NBA NATIONAL BOARD OF ACCREDITATION Accredited college

Sub- ET
Mech. III Sem.
Solution Set-A

RIET

Sec A

Ans1. System - It is defined as a quantity of matter or a region in space upon which attention is concentrated in the analysis of a problem.

Surrounding :- Everything out of the system is called surrounding.

Boundary :- The system is separated from the surrounding by the system boundary.

Ans2. Clausius statement :- It is impossible to construct a device which operating in a cycle, will produce no effect other than transfer of heat from a cooler to a hotter body.

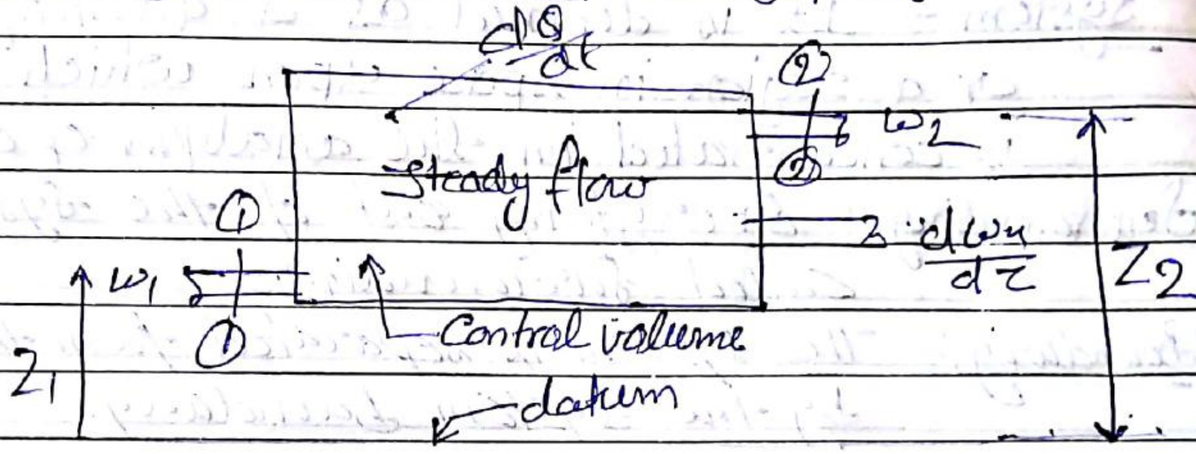
Ans3 :- Extensive properties :- which properties depend on the mass called extensive.

Intensive properties :- which properties independ on the mass called intensive.

Ans.5 :- Steady state process :- Any thermodynamics property will have a fixed value at a particular location, and will not alter alter with time.

SecB

Ans.1 Steady flow process energy eq^n →



$$\boxed{h_1 + \frac{V_1^2}{2} + Z_1 g + \frac{dQ}{dm} = h_2 + V_2^2 + Z_2 g + \frac{dw_x}{dw}}$$

Q.2 $T_1 = 273 + 25 = 298$

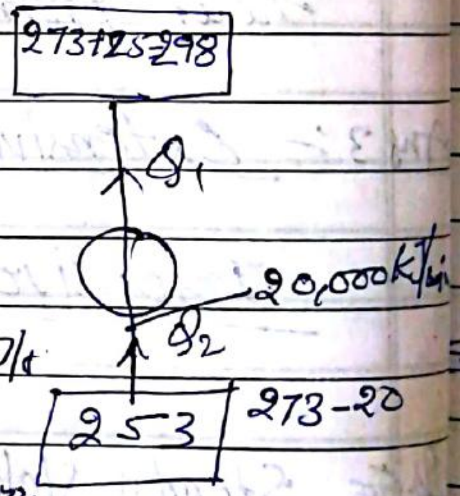
$T_2 = 273 + -20 = 253$

Power requirement

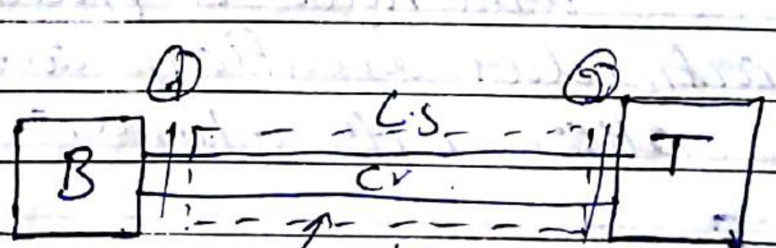
$$\frac{Q_2}{T_2} = \frac{Q_1}{T_1}$$

$$Q_1 = \frac{333 \cdot 33}{253} \times 298 = 392.16 \ kJ/s$$

$$W = Q_1 - Q_2 = 392 - 333 = 59 \ kw.$$



Ans.3 →



$$\frac{dQ}{dm} = -8.5 \ kJ/kg.$$

$$\frac{A_1 V_1}{v_1} = \frac{A_2 V_2}{v_2}$$

$$V_2 = \frac{A_1 V_1}{v_1} \cdot \frac{v_2}{A_2} \cdot V_1 = \frac{0.084}{0.073} V_1 = 1.15 V_1$$

$$\frac{dW_x}{dm} = 0$$

$$h_1 + \frac{V_1^2}{2} + \frac{dQ}{dm} = h_2 + \frac{V_2^2}{2}$$

$$\frac{(V_2^2 - V_1^2) \times 10^{-3}}{2} = h_1 - h_2 + \frac{dQ}{dm}$$

$$= 3213.6 - 3202.6 + (-8.5) = 2.5\ kJ/kg$$

$$V_1^2 (1.15^2 - 1^2) = 5 \times 10^3$$

$$V_1^2 = 15{,}650\ m^2/s^2$$

$$V_1 = 125.1\ m/s$$

$\therefore$ mass flow rate $w = \frac{A_1 V_1}{v_1} = \frac{\frac{\pi}{4}(0.2)^2\ m^2 \times 125.1\ m/s}{0.073\ m^3/kg}$

$$= 53.8\ kg/s$$

4:- $\eta_{th} = \frac{\text{work output}}{\text{heat supplied}} = \frac{W}{Q_1}$

$W = 10\ kW = 10\ kJ/s = 600\ kJ/min$, $Q_1 = 2250\ kJ/min$

$$\therefore \eta_{th} = \frac{600}{2250} = 0.267 \text{ or } 26.7\%$$

$$Q_1 = W + Q_2$$

$$Q_2 = Q_1 - W = 2250 - 600$$

$$\boxed{Q_2 = 1650\ kJ/min}$$

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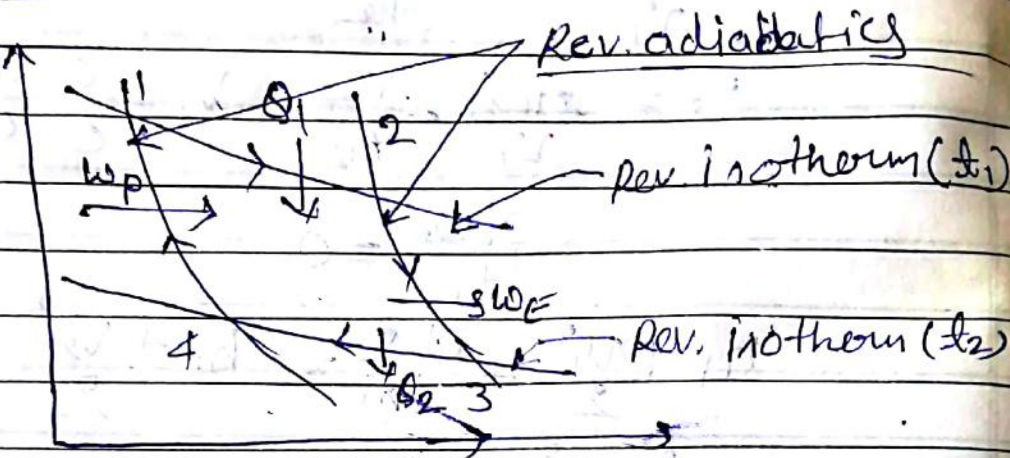
Ans.5:- Carnot cycle:-



① $Q_1 = U_2 - U_1 + W_{1-2} \quad U_1 = U_2$

② $0 = U_3 - U_2 + W_{2-3}$

③ $-Q_2 = U_4 - U_3 - W_{3-4} \quad U_3 = U_4$

④ $0 = U_1 - U_4 - W_{4-1}$

$Q_1 - Q_2 = (W_{1-2} + W_{2-3}) - (W_{3-4} + W_{4-1})$

$$\boxed{\text{Or} = \sum_{\text{cycle}} Q_{net} = \sum_{\text{cycle}} W_{net}}$$

Carnot theorem:-

It state that ~~of~~ all of heat engine operating b/w a given constant temp. source and a given constant temp. sink. none has a higher efficiency than a reversible engine.

Sec-C

Ans.1 Given - $T_1 = 273+15 = 308k$

$P_1 = 0.1\,mpa = 100\,kN/m^2$

$Q_1 = 2100\,kJ/kg$

$r_k = 8, \quad \gamma = 1.4$

$$\eta_{cycle} = 1 - \frac{1}{r_k^{\gamma-1}} = 1 - \frac{1}{8^{0.4}}$$

$$\boxed{\eta_{cycle} = 0.565 \text{ or } 56.5\%}$$

We know that

$$\frac{T_2}{T_1} = \left(\frac{V_1}{V_2}\right)^{\gamma-1} \Rightarrow T_2 = \frac{T_1}{r_k}$$

$$T_2 = 308 \times 2.3 = 708.4K$$

$$\frac{V_1}{V_2} = 8 = \frac{RT_1}{P_1} = \frac{0.287 \times 308}{100} = 0.844\,m^3/k$$

$$V_2 = \frac{0.884}{8} = 0.11\,m^3/kg$$

$$Q_1 = C_V(T_3 - T_2) = 2100\,kJ/kg$$

$$T_3 - 708.4 = \frac{2100}{0.718} = 2925k$$

$$T_{max} = T_3 = 2925 + 708 = 3633k$$

Now, $\left(\frac{P_2}{P_1}\right) = \left(\frac{V_1}{V_2}\right)^{\gamma} = (8)^{1.4} = 18.37$

$$P_2 = 1.873\,mpa$$

Again $\frac{P_2 V_2}{T_2} = \frac{P_3 V_3}{T_3}$

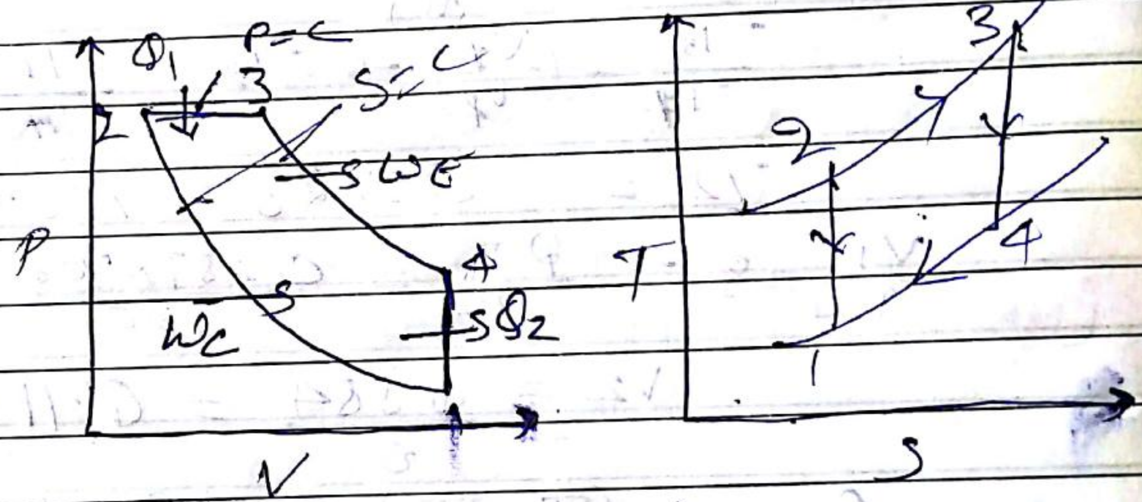
$$P_3 = \frac{P_2 V_2}{T_2} \times \frac{T_3}{V_3} \Rightarrow 1.837 \times \frac{363}{708} = 9.426$$

$W_{net} = Q_1 \times \eta_{cycle} = 2100 \times 0.565$
$= 1186.5$ kJ/kg
$= P_m (v_1 - v_2) = P_m (0.884 - 0.11)$

$P_m = m.e.p = \frac{1186.5}{0.774}$

$= 1533$ kPa $= 1.533$ MPa.

Ans.2 Diesel cycle :-



H.S $\Rightarrow Q_1 = mc_p (T_3 - T_2)$
H.R $\Rightarrow Q_2 = mc_v (T_4 - T_1)$

$$\eta = 1 - \frac{Q_2}{Q_1} \Rightarrow 1 - \frac{mc_v (T_4 - T_1)}{mc_p (T_3 - T_2)}$$

$$\boxed{\eta_{cycle} = 1 - \frac{(T_4 - T_1)}{\gamma (T_3 - T_2)}}$$

Now we have

$r_k = \frac{v_1}{v_2}$, $r_c = \frac{v_3}{v_2}$, $r_e = \frac{v_4}{v_3}$

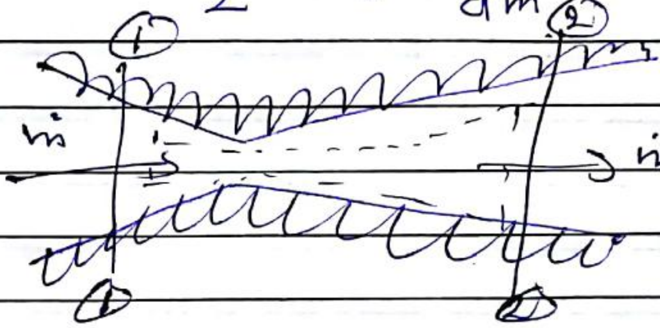
$r_k = r_e . r_c$

So we get value of T_1 & T_2, T_3 & T_4 by relation.

$$\boxed{\eta_{Diesel} = 1 - \frac{1}{r} \cdot \frac{1}{r_k^{n-1}} \cdot \frac{r_c^{n}-1}{r_c-1}}$$

Ans 3. (a) S.F.E.E for Nozzle :-

we know that, $h_1 + \frac{V_1^2}{2} + Z_1 g + \frac{dQ}{dm} = h_2 + \frac{V_2^2}{2} + Z_1 g + \frac{dW_4}{dm}$



$\frac{dQ}{dm} = 0$

$\frac{dW_x}{dm} = 0$

$$h_1 + \frac{V_1^2}{2} = h_2 + \frac{V_2^2}{2}$$

$$h_1 = h_2 + V_2^2/2$$

$$\boxed{V_2 = \sqrt{2(h_1 - h_2)} \ m/s}$$

(b) S.F.E.E for turbine

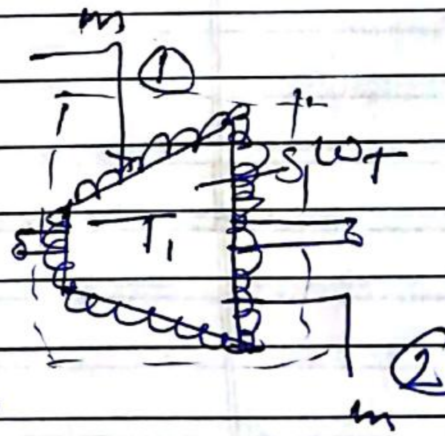
here, $V_1 = 0$, $\frac{dQ}{dm} = 0$ $V_2 = 0$

so

S.F.E.E eqⁿ for turbine is

~~$h_1 + V_1$~~

$$h_1 = h_2 + \frac{dW_x}{dm}$$



$$\boxed{\frac{W_x}{m} = (h_1 - h_2)}$$