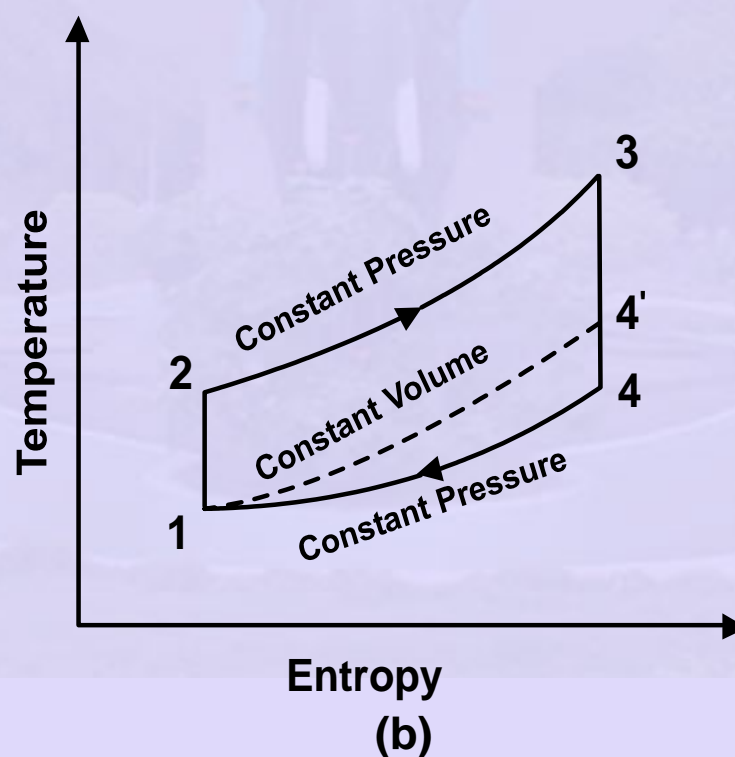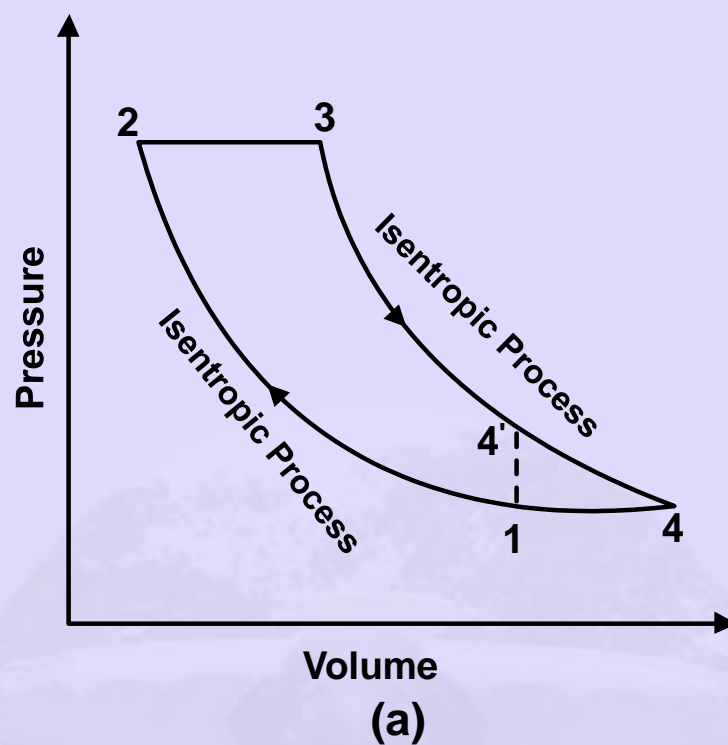## 4.10 Brayton Cycle (Simple Gas Turbine Cycle):

Fig.4.10. Brayton cycle on p-v and T-s diagram

The Brayton cycle is a theoretical cycle for simple gas turbine. This cycle consists of two isentropic and two constant pressure processes. Figure.4.10 shows the Brayton cycle on p-v and T-s coordinates. The cycle is similar to the Diesel cycle in compression and heat addition. The isentropic expansion of the Diesel cycle is further extended followed by constant pressure heat rejection. The thermal efficiency is given by,

$$\eta_{th} = \frac{\text{Heat added - Heat rejected}}{\text{Heat added}}$$

$$\eta_{th} = \frac{mC_p\left(T_3 - T_2\right) - mC_p\left(T_4 - T_1\right)}{mC_p\left(T_3 - T_2\right)} = 1 - \frac{T_4 - T_1}{T_3 - T_2}$$

For isentropic processes, we have,

$$\frac{T_2}{T_1} = \left(\frac{p_2}{p_1}\right)^{\frac{\gamma-1}{\gamma}} \quad \text{and} \quad \frac{T_3}{T_4} = \left(\frac{p_3}{p_4}\right)^{\frac{\gamma-1}{\gamma}}$$

But, $p_2 = p_3$ and $p_1 = p_4$, thus,

$$\frac{T_2}{T_1} = \frac{T_3}{T_4}$$

and we can write,

$$\eta_{th} = 1 - \frac{T_4}{T_3} = 1 - \frac{T_1}{T_2}$$

$$\frac{T_4}{T_3} = \frac{T_1}{T_2} = \frac{v_2}{v_1} = \frac{1}{r^{\gamma - 1}}$$

$$\frac{1}{r^{\gamma - 1}} = \left(\frac{v_2}{v_1}\right)^{\gamma - 1} \left\{\left(\frac{p_2}{p_1}\right)^{\frac{1}{\gamma}}\right\}^{\gamma - 1} = \left(r_p\right)^{\frac{\gamma - 1}{\gamma}}$$

$$\eta_{th} = 1 - \frac{1}{r_p^{\frac{\gamma - 1}{\gamma}}}$$

Deviation of Actual Cycles from Air Standard Cycles:

The actual Otto and Diesel engines show marked deviations form the air-standard cycles described above. Above fig shows p-v-diagram for a high-speed diesel engine would be very similar in appearance. The main differences between the actual and theoretical cycles are as follows.

(a) *Compression and expansion are not friction less adiabatic processes. A Certain amount of friction is always present and there is considerable heat transfer between the gases and cylinder wall.*

(b) *Combustion does not occur either at constant volume or at constant pressure.*

(c) *The thermodynamics properties of the gases after combustion are different than those of the fuel-air mixture before combustion..*

(d) *The combustion may be incomplete.*

(e) *The specific heats of the working fluid are not constant but increases with temperature.*

(f) *The cylinder pressure during exhaust process is higher than the atmosphere. As a result, more work has to be done by the piston on the gases to expel them out of the cylinder, than work done by the gases on the piston during the intake stroke. This difference in work, called pumping work, is represented by the pumping loop shown by hatched area. Note that this work is negative and represents loss of work called pumping loss.*