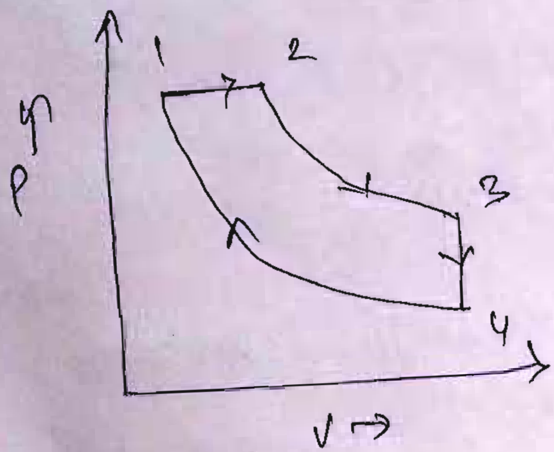
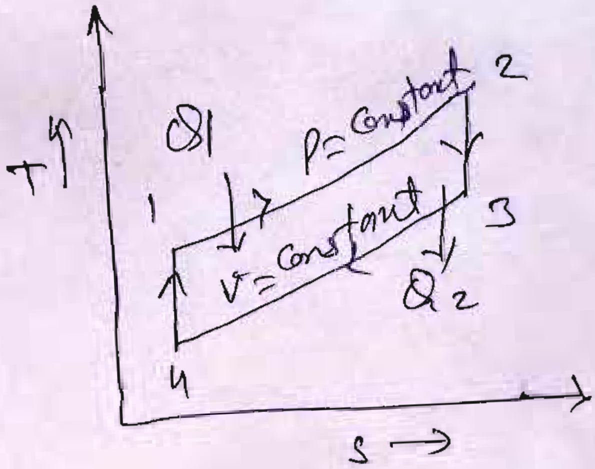
Agricultural Engg. II^{nd} Sem, – Thermodynamics, Refrigeration and Air Conditioning – Lecture-3- Yogesh Kumar

Topic- Diesel cycle →





Let the engine cylinder contain m kg of air at Point 1 of the cycle and at Point 1, Pressure, Tempr. and volume are – P_1, T_1 and V_1.

1– Process (1-2) – Constant Pressure Heat Addition –
Heat is absorbed by air getting Heated from Tempr T_1 to T_2 ⇒ Heat supplied, $Q_{1-2} = m\,C_p(T_2 - T_1)$
Point 2 is called cut-off Point as at this point the fuel supply is stoped.

2– Process (2-3) (Reversible adiabatic or isentropic expansion)
No Heat is supplied or rejected in this process
$Q_{2-3} = 0$

3– Process (3-4) (Constant volume Heat Removal) –
Heat is rejected by air getting Cooled from tempr T_3 to T_4 ⇒ $Q_{3-4} = m\,C_v(T_3 - T_4)$

4– Process (4-1) (Reversible adiabatic or isentropic compression)
In this process no Heat is added or removed.
$Q_{4-1} = 0$

work done = Heat absorbed – Heat Rejected
$W = m\,C_p(T_2 - T_1) - m\,C_v(T_3 - T_4)$

Air standard efficiency

$$\eta = \frac{\text{work done}}{\text{Heat absorbed}}$$

$$\eta = \frac{mc_p(T_2-T_1) - mc_v(T_3-T_4)}{mc_p(T_2-T_1)}$$

$$\eta = 1 - \frac{c_v}{c_p}\left[\frac{(T_3-T_4)}{(T_2-T_1)}\right]$$

$$\eta = 1 - \frac{1}{\gamma}\left[\frac{T_3-T_4}{T_2-T_1}\right] \quad -(i)$$

compression ratio $(r_c) = \frac{V_4}{V_1}$

cut-off ratio $(\rho) = \frac{V_2}{V_1}$

expansion ratio $(r_e) = \frac{V_3}{V_2}$

$$\frac{V_3}{V_2} = \frac{V_4}{V_2} = \frac{V_4}{V_1} \times \frac{V_1}{V_2} \quad [V_3 = V_4]$$

[multiply and divide by V_1]

$$\eta = r_c \times \frac{1}{\rho}$$

$$\therefore r_e = \frac{r_c}{\rho}$$

for constant pressure process (1-2) –

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

$$T_2 = T_1\left(\frac{V_2}{V_1}\right) = T_1 \times \rho \quad -(ii)$$

For process (2-3) Isentropic expansion

$$\frac{T_3}{T_2} = \left(\frac{V_2}{V_3}\right)^{\gamma-1} \Rightarrow \frac{T_3}{T_2} = \left(\frac{1}{r_e}\right)^{\gamma-1}$$

$$\frac{T_3}{T_2} = \left(\frac{\rho}{r_c}\right)^{\gamma-1}$$

$$T_3 = T_2\left(\frac{\rho}{r_c}\right)^{\gamma-1} \Rightarrow T_1 \times \rho\left(\frac{\rho}{r_c}\right)^{\gamma-1} \quad -(iii)$$

for process (4-1) - Isentropic compression –

$$\frac{T_1}{T_4} = \left(\frac{V_4}{V_1}\right)^{\gamma-1} = (r_c)^{\gamma-1}$$

$$T_1 = T_4(r_c)^{\gamma-1} \quad - IV$$

substituting the values of T_1 from eqn (IV) into eqn (II) & (iii)

$$T_2 = T_4(r_c)^{\gamma-1} \times \rho \quad - V$$

$$\text{and } T_3 = T_4(r_c)^{\gamma-1} \times \rho\left(\frac{\rho}{r_c}\right)^{\gamma-1}$$

$$= T_4(\rho)^{\gamma} \quad -(vi)$$

substituting the values of T_1, T_2 and T_3 into eqn (i) –

$$\eta = 1 - \frac{1}{\gamma}\left[\frac{(T_4\rho^{\gamma}) - T_4}{T_4(r_c)^{\gamma-1}\rho - T_4(r_c)^{\gamma-1}}\right]$$

$$\boxed{\eta = 1 - \frac{1}{(r_c)^{\gamma-1}}\left[\frac{\rho^{\gamma}-1}{\gamma(\rho-1)}\right]}$$