5.4 Capacity of Steam Power Plant:

Steam rate: It is defined as the rate of steam flow (kg/hr) required for producing unit shaft output (1 kW), therefore,

$$\text{Steam rate} = \frac{3600}{w_{net}} \left(\text{kg/kWh}\right)$$

Heat rate: It is rate of heat input (Q_1) required for producing unit work output (1 kW).

$$\text{Heat rate} = \frac{3600}{w_{net}} \cdot Q_1 \left(\text{kJ/kWh}\right)$$

where, Q_1 is heat added per kg of steam

Effect of Varying the Operating Conditions on the Efficiency of the Simple Rankine Cycle:

(a) Effect of Superheat:

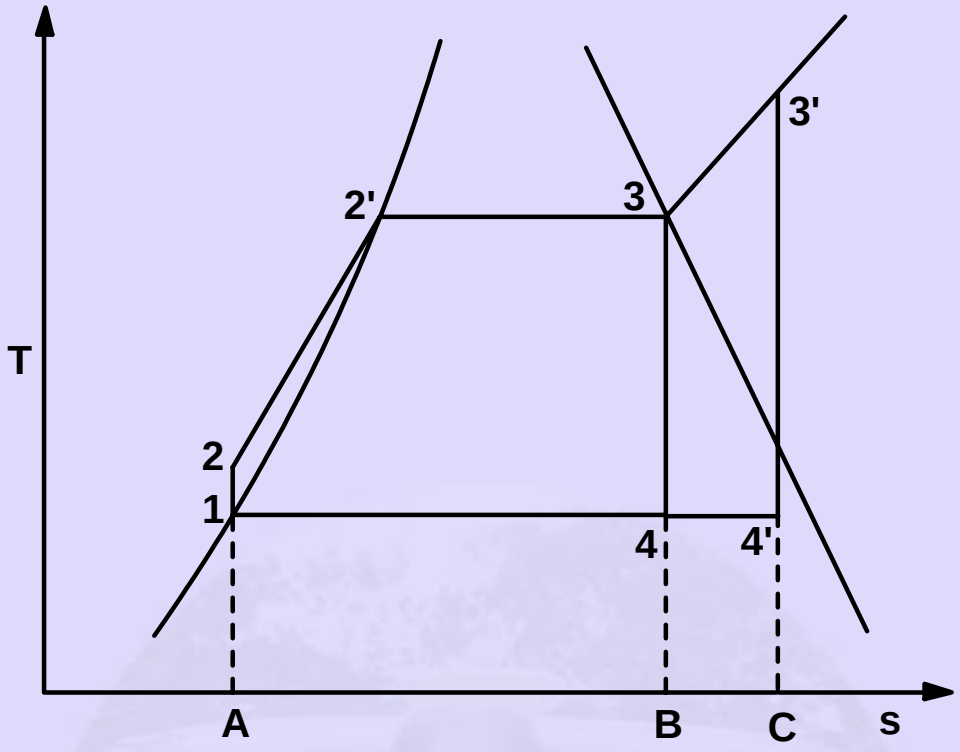

Fig.5.4(a). Effect of superheating

In the above figure two Rankine cycles are compared, cycle 1-2-3-4-1 using dry saturated steam at the exit of the boiler and cycle 1-2-3'-4'-1 using superheated steam at the exit of the boiler. The superheat steam cycle delivers more work and this excess work is represented by area 3-3'-4'-4, and also it takes in more amount of heat and this excess is represented by area 3-3'-C-B. The net effect is to increase the thermal efficiency of the cycle. This increase could have been anticipated from second law, because superheating increases the average temperature of heat addition to the cycle.

(b) Effect of Maximum Pressure:

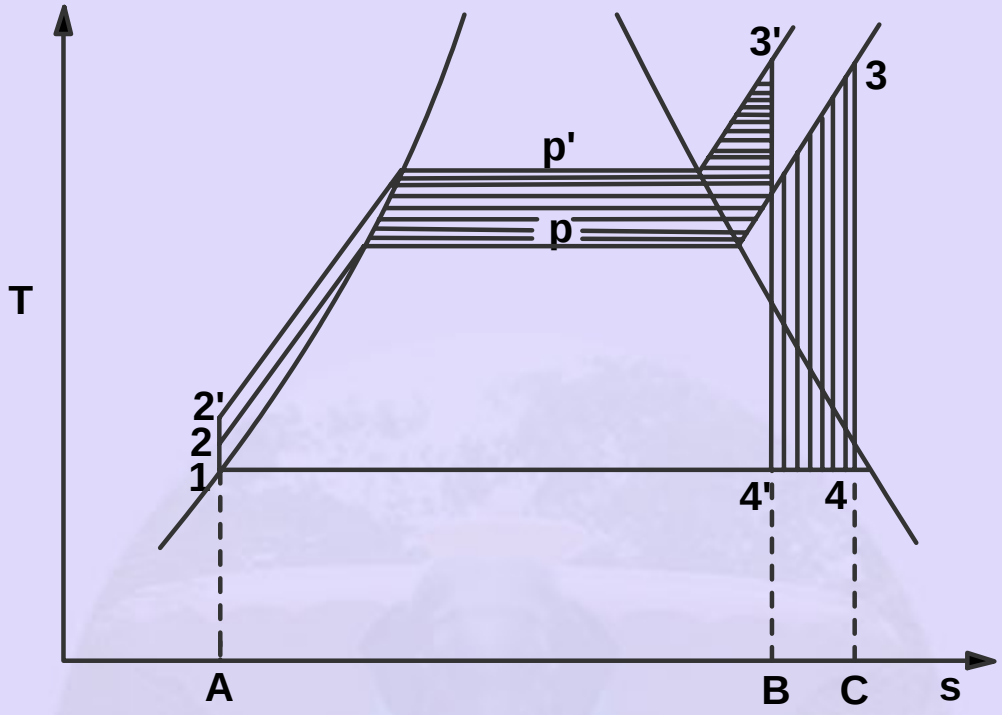

Fig.5.4(b). Effect of maximum pressure on Rankine cycle

The two cycles are shown above 1-2-3-4-1 and 1-2'-3'-4'-1 have the same minimum pressure but different maximum pressures. As the result of increasing the maximum pressure from p to p', the net work output has increased by the area shown by horizontal hatching and decreased by the area shown by vertical hatching. Since, these two areas are nearly equal, the network is nearly the same, but the net heat rejected decreases by the area 4'-4-C-B. Hence, the thermal efficiency increases.

(c) Effect of Condenser Pressure:

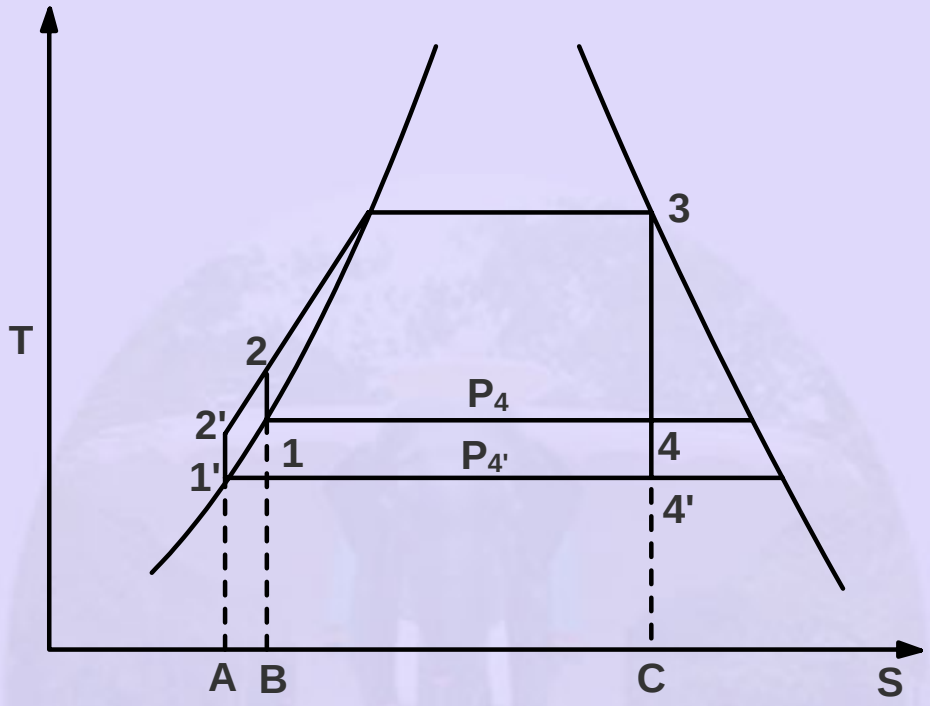

Fig.5.4(c). Effect of condenser pressure on Rankine cycle

If the condenser pressure is reduced from p_4 to p^1_4, the net work is increased by area 1-4-4'-1'-2'-2-1. And the heat supplied to steam increases by the area A-2'-2-B. These two areas are nearly equal; however, the net effect is to increase the thermal efficiency. This could be expected because the average temperature of heat rejection of the cycle decreases with decrease in condenser pressure.