Important Instructions to examiners:

1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling errors should not be given more Importance (Not applicable for subject English and Communication Skills.
4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any
equivalent figure drawn.
5) Credits may be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer.
6) In case of some questions credit may be given by judgement on part of examiner of relevant answer based on candidate's understanding.
7) For programming language papers, credit may be given to any other program based on equivalent concept.

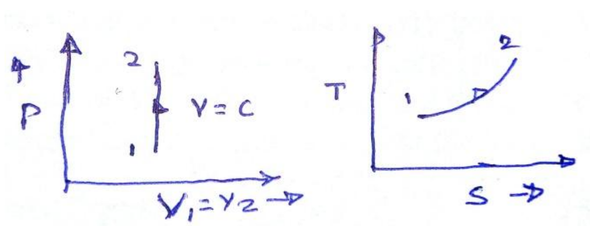
Q.1- a) Attempt any Six (2 marks each)

i) Path function – The thermodynamics quantities which are dependent on path followed between two ends. **States of process** and independent of two end states are called path function.

ii) Kelvin plank statement – It is impossible to construct an engine that operating in a cycle, will produce **no** effect other than extraction of heat from single reservoir and the performance of an equivalent amount of work.

iii) Charle's Law – It state that if the perfect gas is heated at constant pressure its volume varies directly with absolute temperature.

iv) Isochoric process. (1 + 1)



v) Boiler mountings – Pressure gauge, steam stop valves, blow off cock, safety valve, water level indicator, fusible plug. (Any two)

Boiler Accessories – Feed water pump, injector, air preheater economizer & superheater. (Any two)

vi) Degree of reaction is defined as the ratio of energy transfer by change in static head to the total energy transfer in the rotor i.e.

$$R = \frac{\text{Isontropic enthalpy change in rotor}}{\text{Isontropic enthalpy change in stage}}$$

vii) Significance of mach number –

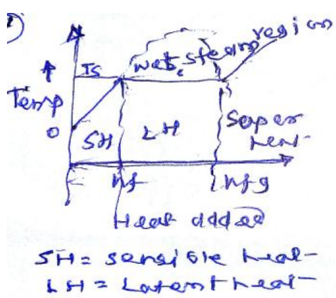
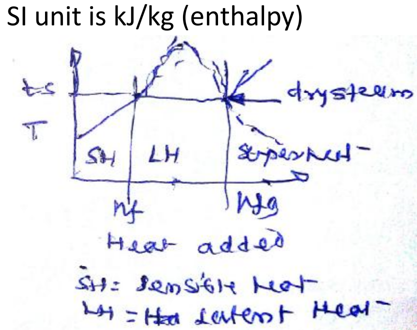
- If Mach number is less than one, flow is sonic, and nozzle is convergent.
- If Mach number is equal to one, flow is sonic.
- If Mach number is greater than one, flow is supersonic and nozzle is divergent.

viii) Vacuum efficiency – Is defined as the ratio of actual vacuum as recorded by vacuum gauge to ideal vacuum due to steam alone when air is absent.

$$\eta_{\text{vacuum}} = \frac{\text{Actual vacuum at steam inlet to condensor}}{\text{Boimatric pressure - Asolute pressure of steam}}$$

Q.1- b) Attempt any Two

i) Differentiate (Any four point one mark each)

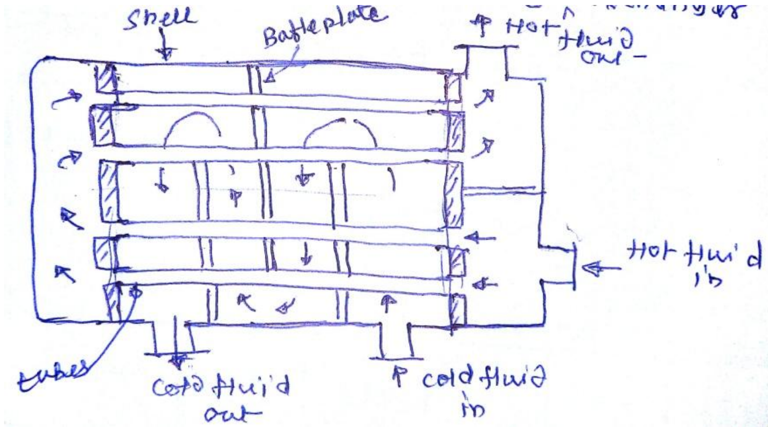
Wet steam	Dry steam
i) Wet steam is defined as steam which is partly liquid water suspended in it. ii) Dryness fraction of wet steam is less than one. iii) Enthalpy of wet steam $H_{wet} = h_f + x\, h_{fg}$ where H_f = sensible heat x = dryness fraction h_{fg} = latent heat of evaporation. iv) SI unit is kJ/kg (enthalpy) v) 	i) Dry steam – The steam which do not contains any amount of water particle in it is called dry steam. ii) Dryness fraction of dry steam is equal to one. iii) Enthalpy of dry steam $H_s = h_f + h_{fg}$ where hs = enthalpy of dry stem h_f = sensible heat h_{fg} = latent heat of evaporation iv) SI unit is kJ/kg (enthalpy) v) 

ii) Factors affecting cooling of water in a cooling towers are

a) Temperature of air, b) Humidity of air, c) Temperature of hot air, d) Size & height of tower, e) Velocity of air entering tower, f) Accessibility of air to all parts of towers. g.)Degree of uniformity in descending water. h) Arrangement of plates in towers.

(Any Eight point four marks)

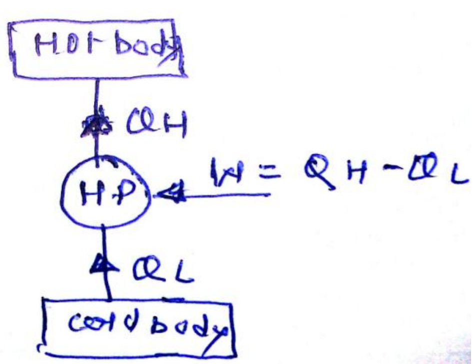
iii) Explain shell & tube heat exchanger (2 + 2 marks)



It consist of buddle of round of tube placed inside cylindrical shell with tube axis parallel to that of shell. One fluid is carried through a bundle of tubes enclosed by shell. The other fluid forced through shell and flow over the outside the surface of tube. Heat is exchanged take place between hot fluid & cold fluid.

Q.2 Attempt any Four

i) Heat pump – It is a device which operating in a cycle, maintain a body, at a temperature higher than the temperature of its surrounding.



OR It is a device in which transfer of heat energy from cold body to hot body by means of supplying work.

$$COP = \frac{\text{Desired Heating effect}}{\text{Work supplied}}$$

$$COP = \frac{Q_H}{Q_H - Q_L}$$

iv) In term of temp $COP = \frac{T_H}{T_H - T_L}$ (2 + 2 marks)

ii) $m = 2\ kg, T_1 = 50^0 c + 273 = 323k, \quad \frac{p_2}{p_1} = 2 \quad , T_2 = ?$

$$\Delta U = mcv(T_2 - T_1) \quad , cv = 0.70\ kJ/kg$$

Taking $\frac{P_1V_1}{T_2} = \frac{P_2V_2}{T_2}$ At const. volume $V_1 = V_2$ 1 mark

$$\frac{P_2}{T_2} = \frac{P_1}{T_1}, \frac{P_2}{P_1} = \frac{T_2}{T_1}$$

$$2 = \frac{T_2}{323}$$

$$T_2 = 646\ k$$

1 mark

$\Delta\mu = mcv(T_2 - T_1) = 2 \times 0.70 \times (646 - 323)$ 1 mark

Change in internal energy $\Delta U = 452.2\ kJ$ 1 mark

iii) Necessity of boiler draft – (2 + 2 marks)

- The purpose of draft is to supply required quantity of air for combustion and remove the burnt product from system.
- To move the air through fuel bed & to produce a flow of hot gases through boiler, economizer, preheater and chimney requires a difference of pressure equal to that accelerate the burnt gases to their final velocity and to overcome the pressure losses equivalent to pressure head draft is necessary.
- Natural boiler draft – when the draft is produced with help of chimney is know as natural draft.
- It doesn't require any external power for producing the draft.
- There is a natural circulation of air through furnace, economizer, air preheater & to the chimney.

iv) Differentiate (Any four point one mark each)

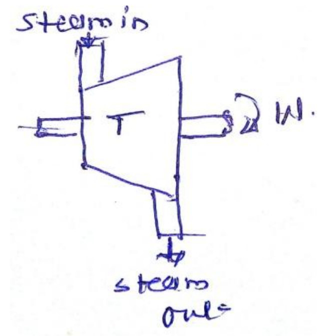
Impulse turbine	Reaction turbine
1. Steam completely expands in nozzle and pressure remains constant during flow through the blade passage. 2. Relative velocity of steam passing over blade of impulse turbine is constant. 3. Pressure is same at inlet and outlet. 4. Steam velocity is very high. 5. Lesser number of stages required. 6. It occupies less space per unit power. 7. Blades are symmetrical profile type. 8. Blade passage of const. cross section	1. Steam expands partly in nozzle and further expansion take place in rotor blade passage. 2. Relative velocity increases as steam passing over the blade expands. 3. Pressure is different at inlet and outlet. 4. Steam velocity is not very high. 5. More numbers of stages required. 6. It occupies more space per unit power. 7. The blades are aerofoil & non symmetrical type. 8. Blade passage or variable cross sectional area.

i) Application of nozzle (Any four point one mark each)

1. In steam turbine.
2. Spray painting.
3. Steam jet refrigeration system.
4. In injectors (steam).

ii) (2 + 2 marks)

a) Turbine – It is a devices which convert heat energy of steam into rotary motion in term of work done. By applying steady flow energy equation.



Steady flow energy equation is

m ($v_1^2/2 + gz_1 + h_1$) + Q = m ($v_2^2/2 + gz_2 + h_2$) + w

$$q + h_1 + \frac{V_1^2}{2} + Z_1 = W + h_2 + \frac{V_2^2}{9} + Z_2$$

Per kg of steam for turbine

$$\therefore Z_1 = Z_2, \quad V_1^2 = \frac{V_2^2}{2} = 0, \quad q = 0$$

$$\therefore h_1 = h_2 + W$$

$$\therefore W = h_1 - h_2$$

work done = change in enthalpy

b) Compressor – It compresses air at high pressure by of supplying work.

In compressor work is done on the system, so W is negative, heat is lost from system, so Q is negative

m h_1 – Q = m h_2 – W

W = Q + m (h_2 - h_1)

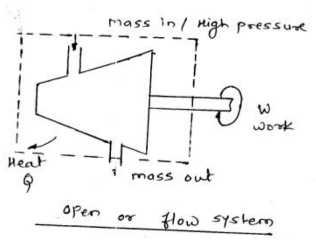
W = Q + (H_2 - H_1)

Q3 Attempt any four.

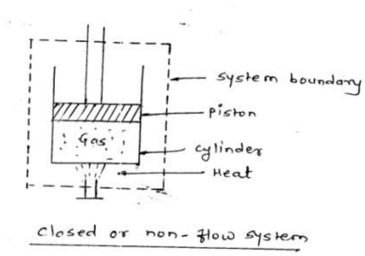
(a) **System --** defined as a specific region where our attention is focused for studying thermodynamic properties such as work & heat transfer.
(system definition -1 mark, Each type- 1 mark each)

Classification:

(1) **Open system** – In this system, both mass & energy may cross the boundary.



(2) **Closed system** – Only transfer of energy but no mass transfer across the boundary.



(3) **Isolated system** – In this system, there is no transfer of mass & energy across the boundary, e.g. Thermos

(b) Given , m = 2 kg, T_1 = 250 K, P_1 = 150kPa, P_2 = 300 kPa, n = 1.25

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

$$\frac{T_2}{250} = \left(\frac{300}{150_1}\right)^{\frac{1.25-1}{1.25}}$$

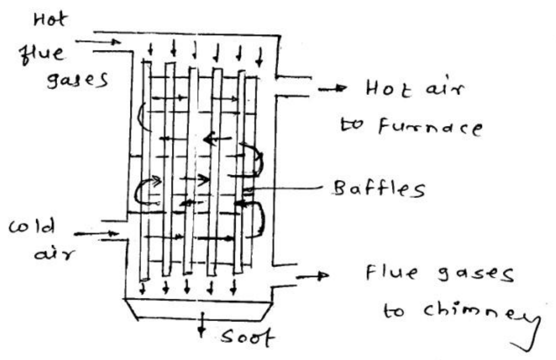
Hence $\mathbf{T_2 = 287\ K}$ **--------------------------------------(2 marks)**

Change in internal energy dU = m C_v ($T_2 – T_1$)
= 2 x 0.7 (287 – 250)
dU = 51.8 kJ ------------(2 marks)

(c) **Air preheater**: (fig-2 marks, explaination – 2 marks)

-It is used to increase the temperature of air before it enters the furnace.

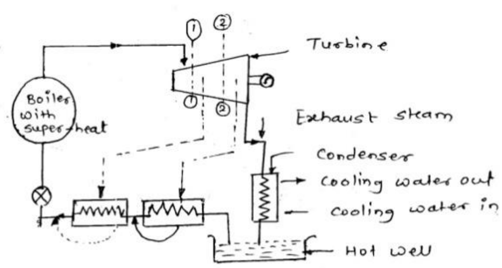
-It is placed after economiser. The flue gases passes through economiser and then to air preheater.
-It is accessory of the boiler.
-It consist of plates tubes with hot gases on one side and air on the other side. It preheats the air which supplied to the furnace.
-Preheated hot air accelerates the combustion and increase efficiency.
-These are three types: (1) Tubular type
(2) Plate type
(3) Storage type



Tubular Type Air-Preheater.

(d) **Regenerative feed heating system:** (fig-2 marks, explanation – 2 marks)

The process of draining steam from certain section of turbine during its expansion and using this steam for heating feed water supplied to boiler is known as bleeding and this process of heating feed water is known as regenerative feed heating.



Regenerative Feed Heating or Bleeding of steam

(e) **Sources of air leakage**: (souces- 2 marks , effects- 2 marks)

The sources of air leakage into the condenser are:
(1) The air leakage in condenser from sources of atmosphere at the joints of the parts due to high vacuum in the condenser. The amount of air depends upon the accurate workmanship of making the vacuum joint.
(2) Air also comes with the steam from boiler feed water. The amount of air coming depends upon the treatment of the feed water. Feed water contains dissolve air.
(3) In jet condenser, air comes with the cooling water in which it is dissolve.

Effects: The following are the effects of air leakage on the performance of condenser:

(1) It reduces vacuum in the condenser.
(2) Since air is poor heat conductor, at low density, it reduces the rate of heat transfer.
(3) Presence of air also lowers the partial pressure of steam which decreases the saturation temperature of steam and hence evaporation enthalpy of steam increases therefore more amount of cooling water required in the condenser.
(4) It requires large air pump.
(5) Presence of air in the condenser increases the corrosive action.

(f) **Applications of heat exchangers (four application – 4 marks)**

(1) These are used in food industries.
(2) These are used in dairy product industry.
(3) In gasket & brazing technology made this heat exchanger in HVAC application.
(4) They are used in refrigeration application in closed loop.

Q.4 . Attempt any four.

(a) **Limitations of first law of thermodynamics:** (Explaination- 4 marks)

- The first law states that the work transfer is equal to heat transfer and does not place any restriction on the direction of flow but the reversal of process not violet the first law.
- According to this statement the first law the potential energy can be converted into kinetic energy and kinetic energy can be converted into potential energy but in natural practice this do not happen .
- e.g A car driver up hill , the level of fuel in the tank drop. If this process reverse i.e. car is coasted down the hill, the fuel consume cannot be reproduced.
- Hence from above example the reversal of process is not true without the aid of external work.

(b) Total volume (v) = 0.125 m^3, Total enthalpy (h) = 1800 KJ, at 10 bar

From steam table, At 10 bar ,

$v_g = 0.194\ m^3/kg$

$h_f = 762.5$ KJ/kg, $h_{fg} = 2013.6$ KJ/kg

m = $v/v_g = 0.125/0.194$ = **0.6443 kg** **-----------------------------------(2 marks)**

Hence for m kg, $h_f = 0.6443 \times 762.5 = 491.278$ KJ

For m kg, $h_{fg} = 0.6443 \times 2013.6 = 1297.362$ KJ

$h = h_f + x\, h_{fg}$

$1800 = 491.278 + 1297.362\,(x)$

Dryness fraction **x = 1.008** **--- (2 marks)**

(Value of x should be less than 1 but for the given data it's value is 1.008)

(C) **Classification of turbine**: (Any four type – 4 marks)

1) According to working principles:
   a) Impulse turbine
   b) Reaction turbine
   c) Combined turbine
2) According to the stages of expansion of steam:
   a) Single stage turbine
   b) Multistage turbine
3) According to position of shaft axis:
   a) Horizontal axis turbine
   b) Vertical axis turbine
4) According to their nature of steam supply:
   a) High pressure turbine
   b) Low pressure turbine
5) According to direction of steam flow:
   a) Axial flow turbine
   b) Radial flow turbine
   c) Tangential flow turbine
   d) Single flow or double flow

(6) According to exhaust steam pressure:
   a) Condensing type steam turbine
   b) Non-condensing type steam turbine

(d) Given, L_1 = 100 mm, L_2 = 60 mm, L_3 = 40 mm,

K_1 = 400 W/m^{o}C, K_2= 100 W/m^{o}C, K_3 = 25 W/m^{o}C,

$$Q = \frac{A(T_1 - T_4)}{\frac{L_1}{K_1} + \frac{L_2}{K_2} + \frac{L_3}{K_3}}$$

$$\frac{Q}{A} = \frac{(1000-250)}{\frac{0.1}{400}+\frac{0.06}{100}+\frac{0.04}{25}}$$

$\frac{Q}{A} = 306122.45\ W/m^2$ ----------------------------(2 marks)

To find interface temp,

$$\frac{Q}{A} = \frac{(T_1 - T_2)}{\frac{L_1}{K_1}}$$

$$306122.45 = \frac{(1000 - T_2)}{\frac{0.1}{400}}$$

$T_2 = 923.46\ ^oC$ --------------------------------------(1 marks)

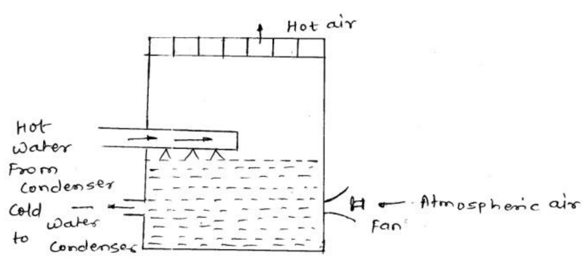
$$\frac{Q}{A} = \frac{(T_2 - T_3)}{\frac{L_2}{K_2}}$$

$$306122.45 = \frac{(923.46 - T_3)}{\frac{0.06}{100}}$$

$T_3 = 739.78^o\ C$ ----------------------------(1 marks)

(e) **Forced draught cooling tower;** (fig-2 marks, explanation – 2 marks)

- In this type of tower fan is located at the base & air is blown by the fan up through the descending water. The water particles are removed at the top of tower by eliminator.



Force draught cooling tower

(f) **La-mont boiler**; (fig-2 marks, explaination – 2 marks)

-It is modern high pressure water tube boiler working on a forced circulation.

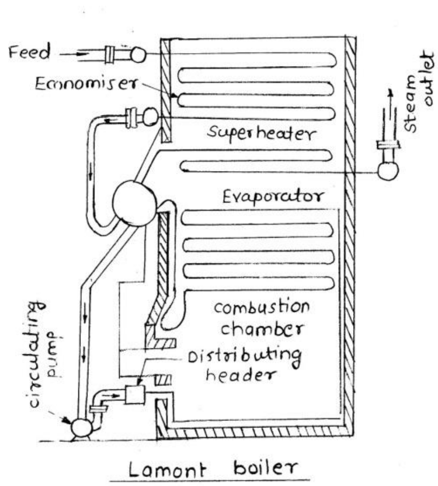
- Capacity of steam generation is @ 45000 kg/hr at 500^{o}C & at a pressure of 120 bar.

-Circulation is done by centrifugal pump.

- The forced circulation causes the feed water to circulate through the water walls & drums equal to ten times the mass of steam evaporated, to prevent the tubes being overheated.

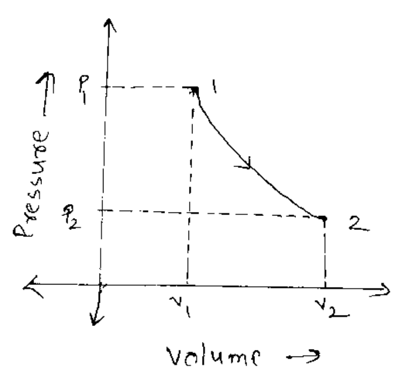
- The feed water passes through the economiser to an evaporating drum. It is then drawn to the circulating pump through the tubes. The pump delivers the feed to the header. The header distributes water through nozzles into the generating tubes acting in parallel. The water & steam from these tubes passes into the drum. The seam in the drum is then drawn through the superheater.

- Advantage – It is flexible , compact & small size of drum.



Q. 5 a) (02 marks each)

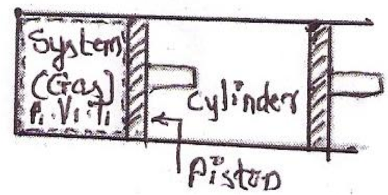
i) Process: - When a system changes its state from one equilibrium state to another equilibrium state, then the path of successive states through which the system has passed is known as Process or thermodynamic process.



In above figure 1-2 represents a thermodynamic process

ii) State of system: - The state of system (When the system is in thermodynamic equilibrium) is the condition of the system at any particular moment which can be identified by the statement of its properties, such as pressure, volume, temperature etc. The number of properties which are required to describe a system depends upon the nature of the system.

Consider a system (gas) enclosed in a cylinder and piston arrangement as shown in figure (b). Let the system is initially in equilibrium when the piston is at position 1, represented by its properties P_1, V_1, T_1. When the system expands, the piston moves towards right and occupies the final position at 2. At this, the system is finally in the equilibrium state represented by the properties P_2, V_2, T_2. The initial and final states, on the pressure volume diagram as shown in figure (a)

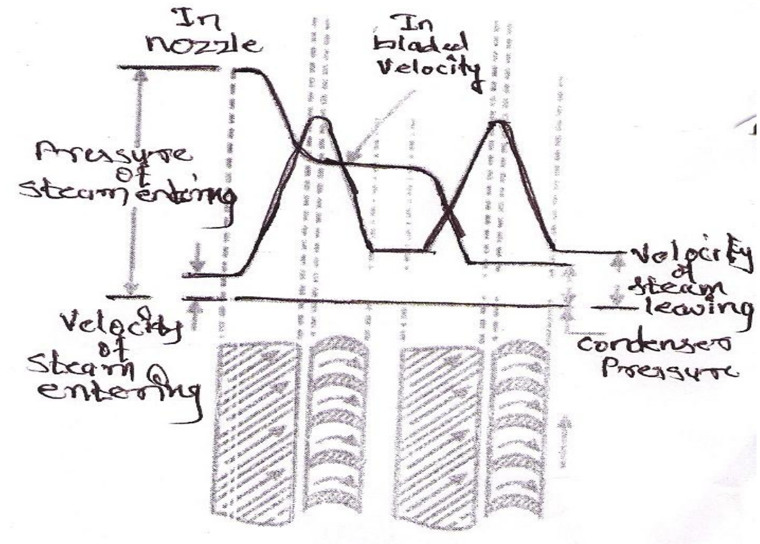


iii) Intensive property: - The properties which do not depend upon the mass of the system, are known as intensive properties. It may be noticed that the temperature of the system is not equal to the sum of the temperatures of its individual parts. It is also true for pressure and density of the system. Thus properties like temperature, pressure and density are called intensive properties.

iv) Extensive property: - The properties, which depend on the mass of the system, are known as extensive properties. A quantity of matter in a given system is divided, notionally into a number of parts. The properties of the system, whose value for the entire system is equal to the sum of their values for the individual parts of the system are also called extensive properties. Example total volume, total mass and total energy of a system are its extensive properties

b) Compounding of steam turbine: - the arrangement to reduce pressure from boiler pressure to condenser pressure by use of multiple system of rotors in series, keyed to common shaft or by increasing number of stages and the steam pressure or steam velocity is absorbed in stages as it flows over moving blades. This is known as compounding. **(02 marks)**

Pressure compounding: - **(04 marks Explanation, 02 marks diagram)**



Pressure compounding is similar to arranging a number of impulse turbines in series. Each of simple turbine is termed as a stage of turbine. Each stage consists of a ring of nozzle and moving blades. The physical arrangement of different units consists of nozzles, usually fitted into diaphragms, which separates one ring of moving blades from another. Complete expansion of steam takes place in the nozzle fig. shows the variation of pressure and velocity. The total pressure drop of steam does not take place in the first nozzle ring but is divided equally amongst all nozzle ring. Thus the total pressure drop is split up into series of smaller pressure drop, so this type of compounding is called as pressure compounding. The pressure of the stem remains constant during its flow over the moving blades.

c) Given data: -

Initial volume (V_1) = 2.5 m^3.

Pressure (P) = 8 bar = constant = 8 X 10^5 N/mm^2.

Initial temperature (T_1) = 180^0 C = 180 +273 = 453 K

Final volume (V_2) = 2 V_1 = 2 X 2.5 = 5 m^3.

Sp. Heat at constant pressure C_p = 1 KJ/Kg K

Sp. Heat at constant volume = C_v = 0.715 KJ/Kg K

Asked : - i) Change in internal (dU)

ii) Work transferred (dW)

iii) Heat transferred (dQ)

iv) Change in entropy (ΔS)

Solution: -

We know that

R = $C_p - C_v$ = 1 – 0.715 = 0.285 KJ/Kg K = 285 J/Kg K

(1/2 marks)

As the process is constant pressure hence we know that

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

$$\frac{2.5}{453} = \frac{5}{T_2}$$

T_2 = 906 K

= 906 – 273 = 633^0 C

(01 mark)

We know ideal gas equation

$P_1V_1 = mRT_1$

$8 * 10^5 * 2.5 = m * 285 * 453$

$$m = \frac{8 * 10^5 * 2.5}{285 * 453}$$

m = 15. 49 Kg

(01 mark)

i) Change in internal energy (dU)

We know that

dU = m C_v ($T_2 - T_1$)

= 15.49 * 0.715 (906 – 453)

= 5017.13 KJ

(1 ½ marks)

ii) Heat transferred (dQ)

We know that

$dQ = m\, C_p\, (T_2 - T_1)$

$= 15.49 * 1\, (906 - 453)$

$= 7016.97$ KJ

(1 ½ marks)

iii) Work transferred (dW)

We know that

$dQ = dU + dW$

$dW = dQ - dU$

$= 7016.97 - 5017.13$

$= 1999.84$ KJ

(01 ½ mark)

iv) Change in entropy (ΔS)

$$\Delta S = m\, C_p log_e \frac{T_2}{T_1}$$

$$\Delta S = 15.49 * 1 * log_e \frac{906}{453}$$

ΔS = 10 74 KJ**/K**

(1 ½ marks)

Q6 a) Classification of steam condenser: - The steam condensers may be broadly classified into two types, depending upon the way in which the steam is condensed

1) Jet condenser or mixing type condensers

   These condensers are further classified as

   a) Parallel flow jet condenser
   b) Counter flow or low level jet condenser
   c) Barometric or high level condenser
   d) Ejector condenser

   (02 marks)

2) Surface condensers or non-mixing type condensers

a) Down flow surface condenser

b) Central flow surface condenser

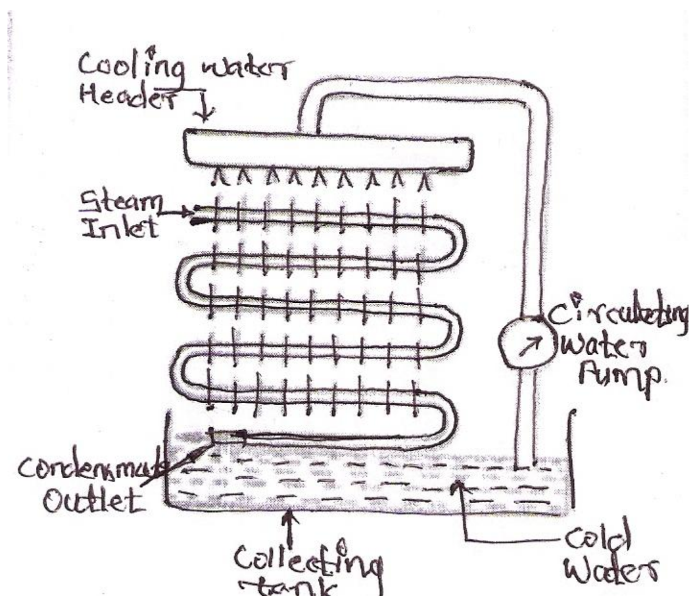
c) Regenerative surface condenser

e) Evaporative Condenser.

(02 marks)

Evaporative condenser: - **(Diagram 01 mark, Explanation 03 marks)**

The steam to be condensed enters at the top of a series of pipes outside of which a film of cold water is falling. At the same time, a current air circulates over the water film, causing rapid evaporation of some of the cooling water. As a result of this, the steam circulating inside the pipe is condensed. The remaining cooling water is collected at an increased temperature and is reused. Its original temperature is restored by the addition of the requisite quantity of cold water.



The evaporative condensers are provided when the circulating water is to be used again and again. These condensers consist of sheets of gilled piping, which is bent backwards and forwards and placed in a vertical plane as shown in figure.

Q. 6 b) Given data: -

Mass (m) = 1 Kg.

Pressure (P) = 7 bar = 7 X 10^5 N/mm^2.

Dryness fraction (x) = 85 % = 0.85

Super heated by 100^0 C.

Sp. Heat at constant pressure C_p = 2.1 KJ/Kg K

Asked : - i) Enthalpy (h)

ii) Entropy (S)

iii) Sp. Volume (v)

iv) Internal Energy (dU)

Solution: -

From Steam Table

Absolute pressure in bar	Saturated Temp.	Sp. Volume in m^3/Kg		Sp. Enthalpy in KJ/Kg			Sp. Entropy in KJ/Kg K		
P	T_{satu}	V_f	V_g	h_f	h_{fg}	h_g	s_f	s_{fg}	s_g
7.0	**165.0**	**0.001108**	**0.27268**	**697.1**	**2064.9**	**2762.0**	**1.992**	**4.173**	**6.705**

First Condition Steam with dryness fraction 85 %

1) $h_{wet} = h_f + x\ h_{fg}$

$= 165 + 0.85 * 2064.9$

$\mathbf{h_{wet} = 2452.265\ KJ/Kg}$

(01 mark)

2) $S_{wet} = S_f + x\ S_{fg}$

$= 1.992 + 0.85 * 4.173$

$\mathbf{S_{wet} = 5.99805\ KJ/\ Kg\ K}$

(01 mark)

3) $v_{wet} = x\ v_g$

$= 0.85 * 0.27268$

$\mathbf{v_{wet} = 0.231778\ m^3/Kg}$ **(01 mark)**

4) $h_{wet} = dU + P\ v_{wet}$

$2452 * 10^3 = dU + 7 * 10^5 * 0.231778$

$dU = 2452 * 10^3 – 7 * 10^5 * 0.231778$

$dU = 2289.755 * 10^3$ J/Kg

dU = 2289.755 KJ/Kg **(01 mark)**

Second Condition Steam is super heated by 100^0 C,It means that

$T_{sup} = T_{satu} + 100$

$T_{sup} = 165 + 100 = 265^0C$

$T_{sup} = 265 + 273 = 538$ K

$T_{satu} = 165 + 273 = 438$ K

1) $h_{sup} = h_g + C_p (T_{sup} – h_{satu})$

$= 2762 + 2.1 (538 – 438)$

h_{sup} = 2972 KJ/Kg **(01 mark)**

2) $S_{Sup} = S_g + C_p * log_e(\frac{T_{sup}}{T_{satu}})$

$$S_{Sup} = 6.705 + 2.1 \, log_e \frac{538}{438}$$

S_{sup} = 7.1368 KJ/ Kg K **(01 mark)**

3) $v_{Sup} = v_g * \frac{T_{sup}}{T_{satu}}$

$v_{Sup} = 0.27268 * \frac{538}{438}$

V_{sup} = 0.334936 m^3/Kg **(01 mark)**

4) $h_{sup} = dU + P \, v_{sup}$

$2972 * 10^3 = dU + 7 * 10^5 * 0.334936$

$dU = 2972 * 10^3 – 7 * 10^5 * 0.334936$

$dU = 2737.5448 * 10^3$ J/Kg

dU = 2737.5448 KJ/Kg **(01 mark)**

Q.6 d)

Absorptivity: - It is defines as the ratio of amount of energy absorbed to amount of energy incident on a body

OR

Fraction of total energy absorbed by the body is called Absorptivity. **(01 mark)**

It is also called as coefficient of Absorptivity

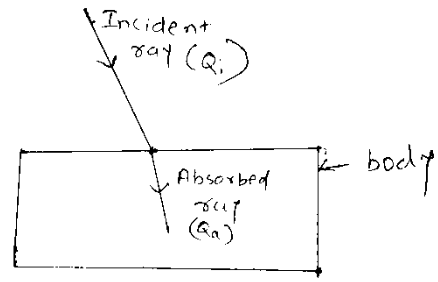
and it is denoted by α

Consider

Q_i is amount of energy falling on a body.

Q_a is amount of energy absorbed by a body.

Mathematically Absorptivity is expressed as



$$Absorptivity\ (\alpha) = \frac{Q_a}{Q_i}$$

(01 mark)

i. **Reflectivity: -** It is defines as the ratio of amount of energy reflected to amount of energy incident on a body

OR

Fraction of total energy reflected by the body is called Reflectivity.

(01 mark)

It is also called as coefficient of reflectivity

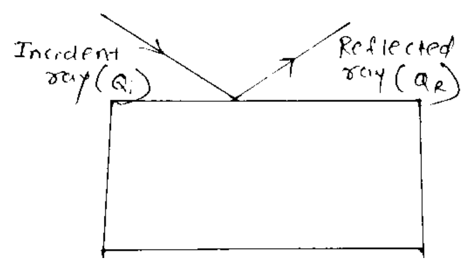
and it is denoted by ϒ

Consider

Q_r is amount of energy falling on a body.

Q_a is amount of energy absorbed by a body.

Mathematically Absorptivity is expressed as

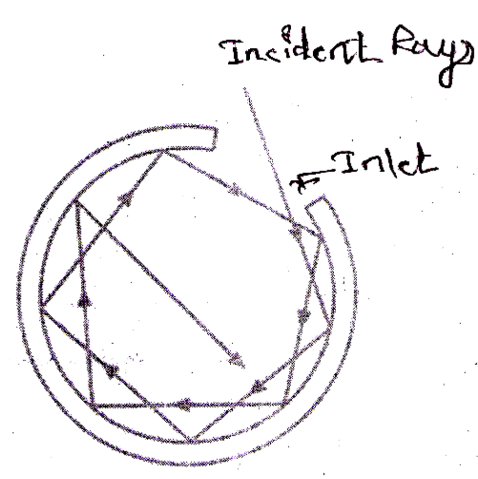


$$Reflectivity\ (\Upsilon) = \frac{Q_r}{Q_i}$$

(01 mark)

ii. **Black body: -** A body which absorbs all the incident radiation is called black body irrespective of its color. For black body condition is α = 1, β = 0, ϒ τ = 0.

Actually no material available with α = 1. To make practically a perfect body, a hollow sphere with



small opening is used. When ray enters the hollow body through an opening, a part of it is absorbed and part is reflected inside. The reflected radiation will not find outlet and will again be incident on the inner surface. Due to this sequence of reflection, almost complete incident radiation will be absorbed and none will come out. Therefore, a small opening provided in a hollow sphere acts like a black body.

iii. **Stefan – Boltzman law: -** This law states that the total emission from a black body per unit time per unit surface area varies directly as the fourth power of the absolute temperature. **(01 mark)**

Mathematically

$E \propto T^4$

$E = \sigma T^4$

Where,

E = emission power of black body per unit time per unit surface area in W/m^2.

T = Absolute temperature in K

σ = Stefan – Boltzman constant

= 5.67×10^{-8} in W/m^2 K

(01 mark)