Gas Turbine Power Plant

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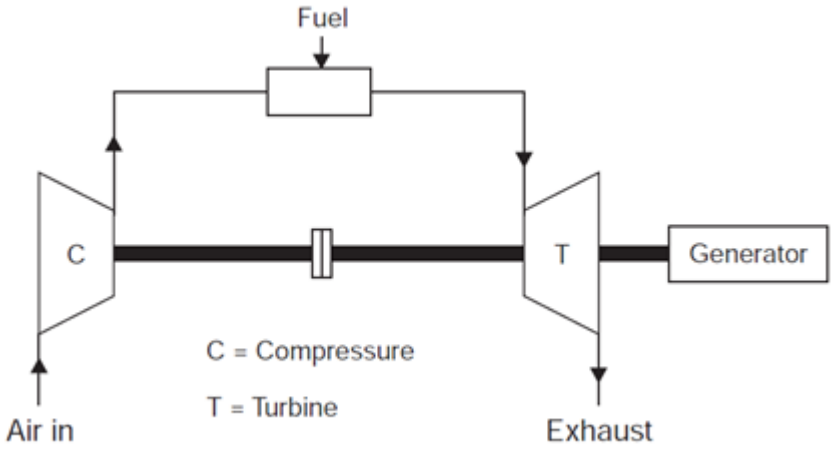
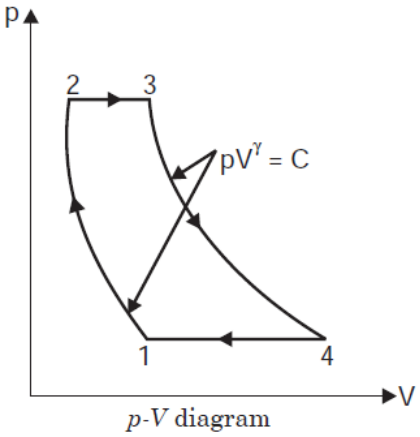


A simple gas turbine plant consists of the following :

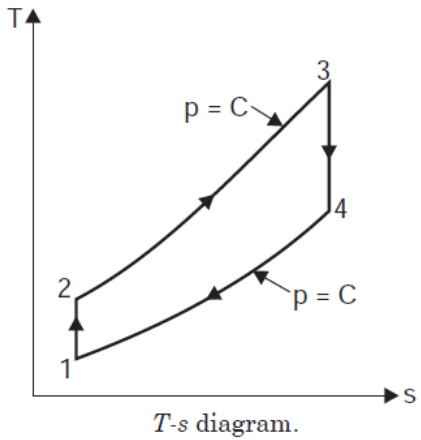
1. *Turbine*.
2. *A compressor* mounted on the same shaft or coupled to the turbine.
3. *The combustor*.
4. *Auxiliaries* such as starting device, auxiliary lubrication pump, fuel system, oil system and the duct system etc.

GAS TURBINE CYCLE—BRAYTON CYCLE

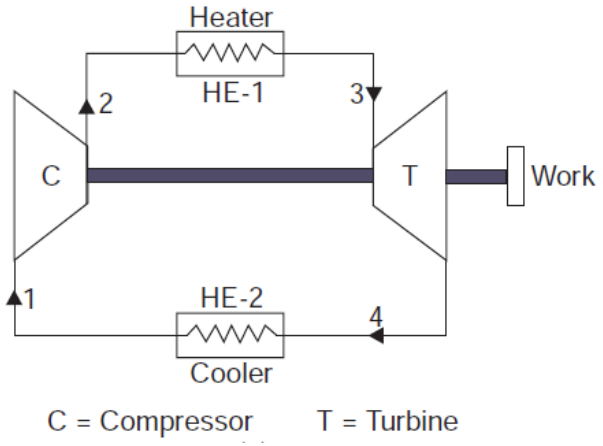
Brayton cycle is *a constant pressure cycle for a perfect gas*. It is also called **Joule cycle.**



p-V diagram



T-s diagram.



Basic components of a gas turbine power plant

Operation 1-2 -- Rev. Adiabatic compression (isentropic)
Operation 2-3 Constant pressure heat supply
Operation 2-3 : Rev. Adiabatic Expansion (isentropic)
Operation 3-4 : Constant pressure heat rejection

Classification of Gas Turbines

Constant pressure combustion gas turbine :

(a) Open cycle constant pressure gas turbine

(b) Closed cycle constant pressure gas turbine

The following are the major fields of application of gas turbines :

1. Aviation

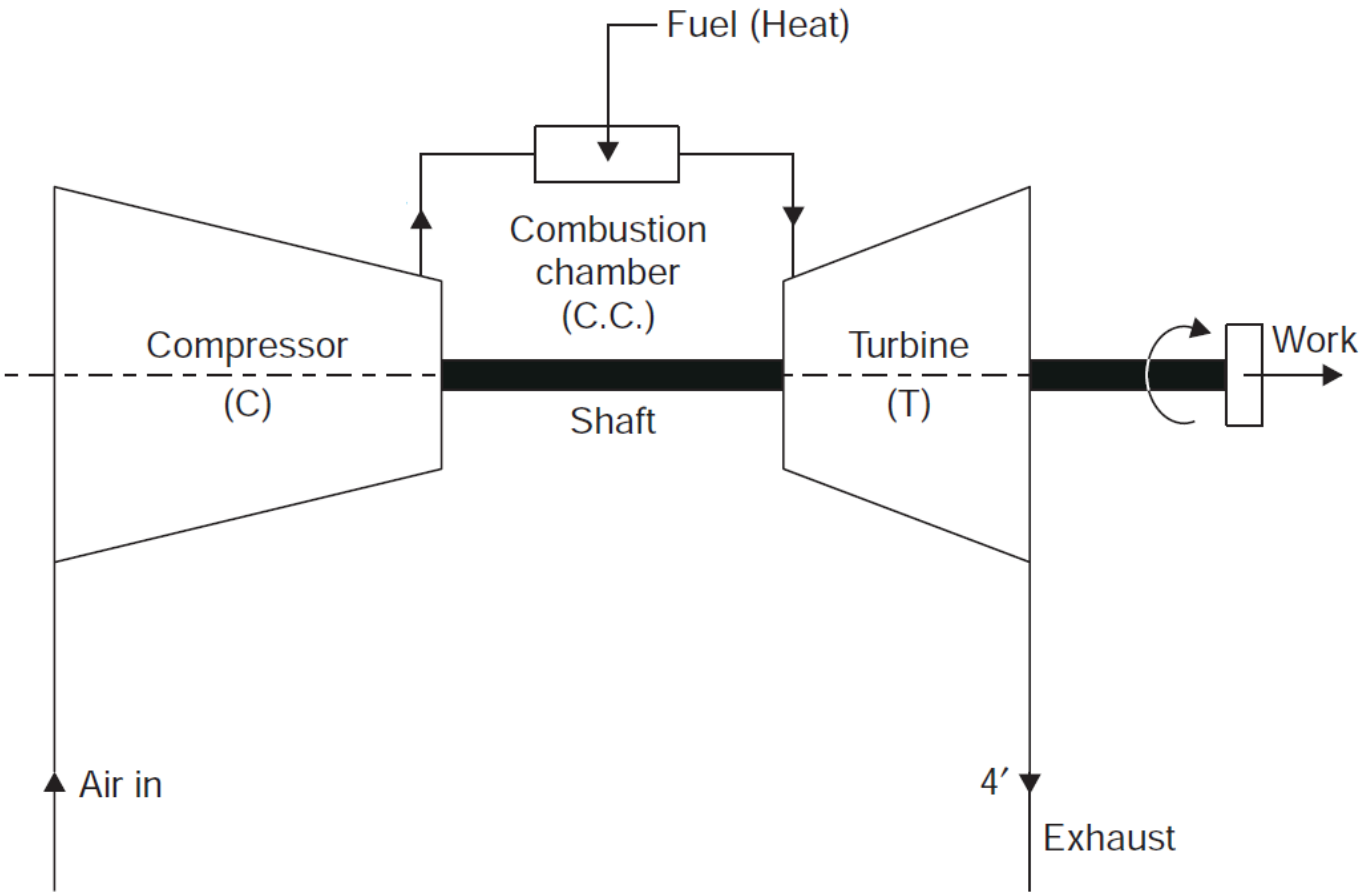
2. Power generation

3. Oil and gas industry

4. Marine propulsion.

The gas turbines have the following limitations : (i) They are not self-starting ; (ii) Low efficiencies at part loads ; (iii) Non-reversibility ; (iv) Higher rotor speeds ; and (v) Overall efficiency of the plant is low

Open Cycle Gas Turbine—Actual Brayton Cycle



Advantages of Gas Turbine

1. The mechanical efficiency of a gas turbine is quite high as compared with I.C. engine since the I.C.
2. A gas turbine does not require a flywheel as the torque on the shaft is continuous and uniform
3. The weight of gas turbine per H.P. developed is less than that of an I.C. engine.
4. The gas turbine can be driven at a very high speeds
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6. Because of low specific weight the gas turbines are particularly suitable for use in aircrafts.

Disadvantages of Gas Turbine

1. The thermal efficiency of a simple turbine cycle is low (15 to 20%) as compared with I.C. engines (25 to 30%).
2. With wide operating speeds the fuel control is comparatively difficult.
3. Due to higher operating speeds of the turbine, it is imperative to have a speed reduction device.
4. It is difficult to start a gas turbine as compared to an I.C. engine.
5. The gas turbine blades need a special cooling system

Work Ratio (r_{bw})

Work ratio is defined as the *ratio of net work output to the work done by the turbine.*

$$\text{Work ratio} = \frac{W_T - W_C}{W_T}$$

$$\left[\begin{array}{ll} \text{where,} & W_T = \text{Work obtained from this turbine,} \\ \text{and} & W_C = \text{Work supplied to the compressor.} \end{array}\right]$$

Back work ratio :

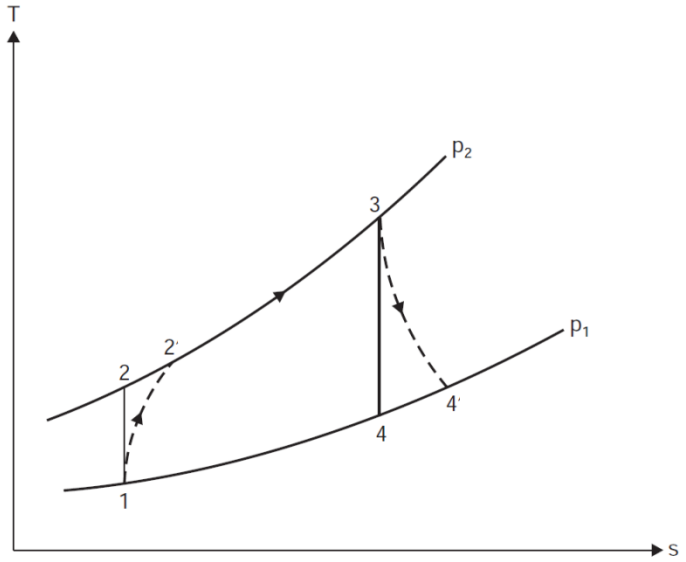
It the ratio of –ve work and +ve work. Or Compressor work and turbine work

$$r_w = 1 - r_{bw}$$

Efficiency of simple gas turbine

$$\eta_{\text{air-standard}} = 1 - \frac{1}{(r_p)^{\frac{\gamma - 1}{\gamma}}}$$

Compressor isentropic efficiency



Compressor isentropic efficiency, η_{comp}

$$= \frac{\text{Work input required in isentropic compression}}{\text{Actual work required}}$$

$$= \frac{c_p(T_2 - T_1)}{c_p(T_2' - T_1)} = \frac{T_2 - T_1}{T_2' - T_1}$$

Turbine isentropic efficiency, $\eta_{turbine}$

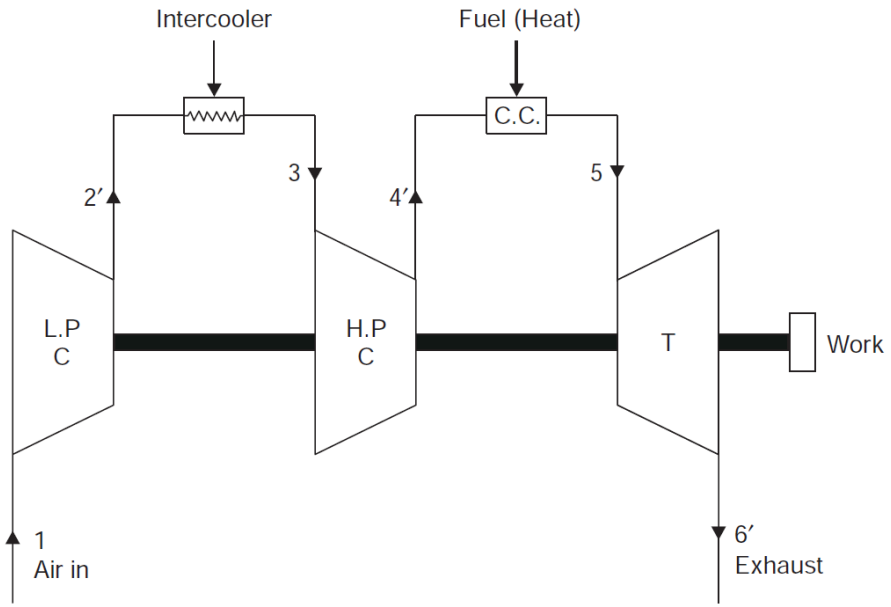
$$= \frac{\text{Actual work output}}{\text{Isentropic work output}}$$

$$= \frac{c_p(T_3 - T_4')}{c_p(T_3 - T_4)} = \frac{T_3 - T_4'}{T_3 - T_4}$$

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

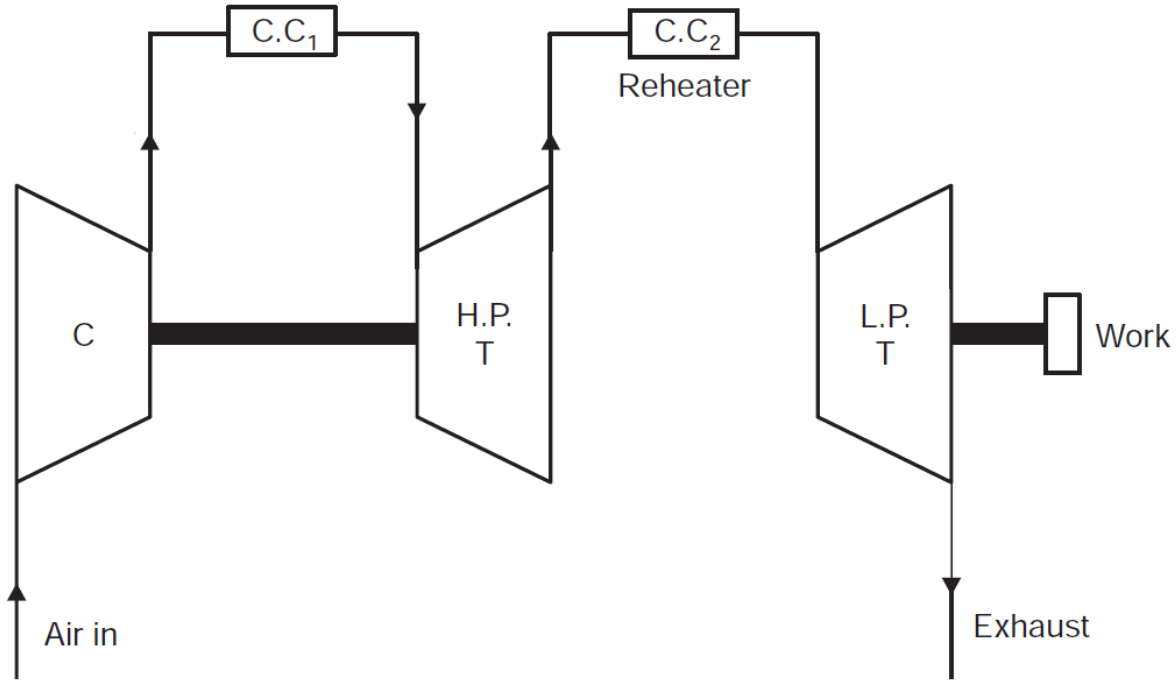
1. Intercooling
2. Reheating

Intercooling: A compressor in a gas turbine cycle utilises 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 an intercooler between the two compressor.



Reheating

The output of a gas turbine can be amply improved by expanding the gases in two stages with a reheater between the two as shown in Fig. . The H.P. turbine drives the compressor and the L.P. .



Regeneration

The exhaust gases from a gas turbine carry a large quantity of heat with them since their temperature is far above the ambient temperature. They can be used to heat the air coming from the compressor thereby reducing the mass of fuel supplied in the combustion chamber. Fig. shows a gas turbine plant with a regenerator.