Data Q1 d ① Q.P. code :- 39559

Constant volume ~~air~~ cycle.

$d = 100 mm = 0.1 m$ $V_c = 2.75$ lit

$L = 200 mm = 0.2 m$ $= 2.75 \times 10^{-3} m^3$

$P_{mep} = 5 \times 10^5 N/m^2$ $N = 120$ rpm

$\dot{m}_g = 8.5 \ kg/hr.$ $CV = 16350 \ KJ/kg$

I] ~~Air standard efficiency~~ $= \frac{\pi}{4} \times d^2 \times L = \frac{\pi}{4} \times 0.1^2 \times 0.2$

$V_s = 1.57 \times 10^{-3} m^3$

compression ratio $(r) = \frac{V_s + V_c}{V_c} = \frac{1.57 \times 10^{-3} + 2.75 \times 10^{-3}}{2.75 \times 10^{-3}}$

$r = 1.57$

I] Air standard efficiency of otto cycle

$\eta_{air\ standar} = \cancel{1 - \frac{1}{r^{\gamma - 1}}}$ $1 - \frac{1}{(r)^{\gamma - 1}}$

$\because \gamma = 1.4$, $\therefore \eta_{air} = \cancel{1 - \frac{1}{(1.57)^{1.4-1}}}$

$\eta_{air.} = 1 - \frac{1}{(1.57)^{1.4-1}} = 0.1650 = 16.5\%$

2] Indicater power $= P_m (A L) N$

$= 5 \times 10^5 \times \frac{\pi}{4} \times 0.1^2 \times 0.2 \times \frac{120}{60}$

$=$ ~~1.57 kw~~ 1.57×10^3 watt $= 1.57$ kW.

3] Indicated thermal efficiency

$= \frac{I.P}{\dot{m}_f \times CV} = \frac{1.57}{\frac{8.5}{3600} \times 16350} = 4.06\%$

Data. 2a 02

$D = 0.15\,m$ $N = 300\,rpm$

$L = 0.3\,m$ $W = 360\,N$

$P_{mi} = 7\times10^5\,N/m^2$ $S = 30\,N$

$(\Delta t)_{cw} = 35^\circ c$

$D_b = 1.2\,m$

$\dot m_f = 2.4\,kg$

$\dot m_a = 52.8\,kg$

$T_{gas} = 410^\circ c$

$C_{pg} = 1\,kJ/kg$

To find

1] Indicated power

2] Brake thermal efficiency

3] Draw the heat balance on minute basis.

$$I.P. = \frac{P_{mi}.L.A.n.i}{60,000} = \frac{7\times10^5\times0.3\times\frac{\pi}{4}(0.15)^2\times\frac{300}{2}\times1}{60,000}$$

$I.P = 9.28\,kW$

$$B.P = \frac{(W-S)\pi.D_B.N}{60,000} = \frac{330\times\pi\times1.2\times300}{60,000} = 6.22\,kW.$$

$B.P = 6.22\,kW$

$$n_{bth} = \frac{6.22}{\frac{2.4}{3600}\times4200} = 22.21\% = n_{bth}$$

1] Heat supplied by fuel $(H.S)$ = $\dot m_f.CV = \frac{2.4}{60}\times42,000 = 1680\,\frac{kJ}{min}$ (H.S)

2] Heat equivalent to BP $(HBP) = 6.22\times60 = 373.2\,kJ/min = HBP$

3] Heat lost to cooling water = $H_{cw} = m_w.C_{pw}.\Delta T$

$$\frac{300}{60}\times4.18\times35 = 731.5\,kJ/min = H_{cw}$$

4) Heat carried away by exhaust gases

$$= m_{eg}.C_{pg}.(T_g - T_a.)$$

$$H_{eg} = 0.92\times1\times(410-20) = 358.8\,kJ/min$$

5] Heat unaccounted. (Residual) = 216.5 kJ/min

H_S — 1680 kJ/min 100%. H_{BP} = 373.2 kJ/min = 22.2%.

H_{CW} = 731.5 kJ/min = 43.54%

H_{cg} = 358.8 kJ/min = 21%.

$Q_{residual}$ = 216.5 kJ/min = 12.89%.

$\boxed{Data}$. 2-stroke, 4 cylinder CI engine K = 4 bore = d = 150 mm = 0.15 m.

$\frac{L}{D} = 0.90$ ∴ $L = 0.90 \times d = 0.9 \times 150 = 135\,mm = 0.135\,m$

B.P = 265 kW speed N = 2400 rpm

∴ n = N = 2400 rpm ∵ 2 stroke engine.

$$P_{mf} = \frac{60{,}000 \times B.P}{L A n K} = \frac{60{,}000 \times 265}{0.135 \times \frac{\pi}{4}(0.15)^2 \times 2400 \times 4}$$

$$= 694{,}313.442\ (N/m^2)$$

$$= 694.313\ kN/m^2$$

$$P_{mf} = \underline{6.943\ bar}.$$

Mean piston speed $\bar{S}_p = \frac{2LN}{60}$ (m/s)

$$= \frac{2 \times 0.135 \times 2400}{60} =$$

$$\bar{S}_p = 10.8\ m/s$$

$$\text{Torque} - T = \frac{60{,}000 \times BP}{2\pi N} = \frac{60{,}000 \times 265}{2\pi \times 2400} = 1054.40\ N.m.$$

$$T = 1.0544\ (kN.m).$$

As. $d = L \rightarrow$ Square engine, $d > L \rightarrow$ Over square engine

$d < L \rightarrow$ Under square engine.

In present case. $d\,(150\,mm) > L\,(135\,mm)$

This is oversquare engine.

Data (4b) (04)

$V_s = 1489cc = 1489 \times 10^{-6}\ m^3$

$N = 4200$ rpm $\quad \eta_v = 75\%$ $\quad$ A/F ratio : 13:1

$C_1 = C_2 = 85$ m/s , $\quad C_{da} = 0.82$ $\quad C_{df} = 0.65$,

$\rho_f = 0.74 \times 1000 = 740\ kg/m^3$ $\quad P_1 = P_a = 1.013$ bar,

$T_1 = T_a = 20+273 = 293\ K$ $\quad Z = 6\ mm = 0.006\ m$

$d = 0.4D$ $\quad P_2 = P_t = ?$

Volume of air inducted, $= \eta_v \times V_s = \dfrac{0.75 \times 1489 \times 10^{-6} \times 4200}{2 \times 60}$

$= 0.03903\ m^3/sec.$

$\therefore$ Mass flow of air $= \dot{m}_a = \dfrac{P_1 V}{RT_1} = \dfrac{1.013 \times 10^5 \times 0.03909}{287 \times 293}$

$\dot{m}_a = 0.04709$ kg/sec

for compressible flow, velocity at throat

$$C_T = \sqrt{\left[2 T_a C_p \left\{1 - \left(\frac{P_t}{P_a}\right)^{\frac{\gamma-1}{\gamma}}\right\}\right]}$$

$$85 = \sqrt{\left[2 \times 293 \times (1.005 \times 10^3)\left\{1 - \left(\frac{P_t}{P_a}\right)^{0.2857}\right\}\right]}$$

$$85 = 767.4 \sqrt{\left\{1 - \left(\frac{P_t}{P_a}\right)^{0.2857}\right\}}$$

$$1 - \left(\frac{P_t}{P_a}\right)^{0.2857} = 0.01226$$

$$\left(\frac{P_t}{P_a}\right)^{0.2857} = 0.98774$$

$\therefore \dfrac{P_t}{P_a} = 0.9577 \quad \therefore P_t = 0.9577 \times 1.013$

$P_t = 0.97$ bar

Volume flow of air at throat, $V_t = 0.03909 \times \left(\frac{P_a}{P_t}\right)^{\frac{1}{\gamma}}$ (0.5)

$$V_t = 0.03909 \times \left(\frac{1.013}{0.97}\right)^{\frac{1}{1.4}} = 0.0403 \text{ m}^3/\text{sec}$$

$$\therefore A_t = \frac{V_t}{C_t \times C_{da}} = \frac{0.0403}{85 \times 0.82} = 5.787 \times 10^{-4} \text{ m}^3$$

$$= 578.5 \text{ mm}^3.$$

Now, $\frac{\pi}{4}(D^2 - d^2) = 578.5$

$$\frac{\pi}{4}\left[D^2 - (0.4D)^2\right] = 578.5$$

$\therefore$ Throat dia $= D = 29.61$ mm

Mass flow of fuel $= \dot{m}_f = \frac{\dot{m}_a}{13} = \frac{0.04709}{13} = 3.622 \times 10^{-3}$ kg/sec

$$\dot{m}_f = C_{df} \cdot A_{jet} \sqrt{2\rho_f(\Delta p - gz\rho_f)}$$

$$3.622 \times 10^{-3} = 0.65 \times A_{jet} \sqrt{2 \times 740 \left\{(1.013 - 0.97) \times 10^5 - (9.81 \times 0.006 \times 740)\right\}}$$

$$A_{jet} = 2.22 \times 10^{-6} \text{ m}^3 = 2.22 \text{ mm}^2$$

$$\frac{\pi}{4} d_{jet}^2 = 2.22$$

Diameter of Jet $= 1.68$ mm

5b 06

Q. Data,

Ambient temp = 27°C = 300K.

Ambient pressure = 1bar.

A/F ratio to be determined at 4km height

= 4000m height

Initial adjustment of carburettor at sea level = 10% lean.

i.e A/F = 15 × 1.1 = 16.5 : 1.

$t = t_s - 0.00675 h.$

$= 27 - 0.00675 \times 4{,}000.$

$= 0°C = 273K.$

$h = 1900 \log_{10}\left(\frac{1}{p}\right)$ ∴ $4{,}000 = 19{,}000 \log_{10}\left(\frac{1}{p}\right)$

$\therefore \log_{10}\left(\frac{1}{p}\right) = \frac{4{,}000}{19{,}000} = 0.21053.$

$p = 0.6158$ bar.

$P_{al} = 0.6158$ bar : $\rho_{al} = \frac{P_{al}}{R \cdot T_{al}} = \frac{0.6158 \times 10^5}{287 \times 273}$

$= 0.786 \ kg/m^3$

$\rho_{sl} = \frac{P_{sl}}{R \cdot T_{sl}} = \frac{1 \times 10^5}{287 \times 300} = 1.161 \ kg/m^3$

$\therefore (A/F)_{al} = (A/F)_{sl} \times \sqrt{\frac{\rho_{al}}{\rho_{sl}}}$

$= 16.5 \times \sqrt{\frac{0.786}{1.161}}$

$(A/F)_{al} = 13.576$

% richness = $\frac{15 - 13.576}{15} \times 100 = 9.49\%$ rich.

∴ The change in A/F — Initial A/F 16.5 (10% lean) to 13.576 (9.49% rich).

Q.

Data (3b)

n is ~~the~~ polytropic $= 1.25$ for air.

$m = 1 \frac{kg}{min} = \frac{1}{60} = 0.0166$ kg/sec.

$V_1 = 0.2 \frac{m^3}{sec}$; $T_1 = 16°c$.

$P_1 = 1$ bar ; $P_3 = 7$ bar.

Soln

a] $P_2 = \sqrt{P_1 P_3} = \sqrt{1 \times 7} = 2.645$ bar. $= P_2$

b] V_1 = Volume of LP cylinder $= 0.2 \frac{m^3}{sec}$

$T_1 = 16°c$

$$V_1 = \frac{0.2}{600/60} \ m^3/cycle = 0.02 \frac{m^3}{cycle}.$$

$$P_1 V_1^{1.25} = P_2 V_2^{1.25}$$

$$V_2 = V_1 \left(\frac{P_2}{P_1}\right)^{\frac{1}{n}} = 0.02 \left(\frac{1}{2.645}\right)^{\frac{1}{1.25}}$$

Volume of HP cylinder $= 0.0092 \frac{m^3}{cycle}$.

c] Minimum Power required.

$$W = \frac{N n P_1 V_1}{n-1} \left[\left(\frac{P_{N+1}}{P_1}\right)^{\frac{n-1}{n.N}} - 1 \right]$$

$$= \frac{2 \times 1.25 \times 100 \times 0.2}{1.25 - 1} \left[\left(\frac{7}{1}\right)^{\frac{1.25-1}{2 \times 1.25}} - 1 \right]$$

$W = 43$ kW

Data (6a) 08

$T_1 = 25 + 273 = 298\,K.$

$Q_{rej} = 1210\ KJ/min$

$P_2 = 1.75\ bar.$

$\eta_v = 72\%.$

$i = 6$ = no. of cylinders

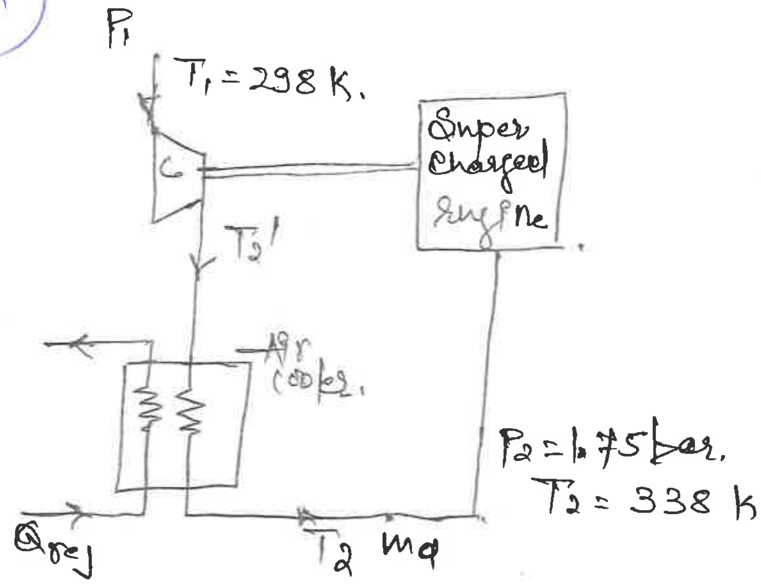
$D = 100\ mm = 0.1\ m$

$L = 110\ mm = 0.11\ m$

$N = 2000\ rpm$

$T_{out} = 150\ Nm$

$\eta_{mech} = 80\%.$



$$BP = \frac{2\pi NT}{60,000} = \frac{2\pi \times 2000 \times 150}{60,000} = 31.42\ KW.$$

$$IP = \frac{BP}{\eta_m} = \frac{31.41}{0.8} = 39.26\ KW.$$

$$IP = \frac{P_{mi} L A n i}{60,000} \qquad P_{mi} = \frac{39.26 \times 60,000}{0.11 \times \frac{\pi}{4}(0.1)^2 \times \frac{2000}{2} \times 6}.$$

$$P_{mi} = 454430.77\ N/m^2 = 4.544\ bar. = P_{mi}$$

$$V_s = \text{Engine swept volume} = i \times \left(\frac{\pi}{4} D^2 L\right)\frac{N}{2}\ m^3/min.$$

$$= 6 \times \frac{\pi}{4} \times 0.1^2 \times 0.11 \times \frac{2000}{2} = 5.184\ m^3/min.$$

Actual volume of air inducted into engine $= \eta_v \times V_s$

$$= 0.72 \times 5.184 = 3.732\ m^3/min$$

Actual mass flow rate of air into the engine $= m_a$.

$$m_a = \frac{P_2 V_2}{R T_2} = \frac{1.75 \times 10^5 \times 3.732}{287 \times 338} = 6.732\ kg/min. = m_a$$

Actual compressor work required comes ~~from~~ from engine output.

$\therefore$ Actual compressor work = Gain in Enthalpy of air in Compressor.

$$31.41 = \dot{m}_C \times C_p \times \Delta T$$

$$31.41 = \dot{m}_C \times 1.005\,(T_2' - 298)$$

$$\cancel{\dot{m}_C\, C_p\, (T_2' - T_2) = Q_{rej}/\text{sec}}$$

$$\cancel{\dot{m}_C\,(T_2' - 338) = \frac{1210}{1.005 \times 60} = 20.07}$$

$$\dot{m}_C\,(T_2' - 298) = \frac{31.41}{1.005} = 31.25 \text{ —— eq}^n\,(\text{I})$$

Heat balance in cooler.

$$\dot{m}_C . C_p\,(T_2' - T_2) = Q_{rej}/\text{sec}$$

$$\dot{m}_C\,(T_2' - 338) = \frac{1210}{1.005 \times 60} = 20.07 \text{ —— eq}^n\,(\text{II})$$

Divide (eq^n I). by (eq^n II)

$$\frac{T_2' - 298}{T_2' - 338} = \frac{31.25}{20.07} = 1.56 \qquad \therefore T_2' = 409.4\,K. = 136.4^\circ C.$$

$$\dot{m}_C = \frac{31.25}{409.4 - 298} = 0.2805 \text{ kg/sec}$$

$\dot{m}_C$ = Air flow into compressor in kg/min.

$\dot{m}_C$ = 16.83 kg/min