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H.W # 1

Q1 Internal compustion engines

1) $r_v = \frac{v_1}{v_2} = \frac{1}{0.17} = 5.85$

2) Displacment volume = cylinder volume − clearence

$= 0.83 * cylinder\ volume$

$= 0.83 * \frac{mRT_1}{P_1}$

$= \frac{0.83 * 0.1 * 0.287 * }{100 * \frac{1}{305}} = 0.0726\ m^3$

$= 72.6$ liter

3) $Q_{in} = 400\ KJ/Kg = C_v(T_3 - T_2)$

$T_2 = T_1 (r_v)^{0.4} = 620\ K$

$T_3 = \frac{400}{0.7} + 620 = 1185.8\ K$

$T_4 = T_3 \left(\frac{1}{r_v}\right)^{0.4} = 584\ K$

$Q_{out} = C_v(T_4 - T_1) = 197\ KJ/Kg$

$w = q_{in} - q_{out} = 400 - 197 = 203\ KJ$

$W = mw = 0.1(203) = 20.3\ KJ$

4) $\eta_{thermal} = \frac{w}{q_{in}} * 100\% = 50.7\%$

5) $v_1 = \frac{V_1}{m} = 0.875\ m^3/Kg$

$v_2 = \frac{v_1}{r_v} = 0.149\ m^3/Kg$

$$\ldots 8.8) * 10^{-2} * \frac{\pi (0.343)^2}{4} =$$

$$= \frac{1}{15}(50.8) * 10^{-2} * \frac{\pi (0.343)^2}{4}$$

$$r_v = \frac{V_1}{V_2} = \frac{50.8 - 8}{\frac{50.8}{15}} = 12.6$$

$$\eta_{otto} = 1 - \frac{1}{r_v^{k-1}} = 0.637 * 100\% = 63.7\%$$

Q4)

$$V_2 = \frac{V_1}{(P_2/P_1)^{1/k}} = 0.0612\ m^3$$

$$r_v = 16.35$$

$$T_2 = T_1 (r_v)^{0.4} = 917K$$

$$T_3 = \frac{V_3}{V_2} T_2 = 1498K$$

$$T_4 = T_3 (V_3/V_4)^{0.4} = 546K$$

$$q_{in} = c_p(T_3 - T_2) = 813.4\ KJ/Kg$$

$$q_{out} = c_v(T_4 - T_1) = 176.4\ KJ/Kg$$

$$\eta = \frac{q_{in} - q_{out}}{q_{in}} * 100\% = 78.3\%$$

Q5

$T_2 = T_1\, r_v^{0.4} = 909\ K$

$T_3 = T_2 \frac{v_3}{v_2} = 1818\ K$

$q_{in} = c_p(T_3 - T_2) = 1273\ KJ/Kg$

$T_4 = T_3 (r_v)^{-0.4} = 600\ K$

$q_{out} = c_v(T_4 - T_1) = 45\ KJ/Kg$

$w = 1058\ KJ/Kg$

$v_1 = \frac{R T_1}{P_1} = 5.861\ m^3/Kg$

$mep = \frac{w}{v_1 - v_2} = \frac{1058}{\frac{15}{16}(5.861} = 1301\ bar$

Q6

Swept volume $= V_S = \frac{(0.15)^2 * 0.2 * \pi}{4} = 0.0035\ m^3$

$V_1 = 1.1\ V_S = 0.00385\ m^3$

$V_2 = 0.1\ V_S = 0.00035\ m^3$

$r_v = \frac{V_1}{V_2} = 11$

$V_3 = V_2 + 0.06\ V_S = 5.6 * 10^{-4}\ m^3$

$x = \frac{V_3}{V_2} = 1.6$

$\eta_{Diesl} = 1 - \frac{1}{r_v^{K-1}} \left[\frac{x^K - 1}{K(x-1)} \right] = 57.5\%$

Scanned by CamScanner

$V_1 = V_s + \frac{1}{8} V_s = \frac{9}{8} V_s$ $\qquad T_3 = 2073 K$

$V_2 = 1/8 \, V_s$

$r_v = \frac{V_1}{V_2} = 9$

$T_2 = T_1 \, r_v^{0.4} = 742 K$

$P_2 = P_1 \, r_v^{K} = 21.7 \text{ bar}$

$X = T_3/T_2 = 2.8$

$P_3 = P_2$, $\frac{V_4}{V_3} = \frac{V_1}{V_3}$, $r_v = \frac{V_1}{V_2}$

$\frac{r_v V_2}{V_3} = \frac{V_4}{V_3}$, $X = \frac{V_3}{V_2}$

$\frac{V_4}{V_3} = \frac{r_v}{X}$

$T_4 = T_3 \left(\frac{r_v}{X}\right)^{-0.4} = 1300 K$

$P_4 = P_3 \left(\frac{X}{r_v}\right)^{1.4} = 4.23 \text{ bar}$

$\eta_D = 1 - \frac{1}{r_v^{K-1}} \left[\frac{X^K - 1}{K(X-1)}\right] = 46.8\%$

$q_{in} = c_p (T_3 - T_2) = 1332 \text{ KJ/Kg}$

$q_{out} = C_v (T_4 - T_1) = 711 \text{ KJ/Kg}$

$w = q_{in} - q_{out} = 621 \text{ KJ/Kg}$

$\dot{m} = \frac{\dot{V}_s}{v_1}$

$v_1 = \frac{R T_1}{P_1} = 0.875 \text{ m}^3/\text{Kg}$

$V_s = 9.42 \times 10^{-4} \text{ m}^3$

$\dot{V} = V_s * \frac{1800}{2} \frac{1}{60} = 14.13 * 10^{-3} \text{ m}^3/\text{s}$

$\dot{m} = \frac{\dot{V}}{V_s} = 1.61 * 10^{-3} \text{ Kg/s}$

Power per cylinder $= \dot{m} w = 1000 W$

for entire engine : Power $= 6000 W$

$T_1 = 273 + 60 = 333\,K$ ... /cycle A/F = 18/1 $r_v = 16/1$

$T_2 = T_1 (r_v)^{0.4} = 1009\,K$ P = 100 KPa

~~$V_1 = 16 V_2$~~ ~~$V_3 = V_1 - V_2$~~ $\Rightarrow V_1$

$m_{air} = V_s / v_1$, $v_1 = \frac{0.287 * 333}{100} = 0.956\ m^3/Kg$

$m_{air} = 1.05 * 10^{-3}$ Kg/cycle

$\Rightarrow \dot{m}_{fuel} = \frac{m_{air}}{18} = 0.058 * 10^{-3}$ Kg/cycle

$q_{in\,total} = \dot{m}_{fuel} * 42500 = 2471$ Kg

q_{in} or constant volume $= q_{in\,total} / 2 = 1237\ KJ = q_{in}$

$T_3 = q_{in}/c_v + T_2 = 2732\,K$

$P_2 = P_1\, r_v^{1.4} = 48.5$ bar

$P_3 = P_2\, T_3/T_2 = 131$ bar

$q_{in}'' = q_{in}'$

$T_4 = \frac{q_{in}''}{c_p} + T_3 = 3964\,K$

$P_4 = P_3$; $V_3 = V_2 = \frac{V_1}{r_v}$

$\frac{T_4}{V_4} = \frac{T_3}{V_3}$

$\frac{T_4}{V_n} = \frac{T_3}{V_1} r_v$, $V_5 = V_1$

$\frac{V_1}{V_4} = \frac{T_3}{T_4} r_v$

$T_5 = T_4 \left(\frac{V_4}{V_1}\right)^{0.4} = T_4 \left(\frac{T_4}{T_3 r_v}\right)^{0.4} = 1518\,K$

$P_5 = P_4 \left(\frac{V_1}{V_4}\right)^{-1.4} = 1.6$ bar

$Q_{out} = m_r\, c_v (T_5 - T_1) = 0.95\ KJ$

$W = q_{in} - q_{out} = 2470\ KJ$

$\eta = \frac{W}{q_{in}} \cong 100\%$