that would be released by complete perfect combustion.
- **Thermal Efficiency**: It is the percentage of total energy input appearing as net work output of the cycle.

6

TYPES OF GAS TURBINE POWER PLANTS

The gas turbine power plants can be classified mainly into two categories. These are :open cycle gas turbine power plant and closed cycle gas turbine power plant.

Open Cycle Gas Turbine Power Plant In this type of plant the atmospheric air is charged into the combustor through a compressor and the exhaust of the turbine also discharge to the atmosphere.

Closed Cycle Gas Turbine Power Plant In this type of power plant, the mass of air is constant or another suitable gas used as working medium, circulates through the cycle over and over again.

7

OPEN CYCLE GAS TURBINE POWER PLANTAND ITS CHARACTERISTICS

Gas turbines usually operate on an open cycle

Air at ambient conditions is drawn into the compressor, where its temperature and pressure are raised. The high pressure air proceeds into the combustion chamber, where the fuel is burned at constant pressure. The high-temperature gases then enter the turbine where they expand to atmospheric pressure while producing power output.

Some of the output power is used to drive the compressor.

The exhaust gases leaving the turbine are thrown out (not re-circulated), causing the cycle to be classified as an **open cycle**

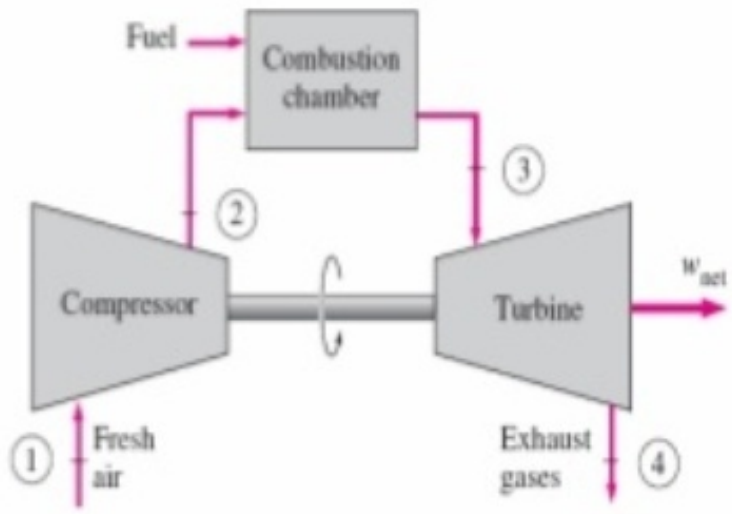


FIGURE 9–29

An open-cycle gas-turbine engine.

8

- The ideal cycle that the working fluid undergoes in the closed loop is the **Brayton cycle.** It is made up of four internally reversible processes:

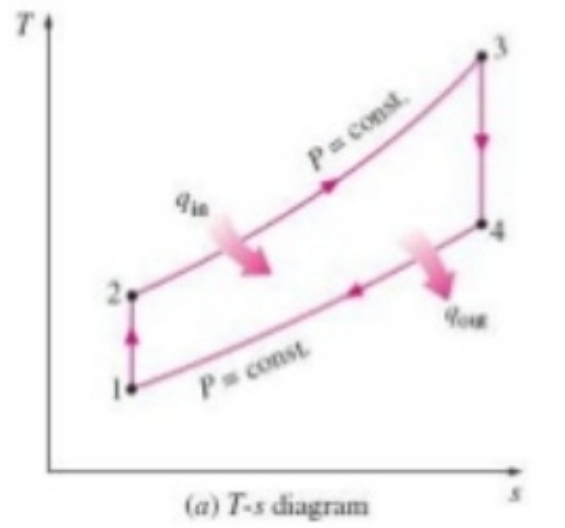
1-2 Isentropic compression;(No change in entropy)

2-3 Constant-pressure heat addition;

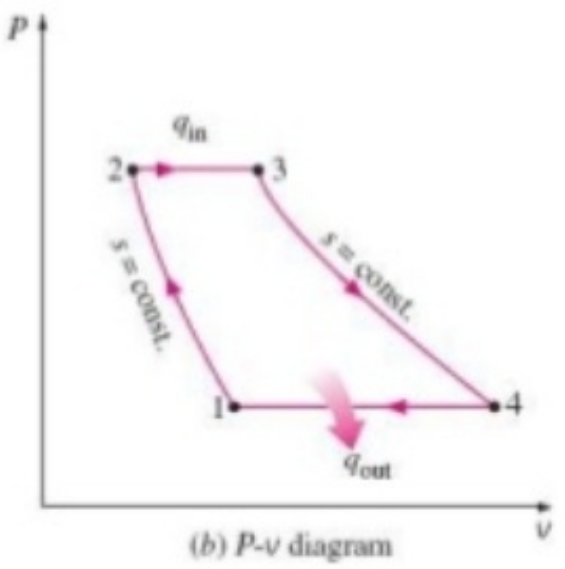
3-4 Isentropic expansion;

4-1 Constant-pressure heat rejection.

The *T-s* diagrams of an ideal Brayton cycle.



(a) *T-s* diagram



(b) *P-v* diagram

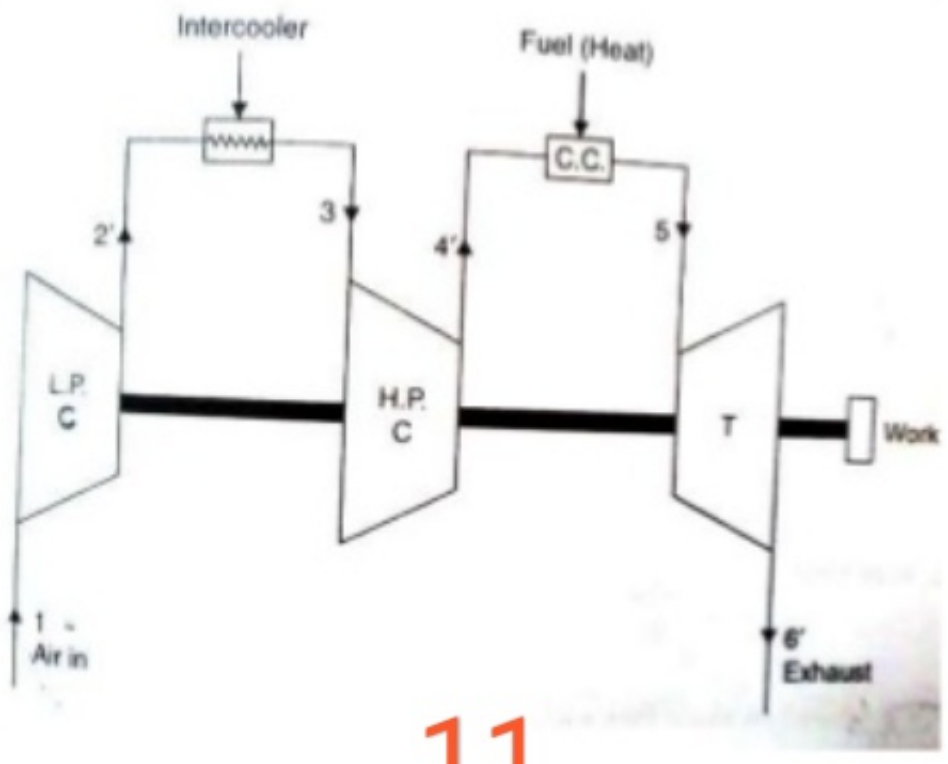
Methods of Improvement of Thermal Efficiency of Open Cycle Gas Turbine Plant

1.Intercooling
2. Reheating
3. Regeneration

10

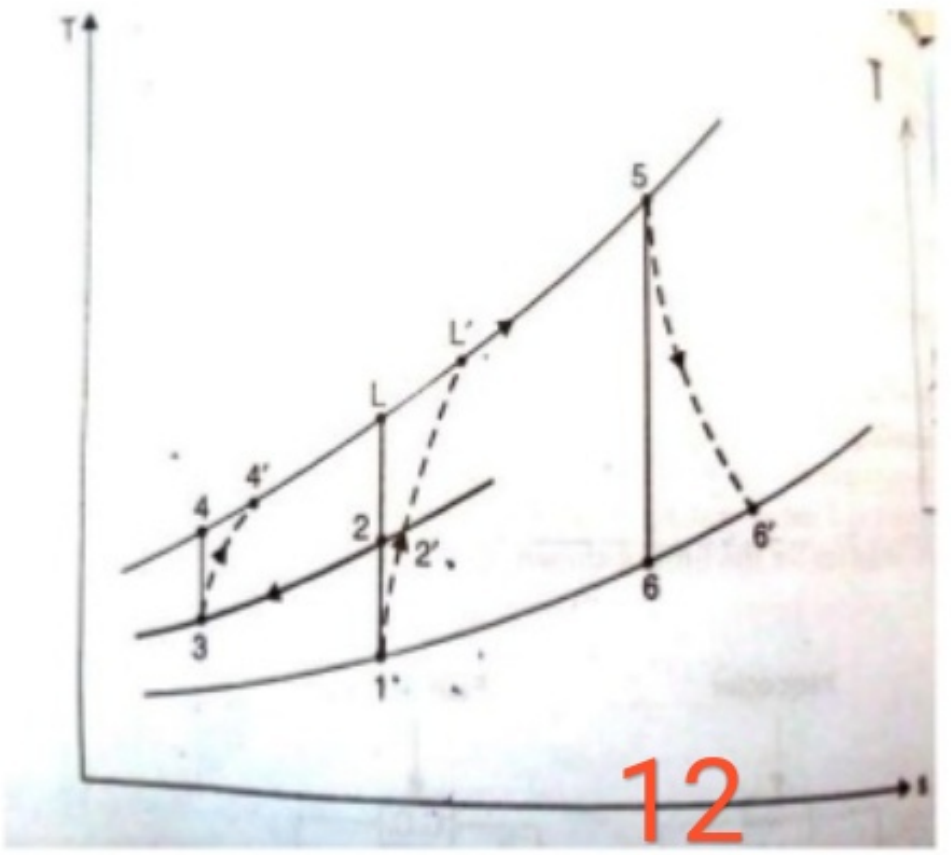
Intercooling

- A compressor utilizes the major percentage of power developed by the gas turbine. The work required by the compressor can be reduced by compressing the air in two stages and incorporation a intercooler between the two.

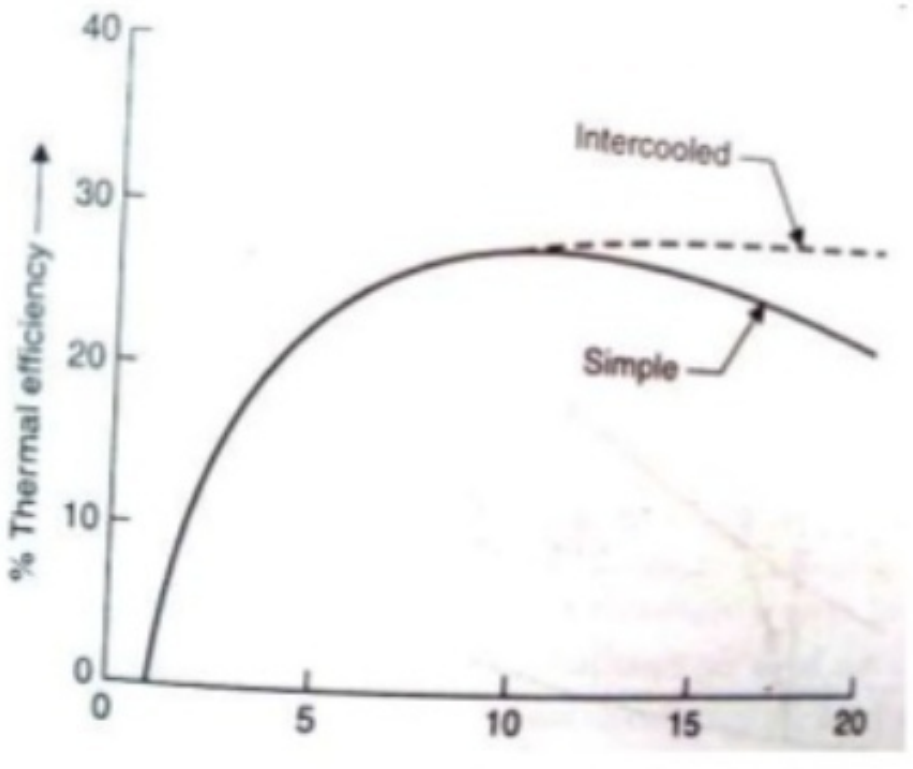


11

- 1-2’: LP compression
- 2’-3: Intercooling
- 3-4’: H.P. compression
- 4’-5: C.C. Combustion chamber(heating)
- 5-6’: T(Turbine) -Expansion



- Work Ratio is increased
- Thermal efficiency decreases but it increases at high pressure ratio.



13