

- Q. 1** Draw and explain layout of hydro-electric power plant (HEPP). What are the important factors while selecting the site for HEPP plant? 4+
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- Q. 2** What are the effects of variation of steam condition on thermal efficiency of steam power plant? 5
- Q. 3** Explain performance parameter for gas turbine power plant with curves. **OR** 5
A turbine is to operate under a head of 24m at 200 rpm. The discharge is 8.5 m³/s. If the overall efficiency is 88%, determine a) power generated; b) Specific speed of the turbine; c) type of turbine
- Q. 4** Compare gas turbine power plant and diesel power plants. 4

Solutions:

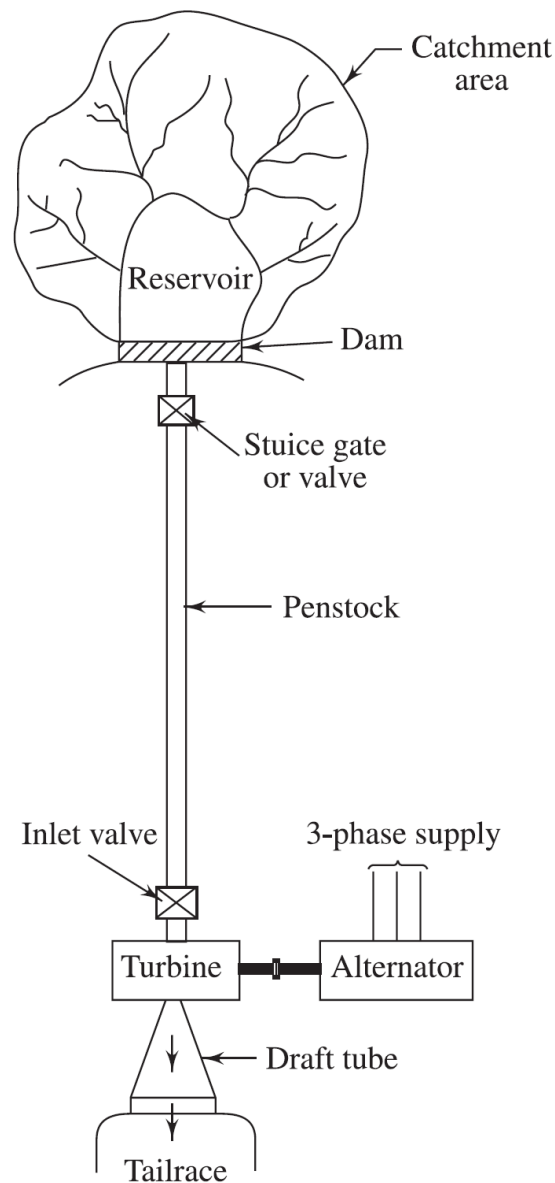
**Q. 1 Draw and explain layout of hydro-electric power plant (HEPP).
What are the important factors while selecting the site for HEPP plant?**

Solution:

Hydroelectric power plants convert the hydraulic potential energy from water into electrical energy. Such plants are suitable where water with suitable head are available. The different parts of a hydroelectric power plant are (explain each part):

1. Catchment area
2. Reservoir
3. Dam
4. Spillways
5. Conduits
6. Surge tanks
7. Water turbine

8. Draft tubes
9. Tail race
10. Powerhouse



Layout of hydro-electric power plant

The selection of site depends on the function of the dam. Smaller the length of dam, less are the costs. The following factors should be considered while selecting the site for hydroelectric power plant (explain each factor).

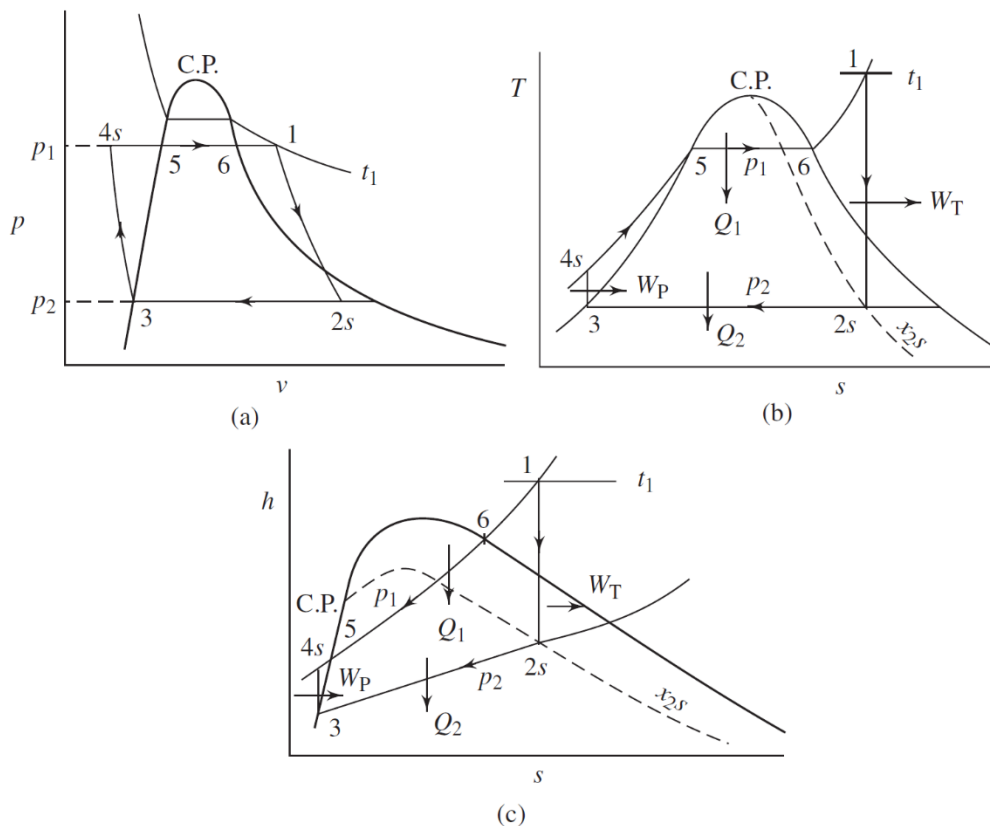
1. Availability of water
2. Water storage capacity
3. Available water head

4. Accessibility of the site
5. Distance from the load centre
6. Type of land of site
7. Geology of foundations
8. Hydrologic factors and river diversion during construction
9. Availability of construction material availability of knowhow
sociological factors like the area which would get submerged under water after the construction of the dam, displacing people and disturbing the ecology.

Q. 2 What are the effects of variation of steam condition on thermal efficiency of steam power plant?

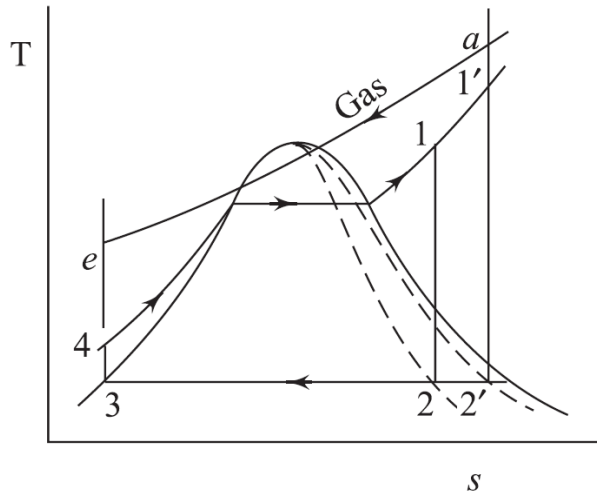
Solution:

Firstly explain Rankine cycle on $p - v$, $T - s$ and $h - s$

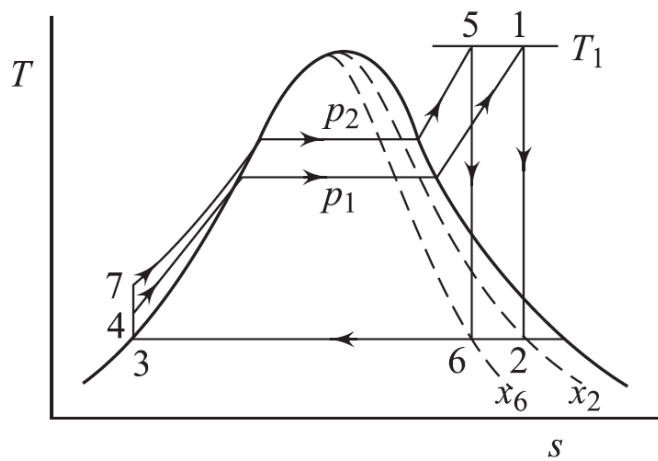


Then discuss the effect of variation of various parameters on efficiencies

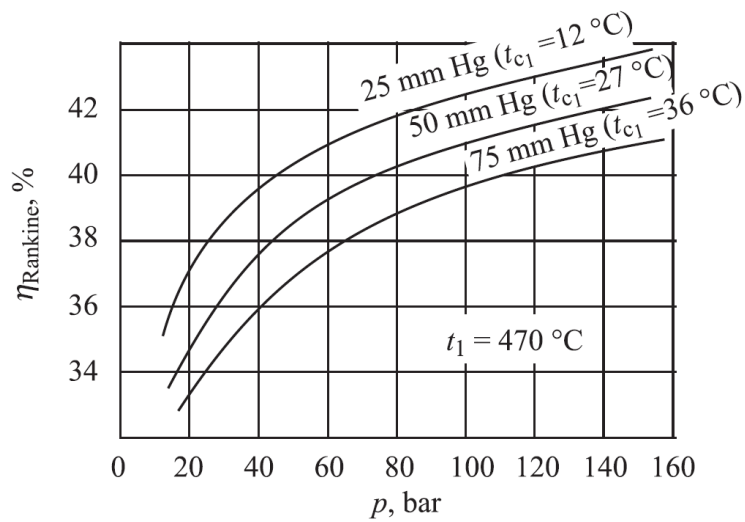
Effect of Superheat



Effect of Increase of Inlet Pressure



Effect of inlet steam pressure (p_1) and condenser pressure on Rankine efficiency with constant inlet steam temperature of $470\text{ }^\circ\text{C}$



Q. 3 A turbine is to operate under a head of 24m at 200 rpm. The discharge is 8.5 m³/s. If the overall efficiency is 88%, determine a) power generated; b) Specific speed of the turbine; c) type of turbine.

Solution: Data given are: H = 24 m; N = 200 rpm; Q = 8.5 m³/sec; $\eta_o = 88\%$

Water Power, $P_w = \rho.g.Q.H/1000$, kW 2001.24 kW;

(i) Power generated

$$\eta_o = \text{Shaft power} / \text{Water Power}$$

$$\text{So, Power Generated} = \eta_o \times \text{Water Power} = 1761.09 \text{ kW};$$

(ii) **Specific speed of the turbine (N_s)**

$$N_s = N \cdot \sqrt{P} / H^{5/4} = 200 \cdot \sqrt{1761.09} / (24)^{5/4} = 158$$

(iii) Here given operating head is 24 meters. Calculated specific speed is 158, these both data indicate towards a criterion of low head and medium specific speed turbine.

Francis turbine is a suitable type of turbine which fulfils both these criteria. Hence, turbine used will be **Francis turbine**.

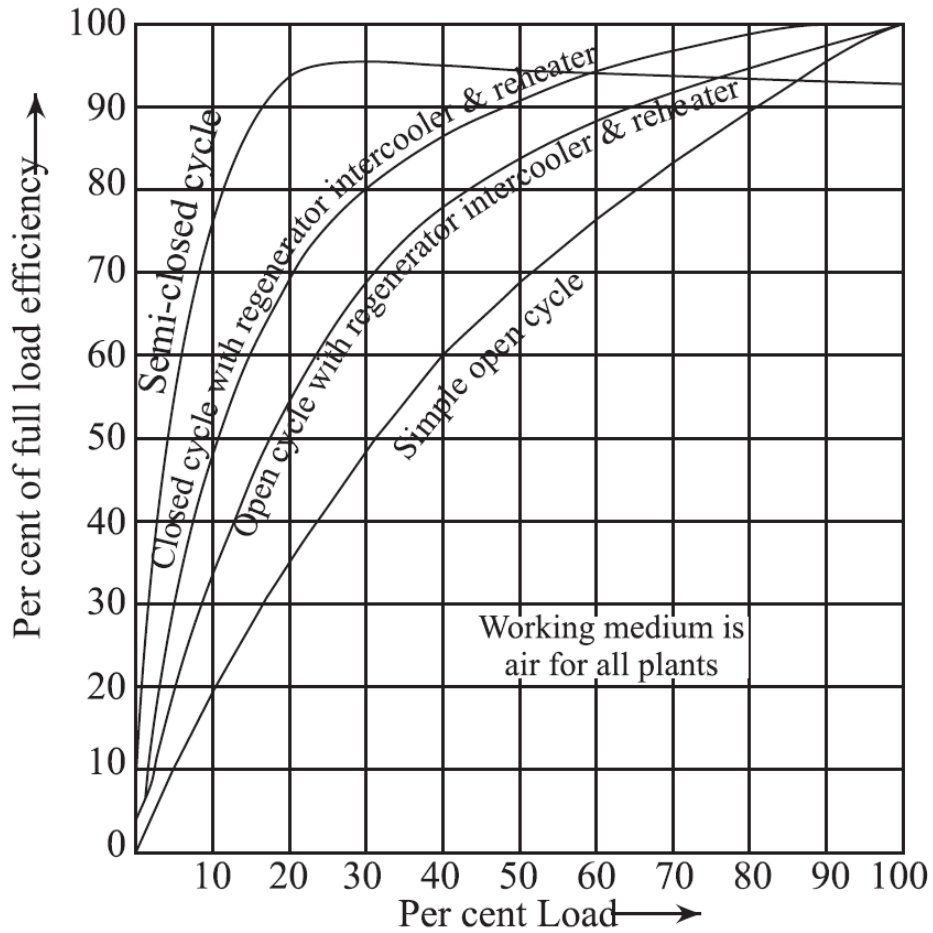
OR

Q. 3 Explain performance parameter for gas turbine power plant with curves.

Solution: Performance parameter for gas turbine power:

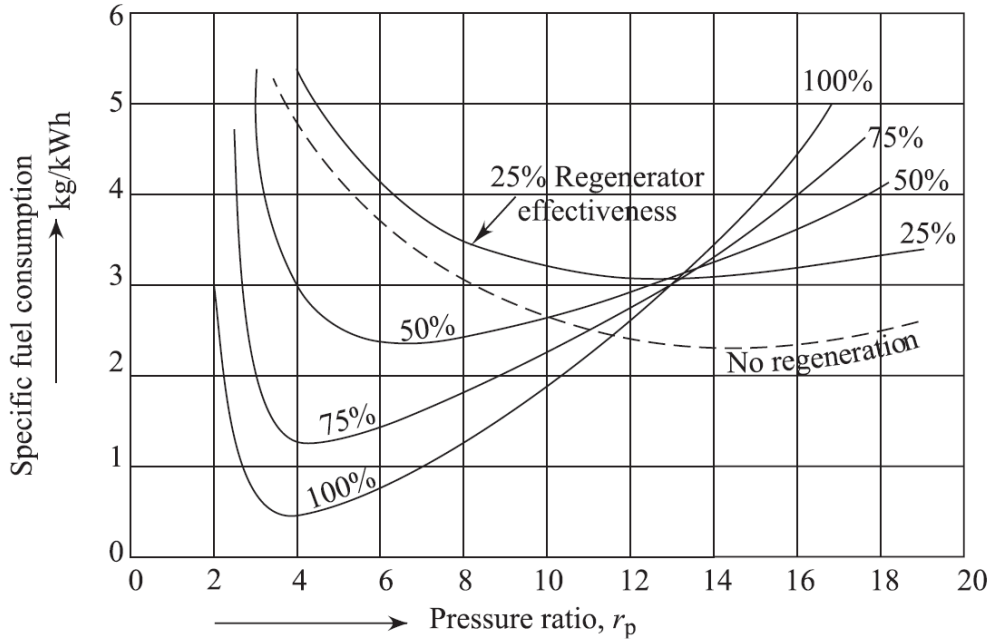
- The turbine plant works under variable load conditions. It is thus necessary to study the effect of load on the cycle efficiency which is directly concerned with the running cost of the plant.
- It is necessary to study the effect of pressure ratio on the thermal efficiency, air mass flow and specific fuel consumption with regenerative reheat and intercooled cycle, because smaller mass flow rate for the given output reduce the component sizes and the plant capital costs. Lower fuel consumption reduces the running cost of the plant.

- ❖ **Part Load Efficiency:** The part load efficiencies for open cycle, closed cycle and semi-closed cycle shown in fig. The part load performance of the semi-closed cycle is seen to be the best.



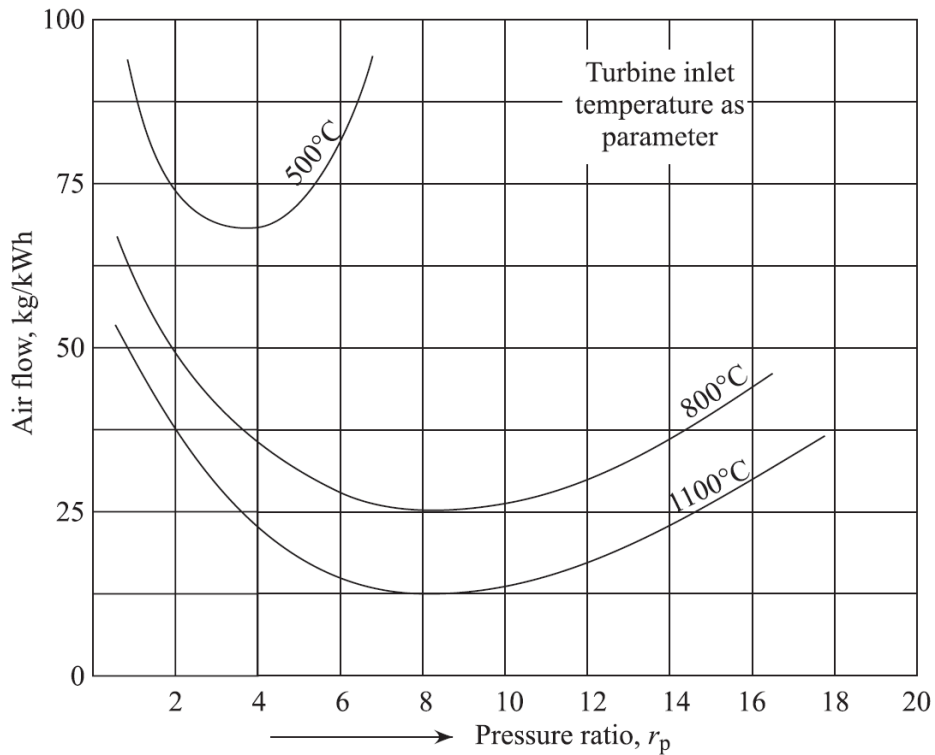
Part load efficiencies for different plants

Fuel Consumption: The effect pressure ratio on the specific fuel consumption of an open cycle plant with degree of regeneration as a parameter is shown in fig. it shows that for each degree of regeneration there is an optimum pressure ratio for minimum specific fuel consumption.



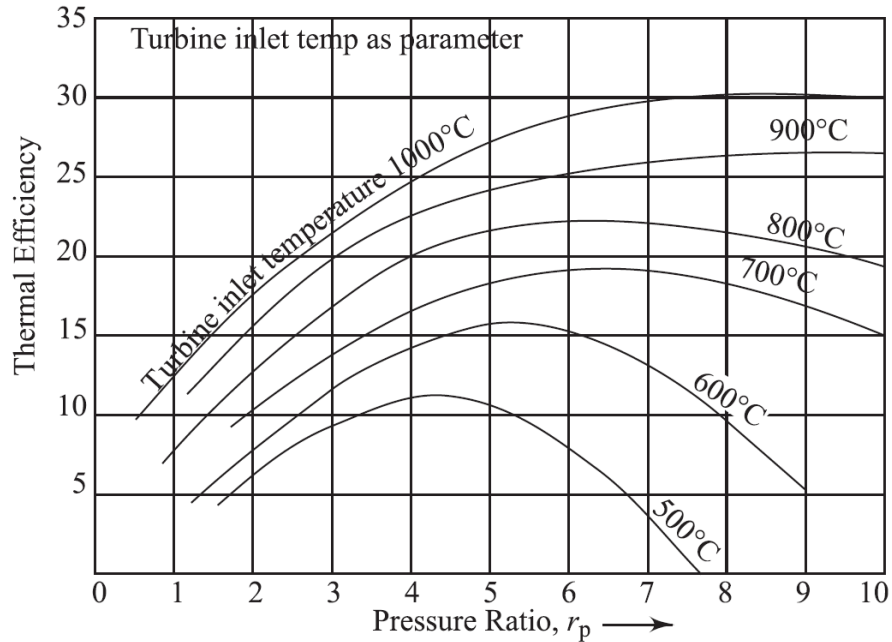
Effect of regenerator effectiveness on specific fuel consumption

Air Flow Rate: The effect of pressure ratio on the air mass flow for an open cycle plant with the turbine inlet temperature as a parameter is shown in fig. It indicates optimum pressure ratio for different turbine inlet temperatures requiring minimum air flow rates.

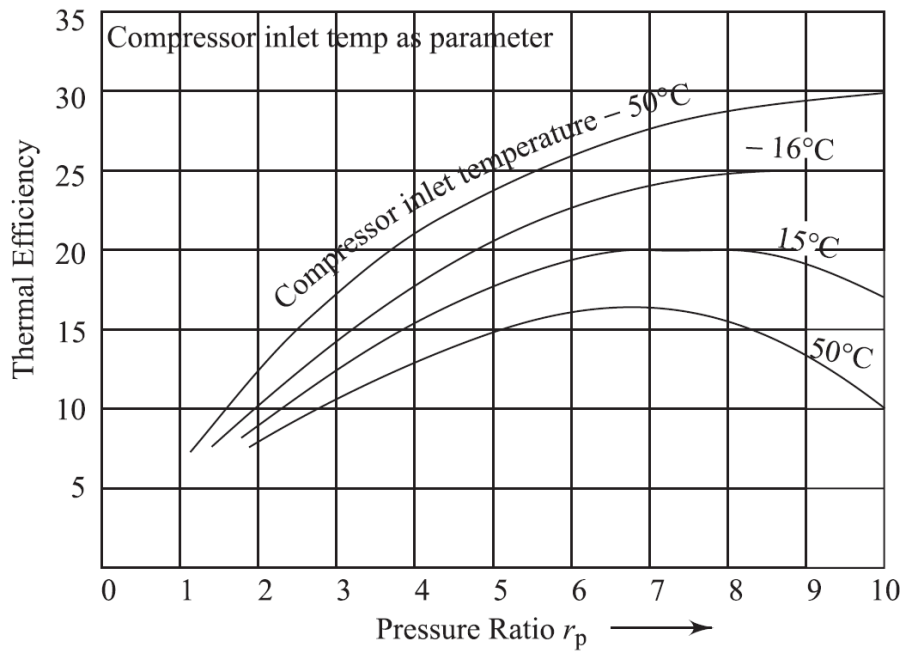


Effect of pressure ratio on air mass flow per unit output

Thermal Efficiency: The effect of pressure ratio of a simple open cycle plant with (a) turbine inlet temperature as a parameter and (b) Compressor inlet temperature as parameter.



(a)



(b)

Q. 4 Compare gas turbine power plant and diesel power plants.

Solution:

Main Difference between GT and Diesel Engine power plants:

The combustion of fuel-air mixture inside the Petrol or Diesel Engine is intermittent. The combustion inside the combustion chamber of a GT is continuous.

Advantages of GT in comparison to diesel power plant:

- ✚ GT is lighter and more compact than Vapor Power Systems or even IC Engines of same power. A gas turbine does not depend on water supply.
- ✚ GT has fewer auxiliary components than Vapor Power System.
- ✚ The favourable power-to-weight ratio of GT compared to others makes it well suited for aviation and maritime applications (commercial and military aircraft propulsion, marine power plants etc.)
- ✚ Short set-up time and less capital cost has made GT to be applicable in stationary power generation too.
- ✚ The starting of this turbine is easy and quick. Starting time of GT is very short (2-3 minutes). It can attain full load within 5 minutes. With the changing load conditions, its control is easy.
- ✚ Moves in one direction only, with far less vibration than a reciprocating engine.
- ✚ Fewer moving parts than reciprocating engines. The mass of gas turbine per kW produced is less. Less installation and running cost.
- ✚ Low lubricating oil cost and consumption.

Disadvantages of GT in comparison to diesel power plant:

- Higher maintenance cost.
- Life span is 12 to 15 years on average.
- Overall efficiency of GT is very low.
- Cost of a GT is higher than the cost of a similar sized reciprocating engine.
- Fabrication process of GT parts is also complex.