Nilachal Polytechnic

Bhubaneswar

[redacted]

Sem. : 6th **Subject : Power Station Engg.**

Branch : Mech. Engg. **Sec : A & B**

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Text Book to be followed : A text book of Power Plant Engg. by R. K. Rajput

Ch. No. : 06 Name : Gas Turbine Power Station

Introduction

In the gas turbine the chemical energy of the fat liquid fuel into mechanical work by internal combustion gaseous product of the fuel are expanded through a turbine.

The gas turbines are mainly used in the following field.

a) Aviation
b) Power generation
c) Oil and gas industry
d) Marine Propulsion

The thermal efficiency of the gas turbine alone is still quite modest 20% to 30% compared with that of a modern steam plant of 38% to 40%.

The gas turbines are mainly used in aviation and marine field because it is self contained, light in weight and does not require cooling. Also it is selected for power generation for its simplicity, lack of cooling water, needs quick installation and quick starting. It is mainly used in oil and gas industries because of cheaper supply of fuel and low installation cost.

Application of gas turbine power plant

a) For peak load.
b) To work as combination plants with conventional steam power plant.
c) To supply mechanical drive for auxiliaries.

Advantage & Disadvantage of Gas turbine Power Plant over Diesel & thermal power station.

Advantage (with Diesel Power Station)

1) Work developed per kg of air is large compared to diesel Power Plant.
2) Less vibration due to perfect balancing.
3) Less space required.

4) Less capital cost.
5) Higher mechanical efficiency.
6) More running speed (i.e 40,000 to 100000 rpm) large in compared to diesel engine (i.e 1000 to 2000 rpm).
7) Lower maintenance and installation cost.
8) Better torque developed in compared to diesel engine.
9) Ignition and lubrication system are simpler.
10) Specific fuel consumption does not increase with time in compared to diesel power plant.

Advantage (with steam power station)

1) No ash handling problem.
2) Low capital cost
3) Less floor area
4) Fewer auxiliaries can run the unit.
5) Quicker installation.
6) Thermal efficiency improve three times when its temp. rises above 550^{o}C in compared to steam power plant.
7) Cooling water is not required so location problem is not a factor.
8) The gas turbine power station can work quite economically for shorter running hour.

Disadvantage

1) Fuel cost is main factor for our country.
2) Poor part load efficiency.
3) Special metals and alloys are required for different components of the plant which leads to the cost factor.
4) Special cooling methods are required for the cooling of the turbine blades.
5) Short life.

Site Selection

1) It should be installed near the load centre to minimize the transmission loss.

2) Availability of worker

3) Availability of means of transportation.

Fuels used in gas turbine

1) Gaseous fuel (Natural gas)

2) Liquid fuel (distillated oils and residual oils, gasoline, kerosene oil etc.)

3) Coal in pulverized form of much lighter and smaller than its counterpart in steam power plant. But it is not preferable.

Components of a gas turbine power station

1) Gas turbine

2) Compressor

3) Combustor

4) Inter coolers and regenerations.

Gas Turbine

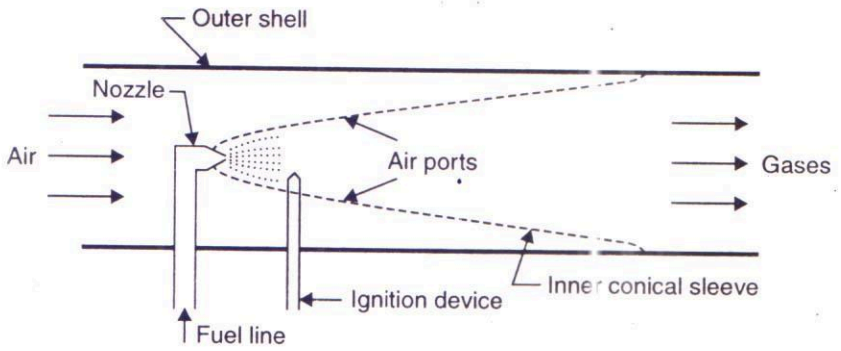
- ✔ The flow of high pressure gas enter to the turbine axially and tangentially to the rotor.
- ✔ The basic requirement of a gas turbines are
  - i) Light in weight.
  - ii) Reliability in operation.
  - iii) Long working life
  - iv) Sustain higher stress.

Compressor

- ✔ It is used to compared the air to high pressure by the help of Centrifugal type or Axial flow type compressor.
- ✔ Mainly the centrifugal type of compressor is used which have impellor and diffuser. The impeller impart high K.E to the air and the diffuser converts the high K.E to pressure energy.
- ✔ It may be of single stage or multi stage. The multi stages produces more presser.
- ✔ The axial flow compressor is capable to deliver. Constant vol. of air over varying discharge pressure.

Combustor / Combustion Chamber

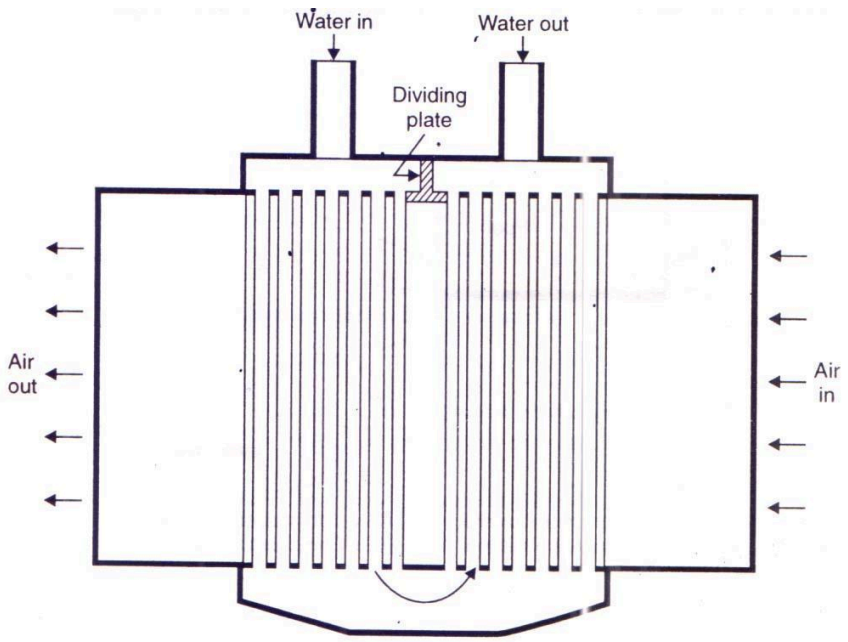
- ✔ The primary function of the combustor is to provide for the the chemical reaction of fuel and air being supplied by the compressor.
- ✔ The physical process of combustion may be follow in following steps.
  - a) Formation of reactive mixture.
  - b) Ignition.
  - c) Flame propagation
  - d) Cooling of combustion product with air



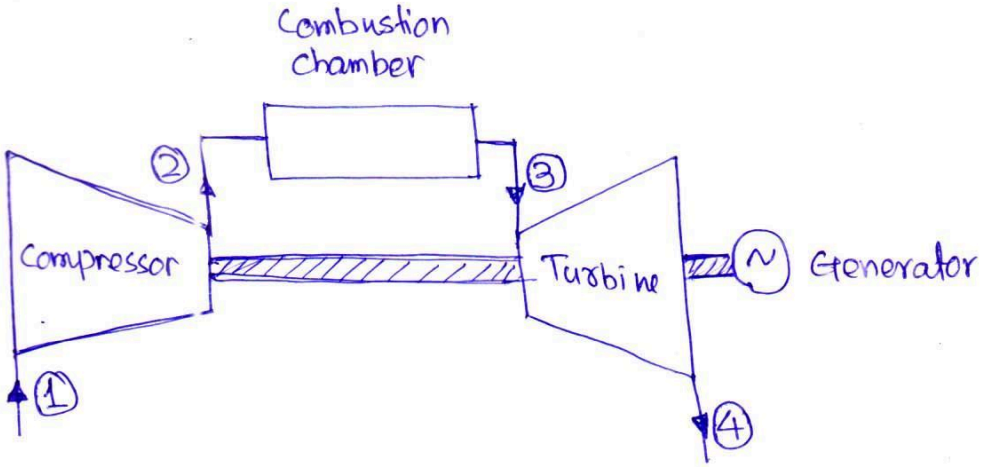
Arrangement of a combustor.

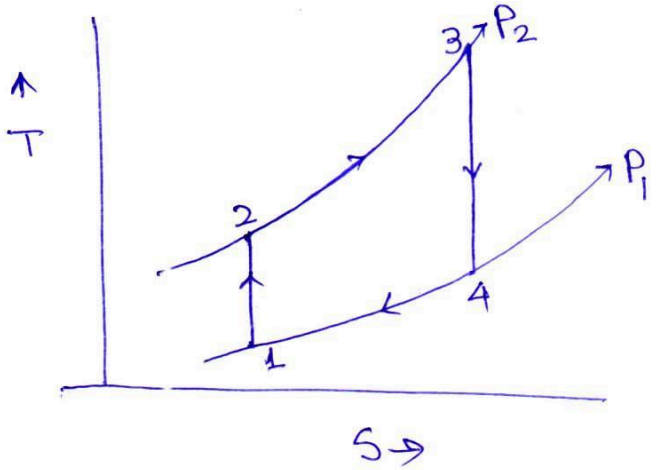
Inter Cooler

- ✔ It is generally used when the pressure ratio used is sufficiently large and compressor is multi stage.
- ✔ The cooling of compressed air is generally done with the use of cooling water.
- ✔ A cross flow type intercooler is generally preferred for effective heat transfer.



Intercooler.





1-2 → Irreversible adiabatic compression.
2-3 → Const. Press. heat addition
3-4 → Irreversible adiabatic expansion.
4-1 → Const. Pressure. heat rejection (if it is a closed cycle)
At Point (4) exhaust if it is an open cycle.

Work out Put in turbine = $C_p(T_3 - T_4)$
work input in Compressor = $C_p(T_2 - T_1)$
heat Supplied in C.C. = $C_p(T_3 - T_2)$

$$\eta_{th.} = \frac{C_p(T_3 - T_4) - C_p(T_2 - T_1)}{C_p(T_3 - T_2)} = \frac{(T_3 - T_4) - (T_2 - T_1)}{(T_3 - T_2)}$$