Steam
Power Plant

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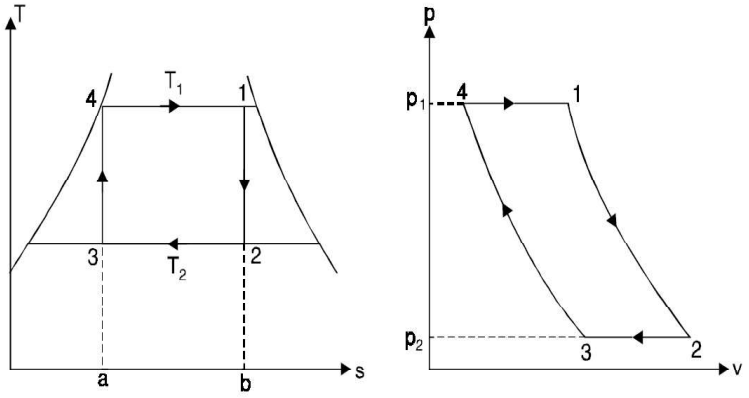
CARNOT CYCLE

1. **Operation (4-1).** 1 kg of boiling water at temperature $T1$ is heated to form wet steam of dryness fraction $x1$. Thus heat is absorbed at constant temperature $T1$ and pressure $p1$ during this operation.

2. **Operation (1-2).** During this operation steam is expanded isentropically to temperature $T2$ and pressure $p2$. The point '2' represents the condition of steam after expansion.

3. **Operation (2-3).** During this operation heat is rejected at constant pressure $p2$ and temperature $T2$. As the steam is exhausted it becomes wetter and cooled from 2 to 3.

4. **Operation (3-4).** In this operation the wet steam at '3' is compressed isentropically till the steam regains its original state of temperature $T1$ and pressure $p1$. Thus cycle is completed.



Carnot cycle on T-s and p-V diagrams.

Net work done = Heat supplied – heat rejected

$$= T_1 (s_2 - s_3) - T_2 (s_2 - s_3)$$

$$= (T_1 - T_2) (s_2 - s_3).$$

$$\text{Carnot cycle } \eta = \frac{\text{Work done}}{\text{Heat supplied}}$$

$$= \frac{(T_1 - T_2)(s_2 - s_3)}{T_1 (s_2 - s_3)} = \frac{T_1 - T_2}{T_1}$$

Limitations of Carnot Cycle

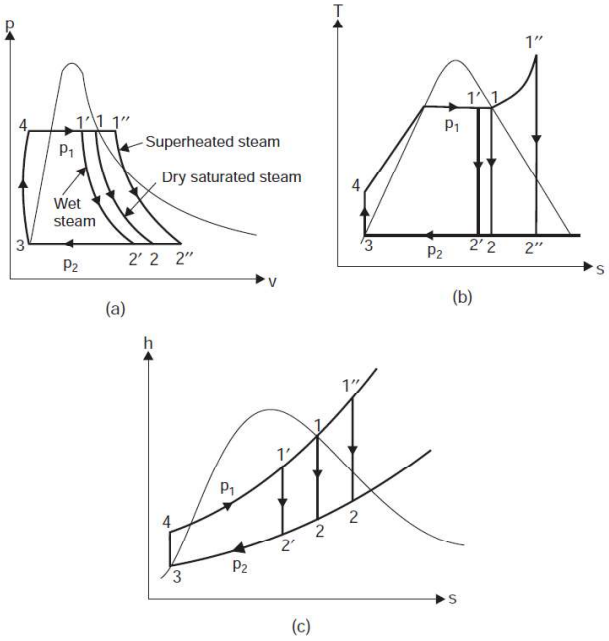
1. It is difficult to compress a wet vapour isentropically to the saturated state as required by the process 3-4.

2. It is difficult to control the quality of the condensate coming out of the condenser so that the state '3' is exactly obtained.

3. The efficiency of the Carnot cycle is greatly affected by the temperature $T1$ at which heat is transferred to the working fluid. Since the critical temperature for steam is only 374°C, therefore, if the cycle is to be operated in the *wet region*, the maximum possible temperature is severely limited.

4. The cycle is still more difficult to operate in practice with superheated steam due to the necessity of supplying the superheat at constant temperature instead of constant pressure (as it is customary).

RANKINE CYCLE

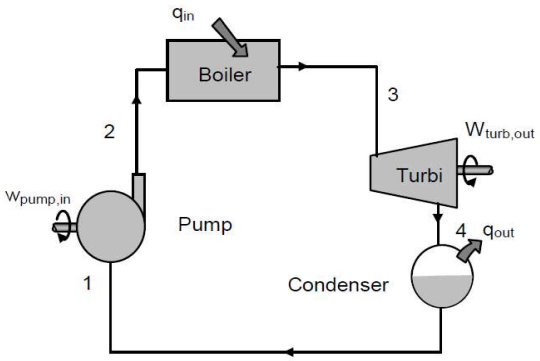


Process 1-2 : Reversible adiabatic expansion in the turbine

Process 2-3 : Constant-pressure transfer of heat in the condenser.

Process 3-4 : Reversible adiabatic pumping process in the feed pump.

Process 4-1 : Constant-pressure transfer of heat in the boiler.



Working of Rankine cycle

Steam power plant basically works on the Rankine cycle in which steam and water is working fluid.

In the boiler steam is generated from water by burning of coal. The Steam which is expanded in a turbine, which produces mechanical power. The output power of turbine is utilized to run the generator. The steam after expansion in turbine is usually condensed in a condenser. The condensed steam (Water) is again feed to the boiler and cycle is repeated.