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COURSE : B.TECH CS WITH CSF (1)

SECTION : 3B

ROLL NO : 76

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SUBJECT : BASIC MECHANICAL ENGINEERING

SUBMITTED TO : Mr. SUNIL KUMAR.

ASSIGNMENT NO: 2.

Q1. Consider 1 kg of gas at P_1, V_1, T_1 & S_1 be heated such that the final values be P_2, V_2, T_2 & S_2 respectively. We know that,

$$\delta Q = du + \delta W$$

$$\delta Q = C_v dT + \frac{P}{T} \cdot dv$$

But,

$$\delta Q = ds$$

$$PV = RT$$

$$P/T = R/V$$

$$ds = C_v \cdot \frac{dT}{T} + R \cdot dv$$

Integrating both sides

$$\int_{S_1}^{S_2} ds = C_v \int \frac{dT}{T} + R \int_{V_1}^{V_2} \frac{dv}{V}$$

$$S_2 - S_1 = C_v \log_e \left[\frac{T_2}{T_1}\right] + R \log_e \left[\frac{V_2}{V_1}\right] \quad (1)$$

∴ We know that from gas eqⁿ

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

$$\frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right) \times \left(\frac{V_2}{V_1}\right)$$

Put in eqⁿ (1)

$$S_2 - S_1 = C_v \log_e\left[\frac{P_2}{P_1} \times \frac{V_2}{V_1}\right] + R \log_e\left[\frac{V_2}{V_1}\right].$$

$$S_2 - S_1 = C_v \log_e\left[\frac{P_2}{P_1}\right] + C_v \log_e\left[\frac{V_2}{V_1}\right] + R \log_e\left[\frac{V_2}{V_1}\right]$$

$$S_2 - S_1 = C_v \log_e\left[\frac{P_2}{P_1}\right] + C_p \log_e\left[\frac{V_2}{V_1}\right] - (2)$$

We know that from gas,

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

$$\frac{V_2}{V_1} = \left[\frac{T_2}{T_1}\right] \times \left[\frac{P_1}{P_2}\right]$$

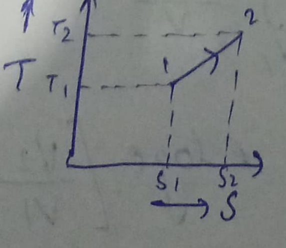
Put in eqⁿ. (1)

$$S_2 - S_1 = C_v \log_e\left[\frac{T_2}{T_1}\right] + R \log_e\left[\frac{T_2}{T_1} \times \frac{P_1}{P_2}\right]$$

$$S_2 - S_1 = C_v \log_e\left(\frac{T_2}{T_1}\right) + R \log_e\left(\frac{T_2}{T_1}\right) + R \cdot \log_e\left(\frac{P_1}{P_2}\right).$$

$$S_2 - S_1 = C_p \log_e\left(\frac{T_2}{T_1}\right) - R \log_e\left(\frac{P_2}{P_1}\right)$$

Q2. (i) Constant Pressure Process.



(3)

Consider 1 kg of gas heated at Constant Volume such that change in entropy & Absolute Temp. from we know that,

$$Q = C_p [T_2 - T_1]$$

On Differentiating both sides

$$\frac{\delta Q}{T} = C_p \frac{dT}{T}$$

On Integrating

$$\int_1^2 ds = C_p \int_1^2 \frac{dT}{T}$$

$$S_1 - S_1 = C_p \ln \left[\frac{T_2}{T_1}\right].$$

(ii) Const. Temperature Process

$du = 0$ $\therefore Q - W.$

we know that

$$Q = \int_{S_1}^{S_2} T \cdot ds = T(S_2 - S_1) \quad \text{— (i)}$$

$$W = P_1 V_1 \log\left(\frac{V_2}{V_1}\right)$$

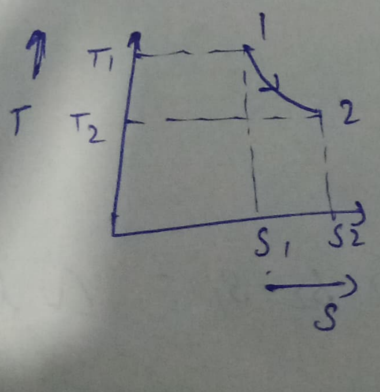
$$W = R T_1 \log_e\left(\frac{V_2}{V_1}\right) \quad \text{— (ii)}$$

eq. (i) & (ii)

$$t(S_2 - S_1) = R T_1 \log_e\left(\frac{V_2}{V_1}\right) \quad [\because T_1 = T_2 = T]$$

$$S_2 - S_1 = R \log_e\left(\frac{V_2}{V_1}\right).$$

(iii) Polytropic Process



(4)

We know that,

$$S_2 - S_1 = C_v \log_e\left(\frac{T_2}{T_1}\right) + R \log_e\left(\frac{V_2}{V_1}\right) \quad -(1)$$

We know that,

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

$$\left(\frac{V_2}{V_1}\right) = \left(\frac{T_1}{T_2}\right)^{1/n-1}$$

Put eq^n (1)

$$S_2 - S_1 = C_v \log_e\left[\frac{T_2}{T_1}\right] + R \log_e\left[\left(\frac{T_1}{T_2}\right)^{1/n-1}\right]$$

$$S_2 - S_1 = C_v \log_e\left[\frac{T_2}{T_1}\right] + R \log_e\left[\left(\frac{T_1}{T_2}\right)^{1/n-1}\right]$$

$$S_2 - S_1 = C_v \log_e\left[\frac{T_2}{T_1}\right] - P(C_p - C_v)\left[\frac{1}{n-1}\right] \log_e\left(\frac{T_2}{T_1}\right)$$

$$S_2 - S_1 = C_v\left[\left(\frac{n-\gamma}{n-1}\right) \log_e\left(\frac{T_2}{T_1}\right)\right]$$

(iv) Constant Volume Process.

we know that,

$$Q = C_v(T_2 - T_1)$$

On Differentiating both sides.

$$\delta Q = C_v\, dT.$$

Dividing T on both sides.

$$\frac{\delta Q}{T} = C_v \frac{dT}{T}$$

$$dS = C_v \frac{dT}{T}$$

On integrating

$$\int_1^2 dS = C_v \int_1^2 \frac{dT}{T} \Rightarrow S_2 - S_1 = C_v \ln\left[\frac{T_2}{T_1}\right].$$

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Q3. Given,

$T_2 = 80°F \quad = 299.667\ K$

$T_1 = 530°F \quad = 549.667\ K$

(a) $\eta_{HE} = 1 - \frac{T_2}{T_1} \Rightarrow 1 - \frac{299.667}{549.667}$

$= 1 - 0.5451$

$= 0.9990 = 99.99\%$.

(b) Heat Supplied = 50 kJ/sec

We know that,

$\eta = \frac{output}{input} = \frac{W}{Q}$

$0.9990 = \frac{W}{50}$

[Work = 49.95 kW]

(c) $(COP)_R = \frac{T_2}{T_1 - T_2} = \frac{299.667}{549.667 - 299.667}$

$= 1.198$

$= 1.2$

$(COP)_{Pumb} = \frac{T_1}{T_1 - T_2} = \frac{549.81}{250} = 2.195$

$= 2.2$.

Q4. $W = 15\ kW\ kJ/s = 15 \times 3600 = 5400\ kJ/hr$

$Q_1 = 4 \times 10^{10}\ kJ/hr$

$W = Q_1 - Q_2$

$Q_2 = Q_1 - W = 4 \times 10^{10} - 54000$

$= 3.99 \times 10^{10}$

$(COP)_{HP} = \frac{Q_1}{Q_1 - Q_2 = W} = \frac{4 \times 10^{10}}{0.54 \times 10^5} = 7.4 \times 10^6$

$(COP)_{Ref} = \frac{Q_2}{W} = \frac{3.99 \times 10^{10}}{0.54 \times 10^5} = 7.40739 \times 10^5$

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Ans $T_2 = 5°C = 278\,K$

$T_1 = 30°C = 303\,K$

$T_3 = 840°C = 1113\,K$

$T_4 = 60°C = 333\,K$

$W_2 = 30\,KW$

$Q_2 = 20.21\,KJ/sec = 20.21\,KW$

(a) $(COP) = \frac{T_1}{T_1 - T_2} = \frac{303}{303 - 278} = \frac{303}{25} = 12.12$

$(COP) = \frac{Q_1}{Q_1 - Q_2}$

$12.12Q = \frac{Q1}{Q - 20.21}$

$12.12Q_1 - 244.94 = Q_1$

$11.12\,Q_1 = 244.94.$

$[\therefore Q_1 = 20.20]$

$\eta = 1 - \frac{T_4}{T_3}$

$= 1 - \frac{333}{113}$

$= 0.7$

Heat supply by source is 47.67 W

$W_1 = Q_1 - Q_2$

$= 20.21 - 20.20$

$= 0.01\,KW$

$\eta = \frac{W_1 + W_2}{Q_4}$

$0.7 = \frac{0.01 + 20.21}{Q_4} = 28.88\,KW$

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(b) $w_1 + w_2 = w$

$w = 0.01 + 20.21$

$= 20.22 \text{ kW}$

$w = Q_4 - Q_3$

$Q_3 = Q_4 - w$

$= 28.88 - 20.22$

$= 8.66 \text{ kW}$

$Q_1 = Q_4 + Q_3$

$= 0.01 + 8.66$

$= 8.76 \text{ kW}$

Heat rejected at $80°C$ is 34.67 kW.

Q6.

$Q_1 = 4000$ kJ

$T_1 = 2000$ K

$WE_1 = 1800$ kJ

$WE_2 = 1200$ kJ

$WE_3 = 500$ kJ

$$HE_1 = \frac{T_1 - T_2}{T_1} = \frac{WE_1}{Q_1}$$

$$\frac{1800}{4000} = \frac{2000 - T_2}{2000}$$

$$\boxed{T_2 = 1100 \text{ K}}$$

$Q_2 = Q_1 - WE_1 = 4000 - 1800$

$= 2200$ kJ

$$HE_2 = \frac{WE_2}{Q_2} = \frac{T_2 - T_3}{T_2}$$

$$\frac{1200}{2200} = \frac{1100 - T_3}{1100}$$

$$\boxed{T_3 = 500 \text{ K}}$$

$Q_3 = Q_3 - WE_2 = 2200 - 1200$

$= 1000$ kJ

$$\eta_{E3} = \frac{W_{E3}}{Q_3} = \frac{T_3 - T_4}{T_3}$$

$$\frac{500}{1000} = \frac{500 - T_4}{500}$$

$$T_4 = 250\,K$$

$$(COP)_R = \frac{T_1}{T_1 - T_2} = \frac{549.667}{549.667 - 299.667}$$

$$= 2.198 \text{ Ans}$$

Q7 for Engine

$T_1 = 875\,K$

$T_2 = 310\,K$

$$\eta = 1 - \frac{T_2}{T_1}$$

$$\eta = 1 - \frac{T_2}{T_1}$$

$$\eta = 1 - \frac{310}{875}$$

$\eta = 0.6457$

$\eta = 64.57$

$$\eta_{HE} = \frac{W}{Q_1}$$

for Refrigerator

$T_1 = 310\,K$

$T_2 = 255\,K$

$$(COP)_R = \frac{T_2}{T_1 - T_2}$$

$$= \frac{255}{310 - 255}$$

$$= \frac{255}{55}$$

$= 4.63.$

Work Output by Heat engine $= 129.42\,kJ$

Work Consumed by Refrigerator

$= 1291.42 - 350$

$= 941.42\,kJ$

Cooling Effect $= (COP)_R \times$ Work

$= 4.63 \times 941.42\,kJ$

$= 4358.81\,kJ$ Ans

(4)

Q8 Let T_f = final equilibrium from energy Conservation principle

Heat lost by steel = heat gain by oil,

$(mcp \cdot dT)_{steel} = (mcp \cdot dT)_{oil}$

$8 \times 0.5 (1000 - T_f) = 80 \times 3.5 \times (T_F - 300$

$[T_f = 309.86 \ K]$

Entropy change of steel:

$(ds)_{steel} = mcp \log_e \left(\frac{T_f}{T_i}\right)$

$= 8 \times 0.6 \times \log_e \left(\frac{309.86}{1000}\right)$

$= -4.686 \ kJ/k.$

Entropy change of oil:

$(ds)_{oil} = mcp \log_e \left(\frac{T_f}{T_1}\right).$

$= 80 \times 3.5 \times \log_e \left(\frac{309.86}{300}\right)$

$= 9.0547 \ kJ/k.$

Entropy change of universe;

$(ds)_{universe} = (ds)_{steel} + (ds)_{oil}.$

$= -4.686 + 9.0547$

$= 4.369 \ kJ/k$ (increase

Q9. Let T_m = Temp. of mixture from energy Conservation principle.

Heat lost by water = heat gain by ice

$(mc_p dT)_{water} = (mc_p \cdot dT)_{ice}$ + latent heat

$5 \times 4.187 \times 30 \cdot 7T_m = 1 \times 4.187 \times (T_m - 0) + 335$

$[T_m = 11.67°C]$

Entropy change of water:-

$(ds)_{water} = mc_p \ln\left(\frac{T_m}{T_1}\right)$

$= 5 \times 4.187 \ln\left(\frac{16.67 + 273}{30 + 273}\right)$

$= -1.3004$ KJ/K.

Entropy change of ice:

$(ds)_{ice} = $ latent heat $+ mc_p \ln\left(\frac{T_m}{T_1}\right)$

$= \frac{335}{273} + 1 \times 411.87 \times \ln\left(\frac{11.67 + 273}{0 + 273}\right)$

$= 1.4024$ KJ/K.

$(ds)_{system} = (ds)_{water} + (ds)_{ice}$

$= -1.3004 + 1.4024$

$= 0.096$ KJ/K (increase).

Q10: Pattern allowances play an important Role in obtaining adequate pattern. The pattern size is never kept the same as that of desired Casting.

- The art of designing patterns is known as pattern in the Casting process. The pattern maker must account for maid type & Casting metal characteristics & make an exact replica of shape. Different types of pattern allowances are:

(i) Shrinkage allowance :- Shrinkage is defined as the reduction during the cooling or Solidification process.

(ii) Draft allowance :- During removing the pattern from the mould Cavity the parallel Surfaces in the direction in which the pattern is withdrawn are slightly damaged & Converted into tapered surfaces.

(iii) Machining allowance :- Product of Casting process gives a poor Surface finish, So the surface of the final product of Casting always is rough. So in order to have a good Surface finish.

(iv) Distortion Allowance :- This allowance is taken into Consideration when Casting produces irregular shape. when they are Cooled they are distorted due to metal shrinkage.

(v) Draft allowance :- pattern draft is a taper placed on pattern surface that are parallel to direction in which the pattern is withdrawn from the mould. to allow removal of patterns without damaging the mould Cavity.