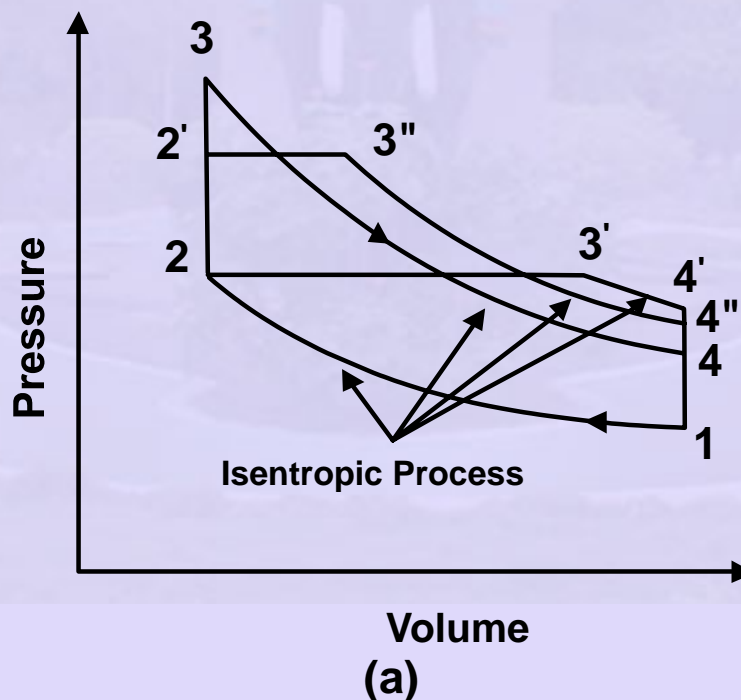


4.7 Comparison of Otto, Diesel and Dual Cycles:

The important variable factors which are used as the basis for comparison of the cycles are compression ratio, peak pressure, heat addition, heat rejection and the net work. In order to compare the performance of the Otto, Diesel and Dual combustion cycles, some of the variable factors must be fixed. In this section, a comparison of these three cycles is made for the same compression ratio, same heat addition, constant maximum pressure and temperature, same heat rejection and net work output. This analysis will show which cycle is more efficient for a given set of operating conditions.

Case 1: Same Compression Ratio and Heat Addition:

The Otto cycle 1-2-3-4-1, the Diesel cycle 1-2-3'-4'-1 and the Dual cycle 1-2-2''-3''-4''-1 are shown in p - V and T - θ diagram in Fig.4.7.1 (a) and (b) respectively for the same compression ratio and heat input.



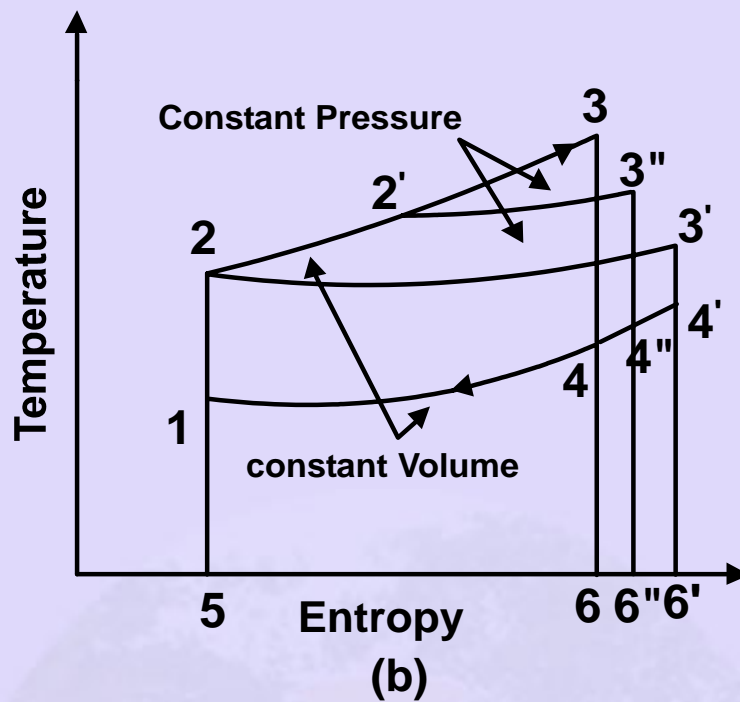
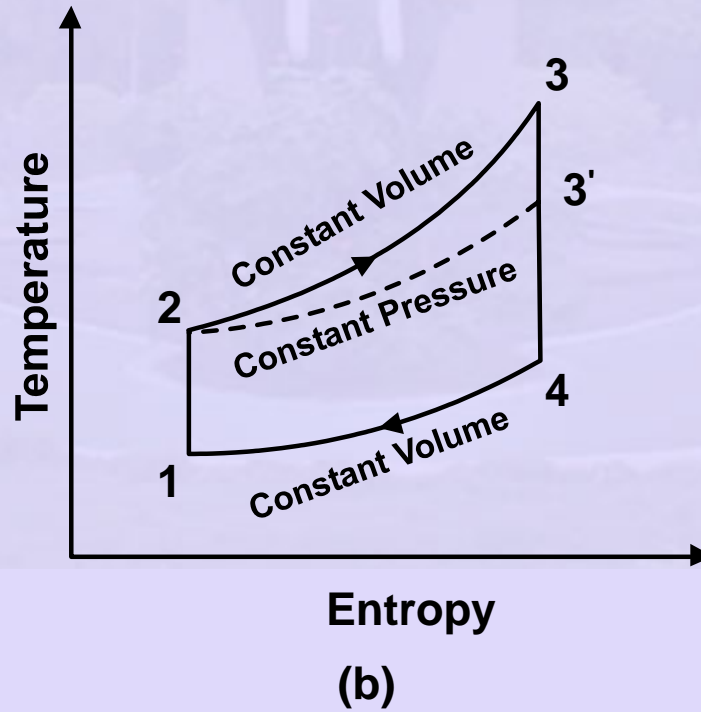
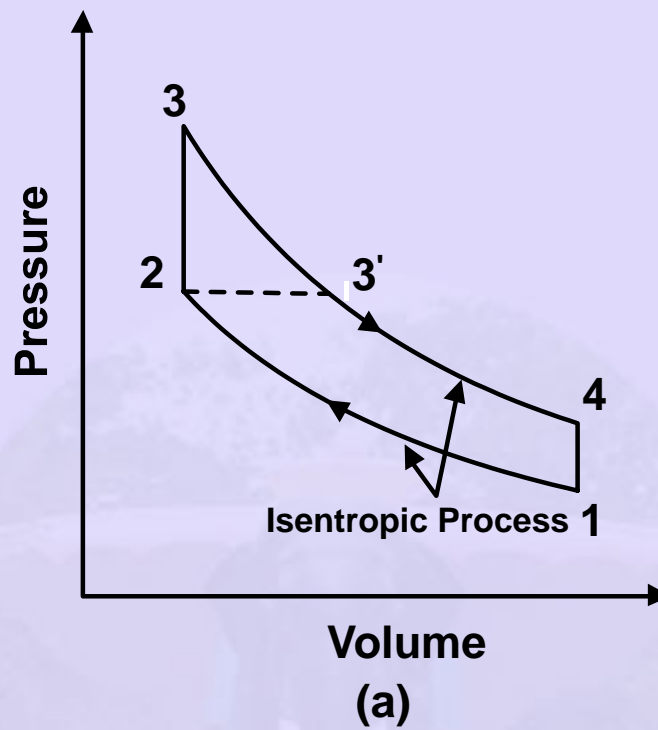


Fig.4.7.1. Same compression ratio and heat addition

From the $T-s$ diagram, it can be seen that Area 5-2-3-6 = Area 5-2-3'-6' = Area 5-2-2''-3''-6'' as this area represents the heat input which is the same for all cycles. All the cycles start from the same initial state point 1 and the air is compressed from state 1 to 2 as the compression ratio is same. It is seen from the $T-s$ diagram for the same heat input, the heat rejection in Otto cycle (area 5-1-4-6) is minimum and heat rejection in Diesel cycle (5-1-4'-6') is maximum.. Consequently, Otto cycle has the highest work output and efficiency. Diesel cycle has the least efficiency and Dual cycle having the efficiency between the two.

One more observation can be made i.e., Otto cycle allows the working medium to expand more whereas Diesel cycle is least in this respect. The reason is heat is added before expansion in the case of Otto cycle and the last portion of heat supplied to the fluid has a relatively short expansion in case of the Diesel cycle.

Case 2: Same Compression Ratio and Heat Rejection:**Fig.4.7.2. Same compression ratio and heat rejection**

Efficiency of Otto cycle is given by [Figs.4.7.2 (a) and (b)],

$$\eta_{\text{otto}} = 1 - \frac{Q_R}{Q_S}$$

Where, Q_S is the heat supplied in the Otto cycle and is equal to the area under the curve 2-3 on the T-s diagram [Fig.4.7.2 (b)]. The efficiency of the Diesel cycle is given by,

$$\eta_{\text{Diesel}} = 1 - \frac{Q_R}{Q'_S}$$

Where Q'_S is heat supplied in the Diesel cycle and is equal to the area under the curve 2-3' on the T-s diagram [Fig.4.7.2. (b)]. From the T-s diagram in Fig.4.7.2, it is clear that $Q_S > Q'_S$ i.e., heat supplied in the Otto cycle is more than that of the Diesel cycle. Hence, it is evident that, the efficiency of the Otto cycle is greater than the efficiency of the Diesel cycle for a given compression ratio and heat rejection.

Case 3: Same Peak Pressure, Peak Temperature and Heat Rejection:

Figures 4.7.3 (a) and (b) show the Otto cycle 1-2-3-4 and Diesel cycle 1-2'-3-4 on p - V and T - s coordinates, where the peak pressure and temperature and the amount of heat rejected are the same.

The efficiency of the Otto cycle,

$$\eta_{\text{otto}} = 1 - \frac{Q_R}{Q_S}$$

Where, Q_S is the area under the curve 2-3 in Fig.4.7.3 (b). The efficiency of the Diesel cycle, 1-2'-3-4 is,

$$\eta_{\text{Diesel}} = 1 - \frac{Q_R}{Q'_S}$$

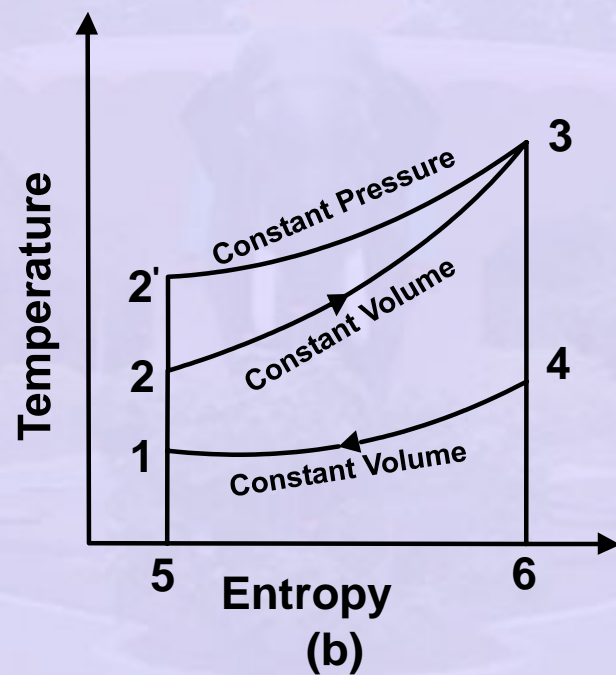
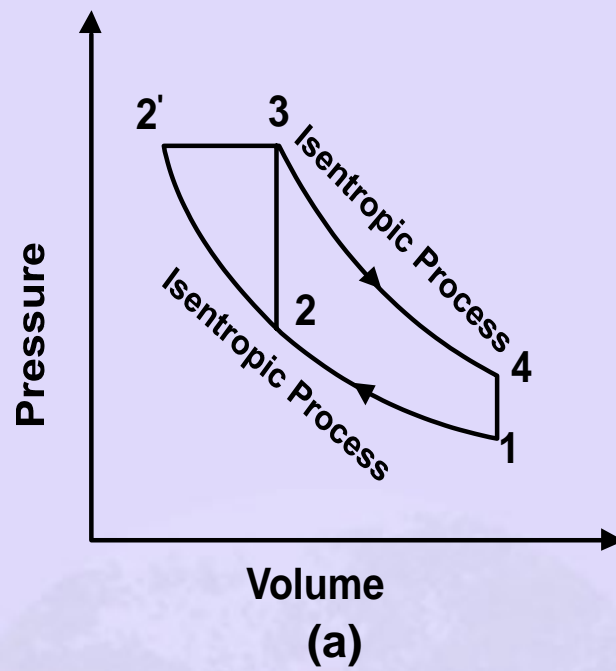


Fig.4.7.3. Same peak pressure and temperature

It is evident from Fig.4.7.3 that $Q_s > Q'_s$. Therefore, the Diesel cycle efficiency is greater than the Otto cycle efficiency when both engines are built to withstand the same thermal and mechanical stresses.

Case 4: Same Maximum Pressure and Heat Input:

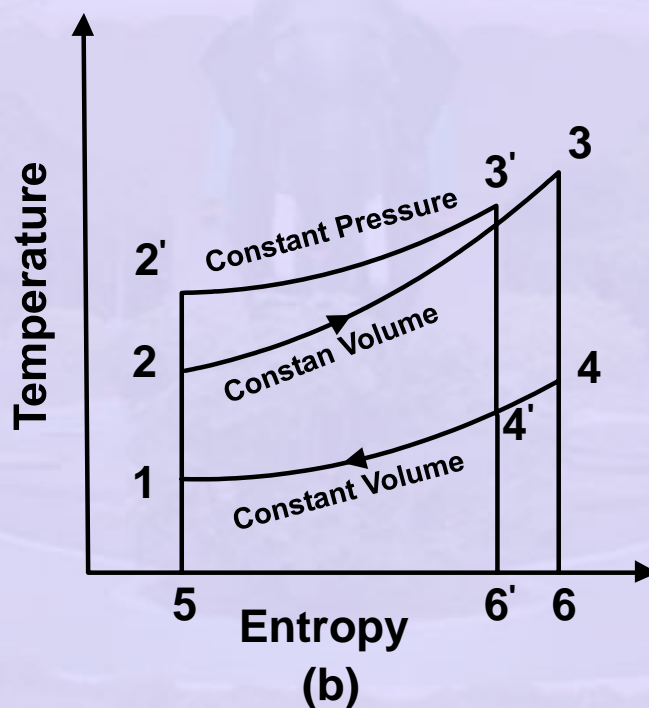
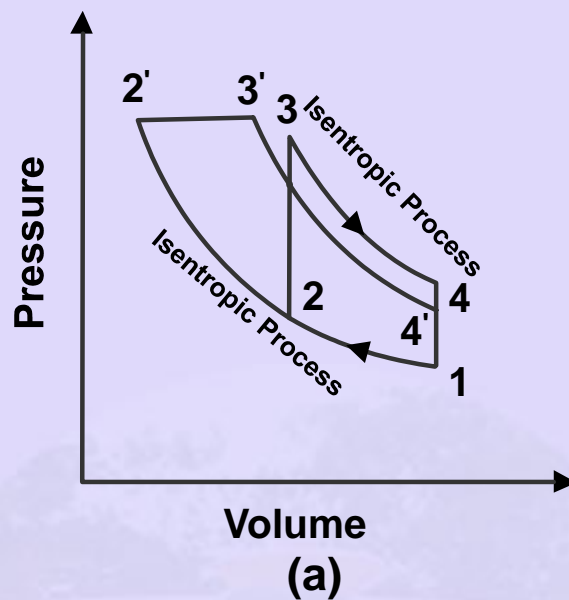


Fig.4.7.4. Same maximum pressure and heat input.

For same maximum pressure and heat input, the Otto cycle (1-2-3-4-1) and Diesel cycle (1-2'-3'-4'-1) are shown on p - V and T - s diagrams in Fig.4.7.4 (a) and (b) respectively. It is evident from the figure that the heat rejection for Otto cycle (area 1-5-6-4 on T - s

diagram) is more than the heat rejected in Diesel cycle (1-5-6'-4'). Hence Diesel cycle is more efficient than Otto cycle for the condition of same maximum pressure and heat input. One can make a note that with these conditions, the Diesel cycle has higher compression ratio than that of Otto cycle. One should also note that the cycle which is having higher efficiency allows maximum expansion. The Dual cycle efficiency will be between these two.

Case 5: Same Maximum Pressure and Work Output:

The efficiency, η can be written as

$$\eta = \frac{\text{Work done}}{\text{Heat supplied}} = \frac{\text{Work done}}{\text{Work done} + \text{Heat rejected}}$$

Refer to T - s diagram in Fig.4.7.4 (b). For same work output the area 1-2-3-4 (work output of Otto cycle) and area 1-2'-3'-4' (work output of Diesel cycle) are same. To achieve this, the entropy at 3 should be greater than entropy at 3'. It is clear that the heat rejection for Otto cycle is more than that of diesel cycle. Hence, for these conditions, the Diesel cycle is more efficient than the Otto cycle. The efficiency of Dual cycle lies between the two cycles.

