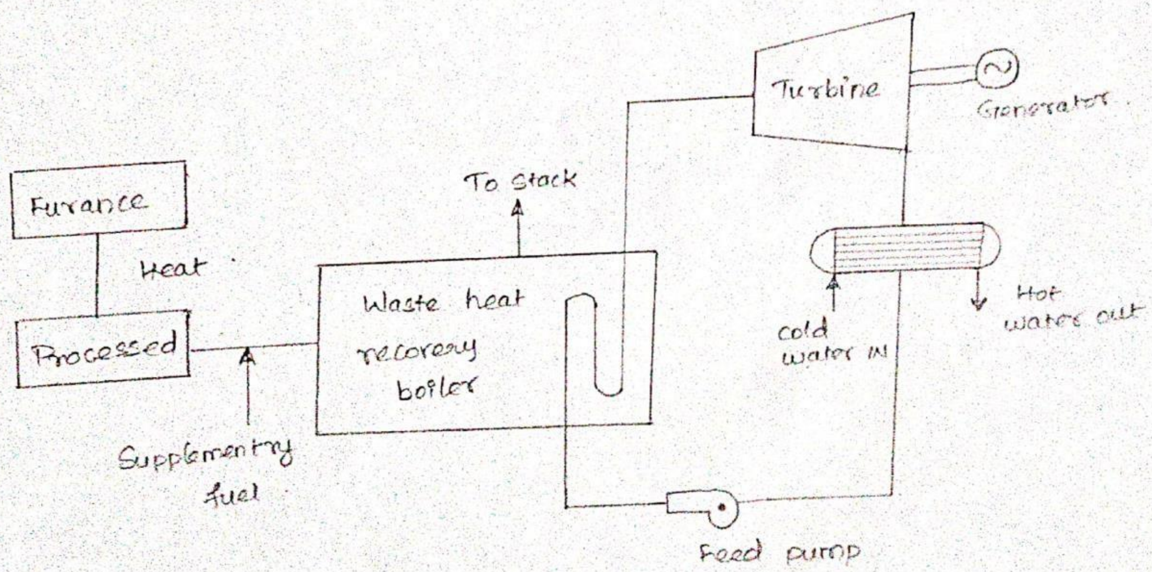
Combined cycle plants for cogeneration :-

Whenever both electrical power and process steam are needed, it is thermodynamically and economically better to produce both the products in a single plant by cogeneration. In this, the primary heat is used at high temperature directly for process requirements and the exhaust gases from the furnace are then heated by supplemental fuel before it goes to the waste recovery boiler.

The steam is produced by passing the feed water through the waste heat recovery system and this steam is used for power generation. The warm water is condensed in the condenser and it is circulated again.

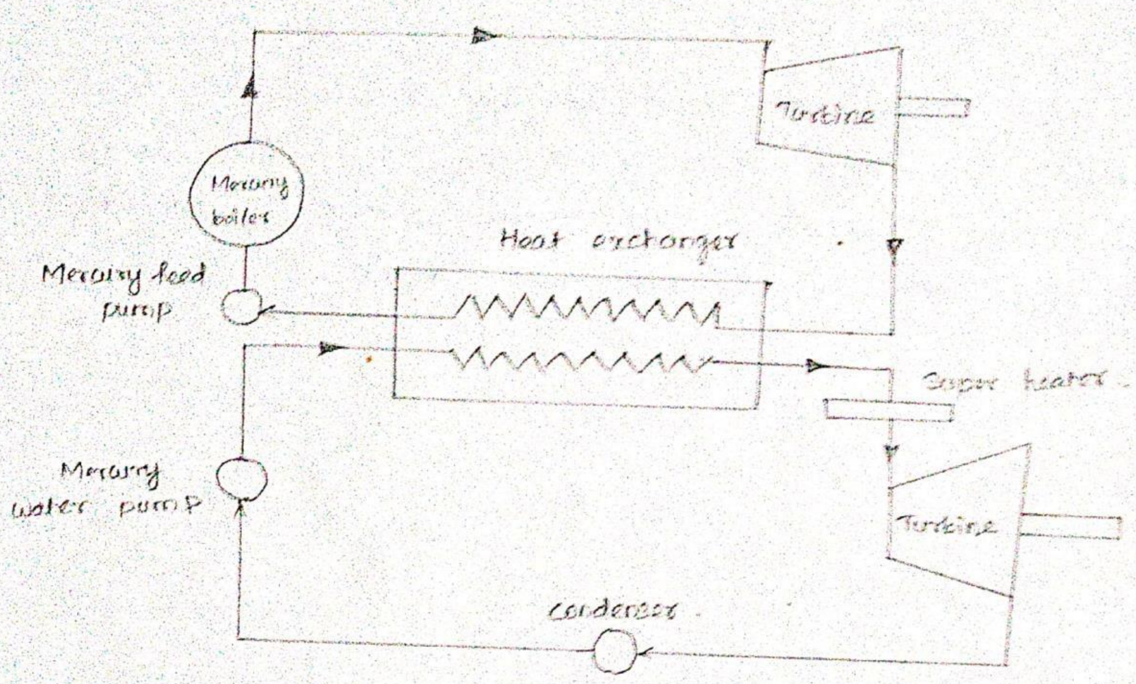


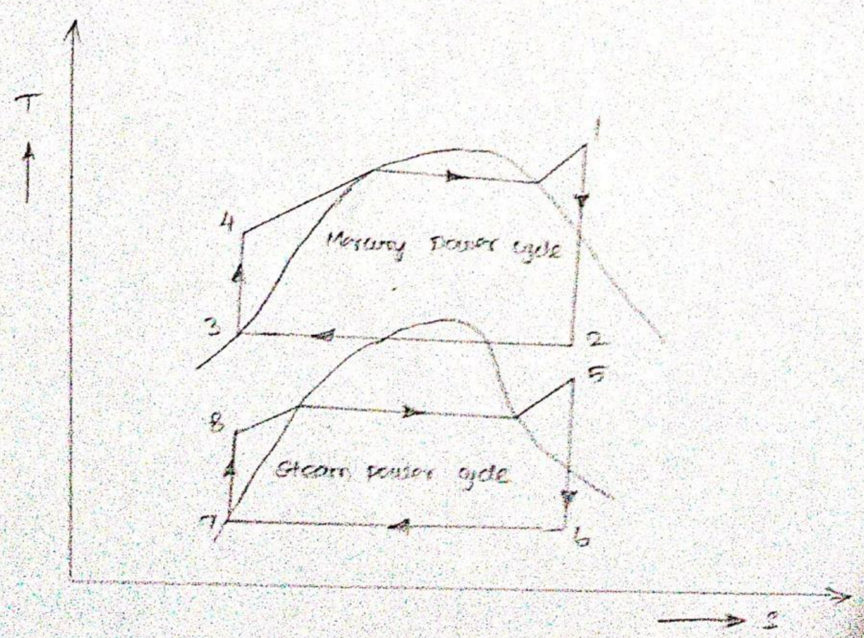
- Combined cycle plant for co-generation.

Binary Vapour cycle :-

It is one type of combined cycles in which usually two working fluids mercury and water are used to improve the overall thermal efficiency of the power plant.

For getting the best performance of vapour power cycle, the working fluid should have the following characteristics.

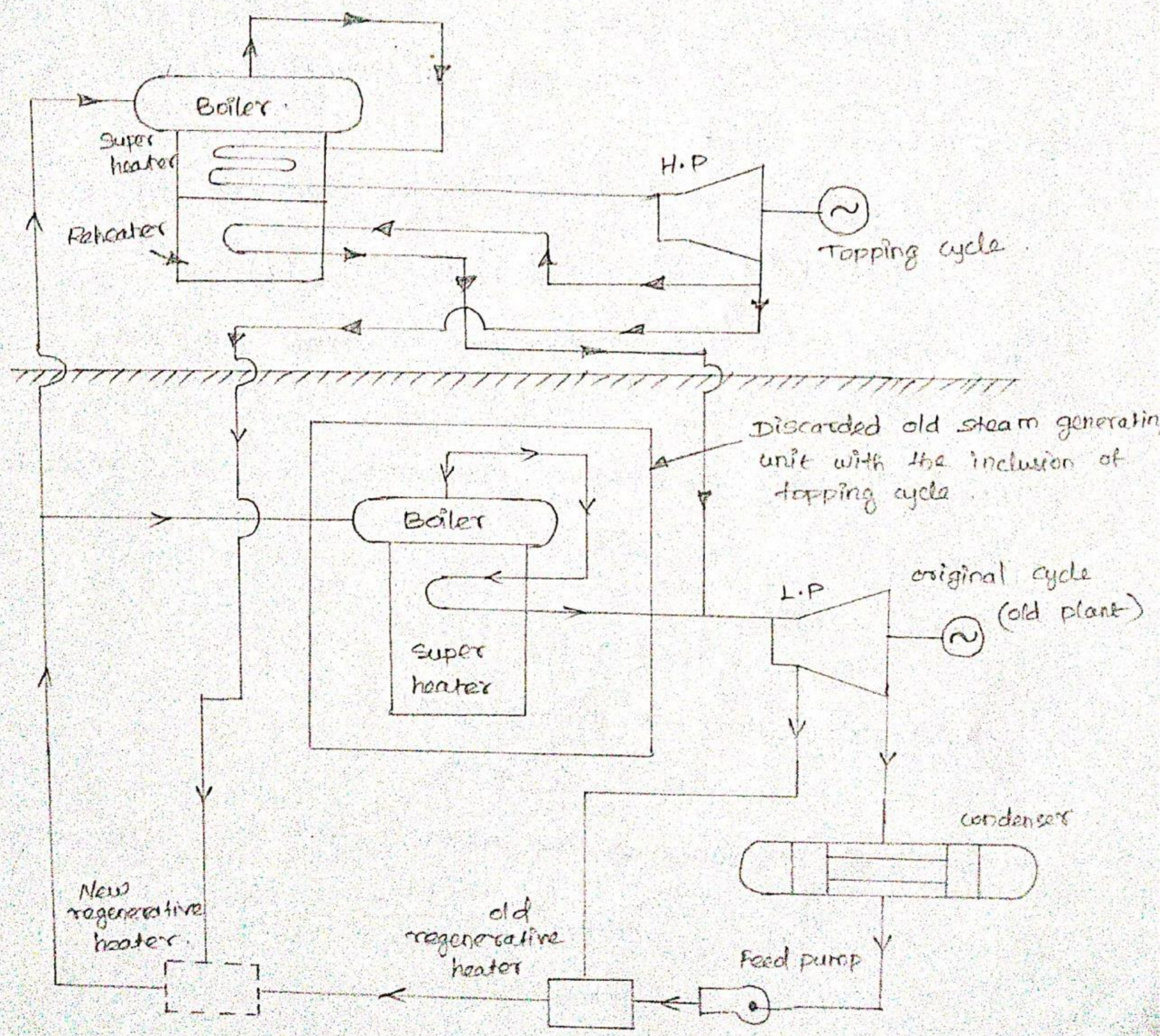




1. High enthalpy of Vapourization
2. Good heat transfer characteristics.
3. High critical temperature with a low corresponding Saturation temperature.
4. High Condenser temperature.
5. Freezing temperature should be below room temperature.

The cycle has one high temperature region and one low temperature region. This is called a binary Vapour cycle. In this cycle, the condensor of the high temperature cycle called topping cycle, and the low temperature cycle termed as bottoming cycle.

1. Topping cycle:-



The process 1-2 shows the expansion of the mercury vapour in the mercury turbine. Process 2-3 represents the condensation of the mercury in the condenser or heat exchanger where the heat exchanger from mercury vapour to water. Process 3-4 shows the pumping work and process 4-1 represents heating of the liquid mercury to the saturation temperature.

2. Bottoming cycle :-

The heat removed from the mercury is used for heating the liquid. It is shown by the process 8-9. The process 9-5 represent the superheated steam in the superheater.

The super heated steam is expanded in the steam turbine and the condensed in condenser. It is shown by the curve 5-6 and 5-7. The process 7-8 represented the pumping process of the feed water in feed pump.

Let m = mass of mercury in the mercury cycle/kg of steam circulated

Heat supplied, $Q_S = m \times (h_1 - h_4) + (h_5 - h_6)$

Work done by mercury turbine/kg of steam generated,

$$W_{T_m} = (h_1 - h_2)$$

Work done by the steam turbine/kg of steam generated

$$W_{T_S} = h_5 - h_6$$

Heat rejected, $Q_R = h_6 - h_7$.

Total work done in binary cycle.

$$W_T = W_{T_m} + W_{T_S}.$$

Thermal efficiency of the mercury cycle.

$$\eta_{binary} = \frac{m \times W_{T_m}}{m \cdot h_1} = \frac{W_{T_m}}{h_1}$$

The efficiency of steam cycle.

$$\eta_{binary} = \frac{W_{T_S}}{h_5 - h_8}.$$

The Value of m can be determined from energy balance equation.

$$m(h_2-h_3) = (h_9-h_8)$$

Mass flow rate of mercury required / kg of steam flow rate.

$$m = \frac{h_9 - h_8}{h_2 - h_3}$$

3. Superposed or Topping cycle :-

Whenever the demand increase, the capacity of the existing thermal power plant may be expanded either by increasing the capacity of existing plant or by purchasing additional equipment. Similar to that the superposed or topping cycle, it is included to the existing unit to increase the power demand.

By suppling the sufficient steam by the superposed unit into original plant heater, the excellent qualities of existing turbines are retained. The economics of plant operation are increased by the help of topping cycle.

A binary cycle geothermal power plant is more suitable binary vapour cycle.