Paper Code - U218-155(T2)

OCTOBER 2018/ IN-SEM (T2)

S. Y. B. TECH. (MECHANICAL ENGINEERING) (SEMESTER - I)

COURSE NAME : Thermodynamics

COURSE CODE : MEUA21175

(PATTERN 2017)

Marking Scheme

Q.1) a) Change in entropy - 2 marks
Work done - 2 marks
Correct formula -1 mark each

b) P-v/T-s diagram - 2 marks
Derivation – 4 marks

c) Definition - 2 marks each

Q.2) a) Heat supplied - 2 marks
Entropy change - 2 marks
Correct formula -1 mark each

b) Diagram - 2 marks each

c) P-v/T-s diagram - 2 marks
Derivation – 2 marks

Q.3) a) Mass of steam - 2 marks
Mass of water - 2 marks
Correct formula -1 mark each

b) Definitions - 1 marks each

c) P – v & T – s diagram - 2 marks
Explanation – 2 marks

Q.4) a) Volume of tank - 2 marks
Moisture content - 2 marks
Correct formula -1 mark each

b) Definition - 1 mark
Advantages - 3 marks

c) Diagram - 2 marks
Derivation – 2 marks

Paper Code-U218-155(T2)

OCTOBER 2018/ IN-SEM (T2)

S. Y. B. TECH. (MECHANICAL ENGINEERING) (SEMESTER - I)

COURSE NAME: Thermodynamics

COURSE CODE: MEUA21175

(PATTERN 2017)

Solution

Q.1)	a)	$m = \frac{p_1 v_1}{RT_1}$ $= \frac{1.5 \times 10^5 \times 0.15}{0.295 \times 10^3 \times 300} = 0.254 \text{ kg}$ $v_2 = v_1 \left(\frac{p_1}{p_2}\right)^{\frac{1}{n}}$ $= 0.15\left(\frac{1.5}{15}\right)^{1/1.25} = 0.0238 \text{ m}^3$ $s_2 - s_1 = mc_p \log_e \frac{v_2}{v_1} + mc_v \log_e \frac{p_2}{p_1}$ $= 0.254 \times 1.04 \log_e \frac{0.0238}{0.15}$ $+ 0.254 \times 0.745 \log_e \frac{15}{1.5}$ $= -0.4863 + 0.4357$ $= 0.0506 \text{ kJ/kg}$ $W_{1-2} = \frac{p_1 v_1 - p_2 v_2}{n-1}$ $= \frac{1.5 \times 10^5 \times 0.15 - 15 \times 10^5 \times 0.0238}{1.25 - 1}$ $= -52800 \text{ J} = -52.80 \text{ kJ}$
	b)	An isothermal expansion 1-2 at constant temperature T is shown in Fig. 5.27. Entropy changes from s_1 to s_2 when gas absorbs heat during expansion. The heat taken by the gas is given by the area under the line 1-2 which also represents the work done during expansion. In other words, $Q = W$. But $Q = \int_{s_1}^{s_2} T ds = T(s_2 - s_1)$ and $W = p_1 v_1 \log_e \frac{v_2}{v_1} = RT_1 \log_e \frac{v_2}{v_1}$ per kg of gas [$\because p_1 v_1 = RT_1$]

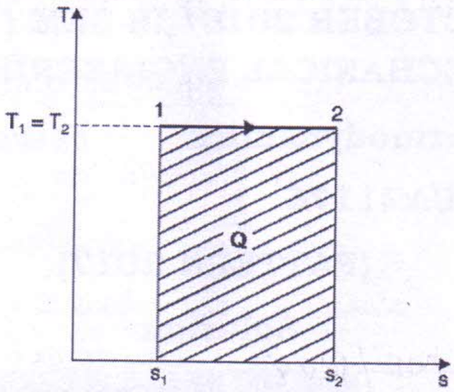


Fig. 5.27. *T-s* diagram : Isothermal process.

$\therefore \quad T(s_2 - s_1) = RT_1 \log_e \frac{v_2}{v_1}$

or $\quad s_2 - s_1 = R \log_e \frac{v_2}{v_1}$. $\quad [\because \; T_1 = T_2 = T] \quad$ ...(5.33)

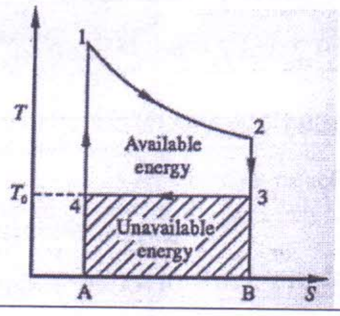
c) **Available energy**

Available energy is the maximum portion of energy which could be converted into useful work by ideal processes which reduce the system to a dead state (a state in equilibrium with the earth and its atmosphere). Because there can be only one value for maximum work which the system alone could do while descending to its dead state, it follows immediately that 'Available energy' is a property.

Unavailable energy

A system which has a pressure difference from that of surroundings, work can be obtained from an expansion process, and if the system has a different temperature, heat can be transferred to a cycle and work can be obtained. But when the temperature and pressure becomes equal to that of the earth, transfer of energy ceases, and although the system contains internal energy, this energy is unavailable.

Q = A.E. + U.E.



Q.2) a)

$$m = \frac{p_1 v_1}{RT_1} = \frac{1 \times 10^5 \times 0.005}{296.93 \times 290}$$

$$= 5.806 \times 10^{-3} \text{ kg}$$

$$c_v = \frac{R}{\gamma - 1} = \frac{296.93}{1.4 - 1}$$

$$= 742.32 \text{ J/kg K}$$

Heat supplied $= mc_v(T_2 - T_1)$

$= 5.806 \times 10^{-3} \times 742.32\ (360 - 290)$

$= 301.694 \cong 0.302$ kJ

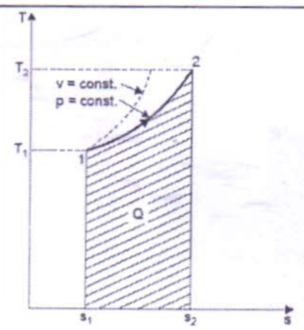
Change in entropy,

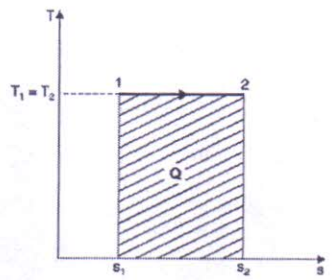
$$(S_2 - S_1) = mc_v \log_e \frac{T_2}{T_1}$$

$$= 5.806 \times 10^{-3} \times 742.32 \log_e \frac{360}{290}$$

$$= 0.9319 \text{ J/kg K}$$

b)





i. isochoric ii. Isobaric iii. Isothermal c)

5.17.5. Adiabatic Process (Reversible)

During an adiabatic process as heat is neither supplied nor rejected,

$$dQ = 0$$

or $$\frac{dQ}{dT} = 0$$

or $$ds = 0 \quad \text{...(5.34)}$$

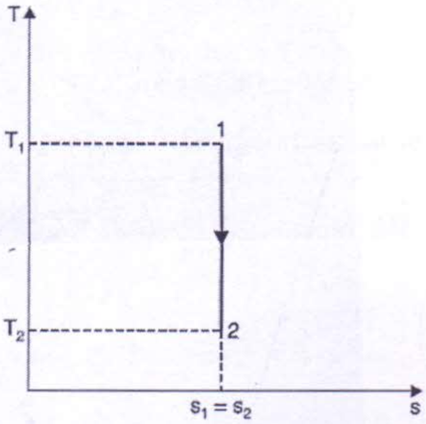


Fig. 5.28. *T-s* diagram : Adiabatic process.

This shows that there is no change in entropy and hence it is known as *isentropic process.*

Fig. 5.28 represents an adiabatic process. It is a vertical line (1-2) and therefore area under this line is nil ; hence heat supplied or rejected and entropy change is zero.

Q.3) a)

lution : Total volume of the shell $= \frac{4}{3}\pi r^3$

$$= \frac{4}{3}\pi (0.3)^3 = 0.1130 \text{ m}^3$$

∴ Volume of vapour and that of water

$$= \frac{0.1130}{2} = 0.0565 \text{ m}^3$$

From steam tables, corresponding to turation temperature of 300°C,

$$v_f = 0.001404 \text{ m}^3/\text{kg}$$

and $$v_g = 0.0216 \text{ m}^3/\text{kg}$$

$$\therefore \text{ Mass of vapour} = \frac{0.0565}{0.0216} = 2.616 \text{ kg}$$

$$\text{Mass of water} = \frac{0.0565}{0.001404} = 40.242 \text{ kg}$$

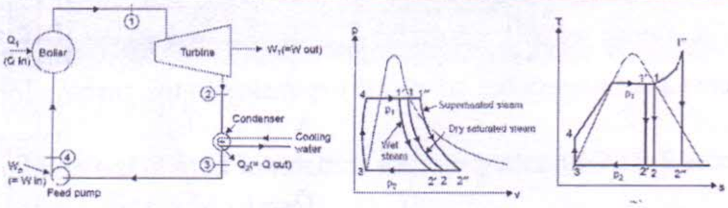
b)

i. **Wet steam –**

Wet steam is a mixture of steam and liquid water.

ii. **Dry saturated steam –**

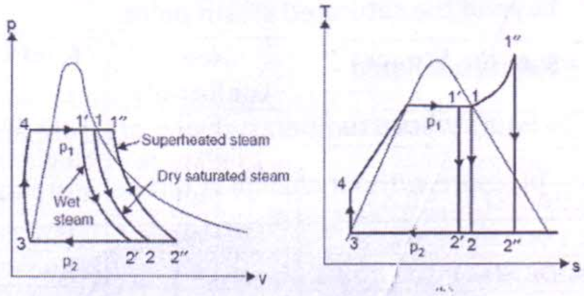
Saturated (dry) steam results when water is heated to the boiling point (sensible heating) and then vaporized with additional heat (latent

		heating). **iii. Superheated steam –** Superheated steam is created by further heating wet or saturated steam beyond the saturated steam point. **iv. Saturated liquid -** a liquid whose temperature and pressure are such that any decrease in pressure without change in temperature causes it to boil.
	c)	 **Process 1-2 :** Reversible adiabatic expansion in the turbine (or steam engine). $W_T = h_1 - h_2$ **Process 2-3 :** Constant-pressure transfer of heat in the condenser. $Q_2 = h_2 - h_3$ **Process 3-4 :** Reversible adiabatic pumping process in the feed pump. $W_P = h_4 - h_3$ **Process 4-1 :** Constant-pressure transfer of heat in the boiler. $Q_1 = h_1 - h_4$
Q.4)	a)	Solution : At 20°C ; $v_f = 0.001002\ m^3/kg$; $v_g = 57.79\ m^3/kg$ That gives $V_f = m_f v_f$ $= 100 \times 0.001002$ $= 0.1002\ m^3$ $V_g = m_g v_g$ $= 5 \times 57.79 = 288.95\ m^3$ $\therefore$ Total volume $V = V_f + V_g$ $= 0.1002 + 288.95 = 289\ m^3$ Moisture content refers to wetness fraction which is given by $x = \frac{m_f}{m_f + m_g}$ $= \frac{100}{100+5} = 0.952$ or 95.2 %
	b)	**Superheated steam** is a **steam** at a temperature higher than its vaporization (boiling) point at the absolute pressure where the temperature is measured. **Advantages** 1. The main advantages of using a superheater are reduced fuel and water consumption

<table>
<tr><td></td><td></td><td>

2. Superheated steam has a high thermal capacity per unit volume, offering extremely high thermal conductivity.
3. Superheated steam has a lower density, so lowering the temperature does not revert it back to its original liquid state

</td></tr>
<tr><td></td><td>c)</td><td>



Process 1-2 : Reversible adiabatic expansion in the turbine (or steam engine).

$$W_T = h_1 - h_2$$

Process 2-3 : Constant-pressure transfer of heat in the condenser.

$$Q_2 = h_2 - h_3$$

Process 3-4 : Reversible adiabatic pumping process in the feed pump.

$$W_P = h_4 - h_3$$

Process 4-1 : Constant-pressure transfer of heat in the boiler.

$$Q_1 = h_1 - h_4$$

$$\eta_{Rankine} = \frac{W_{net}}{Q_1} = \frac{W_T - W_P}{Q_1}$$

$$= \frac{h1-h2}{h1-h3}$$

</td></tr>
</table>