Mid sem

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Sec:- B

Sub:- Applied Thermodynamics.

Q 1 (1) We have,

$W_{net} = 840 \, kJ/kg$

Now,

Specific steam consumption $= \frac{3600}{W_{net}}$

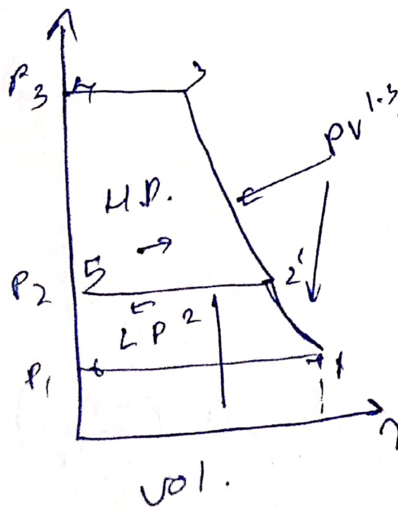
$= \frac{3600}{840} = 4.286 \, kg/kWh$

(b)

Q 2 An (vii)

Now,

$$\frac{V_1}{V_2} = \frac{\pi/4 \, D_{LP}^2 L}{\frac{\pi}{4} D_{H.P.}^2 L} = \frac{D_{LP}}{D_{HP}} = \sqrt{\frac{V_1}{V_2}}$$



$pv^{1.3} = C \Rightarrow P_1 V_1^{1.3} = P_2 V_2^{1.3}$

$\Rightarrow \frac{V_1}{V_2} = \left(\frac{P_2}{P_1}\right)^{1/1.3}$

Condition

η_{max} is, $P_2 = \sqrt{P_1 P_3} = \sqrt{(30)}$

$= 5.48 \, bar$

$\rightarrow \frac{V_1}{V_2} = (5.48)^{1/1.3} = 3.7$

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Now,

Delivery Temp = $T_2 = T_1 \left(\frac{P_2}{P_1}\right)^{\frac{n-1}{n}}$

$$\Rightarrow 288K \left(\frac{5.48\ bar}{1\ bar}\right)^{\frac{1.3-1}{1.3}} = 426.44K$$

For Const Process 2-2', $\frac{V_2}{T_2} = \frac{V_{2'}}{T_{2'}} \Rightarrow \frac{V_{2'}}{V_2} = \frac{T_{2'}}{T_2}$

$$\Rightarrow \frac{426.44}{288} = 1.48$$

$$\therefore \frac{V_1}{V_2} = \frac{V_1}{V_{2'}} \times \frac{V_{2'}}{V_2} = 3.7 \times 1.48 = 5.476$$

$$\Rightarrow \frac{D_{LP}}{D_{HP}} = \sqrt{\frac{V_1}{V_2}} = \sqrt{5.476} = 2.34.$$

(D) ✓

Q 1A for carnot cycle

(1)

$$\frac{Q_1}{Q_2} = \frac{T_1}{T_2}$$

$$\Rightarrow \frac{Q_1}{T_1} - \frac{Q_2}{T_2} = 0 \Rightarrow \frac{Q_1}{T_1} + \left(\frac{-Q_2}{T_2}\right) = 0$$

$$\Rightarrow \sum_{cycle} \left(\frac{Q_1}{T_1}\right) = 0$$

$$\oint \left(\frac{dQ}{T}\right) = 0$$

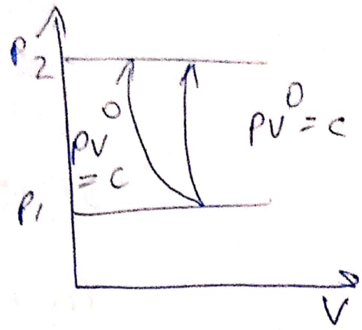
$$\therefore \oint ds = 0 \quad \therefore (C) \text{ Remains unchanged.}$$

Q 1 Ans

(IV)

(D) Adiabatic

$$W = -\int v\,dP$$



area under curve.

$\therefore$ work done is more

Q 2 Ans

(i) Find the calculation.

mechanics

$$h_1 = 340.5\,kJ/kg \;;\; h_2 = h_1 + v_1(P_2 - P_1)$$
$$= 343.5\,kJ/kg$$

$$h_3 = 3115.34\,kJ/kg \;,\; s_3 = 6.7428\,kJ/kg\text{-}K$$

$$x_4 = 0.8669$$

$$h_4 = 2343.9\,kJ/kg$$

$$\Rightarrow \eta = 1 - \frac{Q_{out}}{Q_{in}} = 1 - \frac{(h_4 - h_1)}{(h_3 - h_2)}$$
$$= 27.7\%$$

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$\therefore$ (c) 27.7%.

Q 2 An

(iv) Now,

to calculate turbine work ie W_T

we use the $h_{in} = 3374$ kJ/kg, h_{out}

$= 2346$ kJ/kg.

$h_{b_8} = 2797$ kJ/kg.

Fraction of steam extracted $y = 0.172$.

$$W_T = (h_{in} - h_b) + (1-y)\cdot(h_b - h_{out})$$

$$W_T = (3374 - 2797) + (1 - 0.172) \times (2797 - 2346)$$

$$W_T = 950 \text{ kJ/kg}.$$

Tot mass flow rate. P, Power output of plant

$$m = \frac{P}{W_t} = \frac{120000 \text{ kW}}{950 \text{ kJ/kg}}$$

$$= 126 \text{ kg/s}$$

$\therefore$ (D)

Q 1 Ans

(III) We know, Mollier diagram is h-s plot.

$Tds = dh - vdp$

$\Rightarrow \left(\frac{\partial h}{\partial S}\right)_P = T = \text{slope}$

∴ when T increase the slope increase

& T is always +ve.

∴ (a) Positive slope.

Q 1 Ans

(IV)

Ans (d) 1, 2 and (3)

∴ Rankine cycle increase with Temp ∴ less Q_1 is required

∴ $Q_1 \downarrow$ $\eta_{eff} \uparrow$.

also increase in pressure the T increase.

also $\eta_{eff} \uparrow$ when $Q_{rejection} \downarrow$

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Q1 Ans

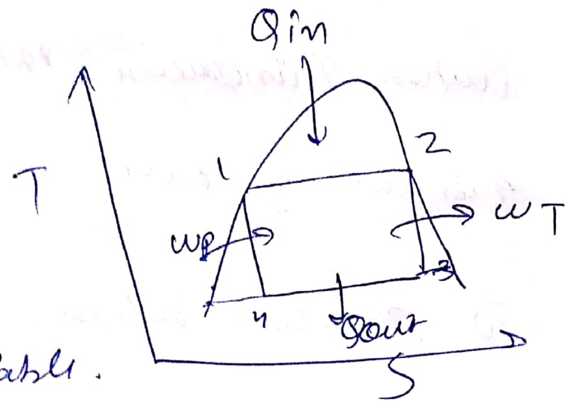
(vi) $\eta_v = 1 - \frac{V_c}{V_s}\left[\left(\frac{P_2}{P_1}\right)^{1/n} - 1\right]$ — (1)

Now, when $n \uparrow$ $\therefore \eta_{vol} \uparrow$ from (1)

$\therefore$ Q with increase in compression index

Q2 Ans

(i)



$P_1 = 8 MPa$

from steam table.

$h_1 = h_f / P.B = 1317.2 \ kJ/kg$

$S_1 = S_f = 3.208 \ kJ/kg$

$P_2 = 20 kPa.$

from $h_2 = h \ / PB = 2259.9 \ kJ/kg$

$S_2 = S / 8 \ PB = 25.742 \ kJ/kg$

$S_1 = S_4 \quad S_2 = S_3.$

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$\Rightarrow 5.242 = S_F/P_L + x_3\, S_{fs}/P_L$

$\Rightarrow \dfrac{5.242 - S_F/P_L}{S_{fs}/P_L} = x_3$

$\Rightarrow \dfrac{5.242 - 0.832}{2.022} = x_3 \Rightarrow x_3 = 0.6945$

Similarly $x_4 = \dfrac{3.208 - 0.832}{2.022} = 0.3354$

$h_3 = h_F/P_L + x_3\, h_{fs}/P_L = 251.5 + (0.6945) \times (2358.4)$

$= 1889.4\ kJ/kg$

$h_4 = 251.5 + 0.3354(2358.4)$

$= 1042.5\ kJ/kg$

$W_{net} = (h_2 - h_3) - (h_1 - h_4) = 598.8$

$= 596\ kJ/kg$

$\therefore$ D $596\ kJ/kg$

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Q 2 An

(VI)

$$IP = x \cdot \frac{n}{n-1} \; P.V. \left[\left(\frac{P_{x+1}}{P_1} \right)^{\frac{n-1}{xn}} - 1 \right]$$

Here $x = 3$,

$$IP \Rightarrow 3 \times \frac{1.25}{1.25-1} \times 100 \times \frac{15}{60} \left[\left(\frac{P_{3+1}}{P_1} \right)^{\frac{1.25-1}{3\times 1.25}} - 1 \right]$$

$$= \frac{3 \times 1.25}{0.25} \times 25 \left[\left(\frac{36}{1} \right)^{\frac{0.25}{3.75}} - 1 \right]$$

$$= 375 \times (1.27137 - 1)$$

$$= 375 \times 0.2713$$

$$= 101.9$$

$\therefore$ (b) 101.11

Q 2 A

(3) $M_1 \Rightarrow$ Tot heat of steam at 15 kg/cm² and 23°C = 698 kcal/kg

$M_2 \Rightarrow$ Tot heat of steam at 5 kg/cm² = 646 kcal/kg

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Now at 200°C reheat

$H_3 = 682$ kcal/kg

when expanded to 0.1 kg cm²

$H_4 = 553$ kcal/kg ⇒ Heat in this stage

~~H sot~~

H_{w4} = Sot heat of water at 0.1 kg cm²

= 45.4 kcal/kg

$$\eta_{\text{theoritical}} = \frac{(H_1 - H_2) + H_3 - H_4}{(H_1 + (H_3 - H_2) - H_{w4})}$$

$$= \frac{698 - 646 + 682 - 533}{698 + (642 - 646) - 45.4}$$

= 0.293.

∴ (D) 29%.

Q 2 (V) Ans

$$w = \frac{n-1}{n} P_1 (V_1 - V_4) \left(1 - \left(\frac{P_2}{P_1}\right)^{\frac{n-1}{n}}\right)$$

$$= \frac{1.32 - 1}{1.32} \left(\frac{1 \times 10^5 \, N/m^2 \times 30 \, m^3/min}{10^3 \times 60}\right.$$

$$\left. \times \left(1 - \frac{16 \, bar}{1 \, bar}\right)^{\frac{1.32-1}{1.32}}\right)$$

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$= 197.64\,kW$

$$W = \frac{197.64}{\eta_{mech}} = \frac{197.64}{0.82} = 241\,kW$$

$\therefore$ (c) 241 kW