4.8. Atkinson Cycle:

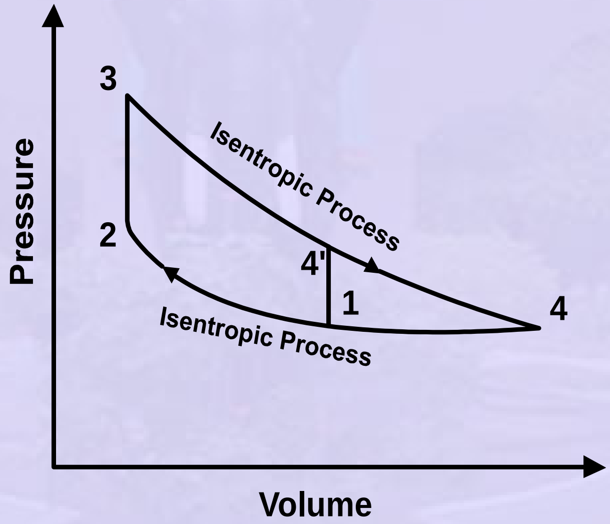
Atkinson cycle is an ideal cycle for Otto engine exhausting to a gas turbine. In this cycle the isentropic expansion (3-4) of an Otto cycle (1-2-3-4) is further allowed to proceed to the lowest cycle pressure so as to increase the work output. With this modification the cycle is known as Atkinson cycle. The cycle is shown on p-v and T-s diagrams in Fig.4.8. Processes involved are:

Process 1-2: Reversible adiabatic compression (v_1 to v_2).

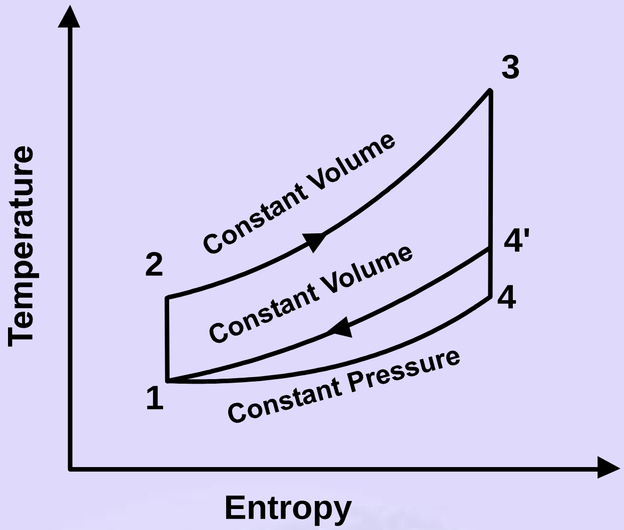
Process 2-3: Constant volume heat addition.

Process 3-4: Reversible adiabatic expansion (v_3 to v_4).

Process 4-1: Constant pressure heat rejection.



(a)



(b)

Fig.4.8. Atkinson cycle on p-v and T-s diagrams

Thermal Efficiency:

$$\text{Heat supplied} = C_v\left(T_3 - T_2\right)$$

$$\text{Heat rejected} = C_p\left(T_4 - T_1\right)$$

$$\text{Net workdone} = C_v\left(T_3 - T_2\right) - C_p\left(T_4 - T_1\right)$$

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

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

$$\text{Let, } r = \frac{v_1}{v_2} = CR$$

$$T_2 = T_1 r^{\gamma - 1}$$

$$\frac{T_3}{T_2} = \frac{P_3}{P_2} = r_p = \text{Pressure ratio}$$

$$T_3 = T_2\, r_p = T_1\, r^{\gamma - 1}\, r_p$$

$$\frac{T_3}{T_4} = \left(\frac{P_3}{P_4}\right)^{\frac{\gamma - 1}{\gamma}} = \left(\frac{P_3}{P_1}\right)^{\frac{\gamma - 1}{\gamma}} = \left(\frac{P_3}{P_2}.\frac{P_2}{P_1}\right)^{\frac{\gamma - 1}{\gamma}} = \left(r_p.\frac{P_2}{P_1}\right)^{\frac{\gamma - 1}{\gamma}} = r_p^{\frac{\gamma - 1}{\gamma}}\,.\,r^{\gamma-1}$$

since,

$$\frac{P_2}{P_1} = \left(\frac{v_1}{v_2}\right)^{\gamma} = r^{\gamma}$$

and

$$T_4 = \frac{T_3}{r_p^{\frac{\gamma - 1}{\gamma}}\; r^{\gamma - 1}} = \frac{T_1\, r_p\, r^{\gamma - 1}}{r_p^{\frac{\gamma - 1}{\gamma}}\; r^{\gamma - 1}} = T_1\, r_p^{\frac{1}{\gamma}}$$

$$\eta_{th} = 1 - \gamma \left[\frac{r_p^{\frac{1}{\gamma}} - 1}{\left(r_p - 1\right) r^{\gamma - 1}}\right]$$