USN

Internal Assessment Test 1 – October, 2018

Sub:	Elements of Mechanical Engineering				Sub Code:	18ME15/25	Branch:	ME, CIV, ECE
Date:	15/10/2018	Duration: 90 min's	Max Marks:	50	Sem / Sec:	I / I,J,K,L,M,N,O	OBE	

		MARKS	CO	RBT
	PART –I (Answer any three FULL Questions)			
1 (a)	Define the following terms with respect to steam: i) Quasi-static Process ii) Quality of steam iii) Thermodynamic equilibrium iv) Degree of superheat v) Enthalpy of superheated steam	[10]	CO1	L2
2 (a)	With the help of T – h diagram, explain the generation of steam from water at 0°C at constant pressure.	[10]	CO1	L2
3 (a)	State zeroth law, first law and second law of thermodynamics.	[10]	CO1	L2
4(a)	Explain heat, work, internal energy, enthalpy and entropy.	[10]	CO1	L2
5(a)	With a neat sketch, explain the construction and working of any one water tube boiler.	[10]	CO1	L2
6 (a)	List and explain the functions of boiler mountings and accessories.	[10]	CO1	L2

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IAT-1 Solution
2018-19 (odd sem).

Q1. (a) Define the following terms with respect to steam:

i) Quasi-static process :- In thermodynamics, a quasi-static process is a thermodynamic process that happens slowly enough for the system to remain in internal equilibrium. An example of this is quasi-static compression, where the volume of a system changes at a slow rate enough to allow the pressure to remain uniform and constant throughout the system.

ii) Quality of steam :-

Steam Quality is the proportion of saturated steam (vapour) in a saturated condensate (liquid)/ steam (vapor) mixture. A steam quality of 0 indicates 100% liquid, (condensate) while a steam quality of 100 indicates 100% steam. One (1) lb of steam with 95% steam and 5% of liquid entrainment has a steam quality of 0.95.

iii) Thermodynamic Equilibrium :-

A System is said to be in equilibrium when no change in any macroscopic property is registered, if the system is isolated from its surrounding.

A system will be in a state of equilibrium if the conditions for the following three types of equilibrium are satisfied.

(a) Mechanical equilibrium :- In absence of any unbalanced force within its system and also between the system and surrounding, the system is said to be

in a state of mechanical equilibrium.
Example:- Combustion inside cylinder.

(b) chemical Equilibrium:- If there is no chemical reaction or transfer of atoms from one part of the system to another (like diffusion), the system is said to exist in an state of chemical equilibrium.
Example:- salt added to water.

(c) Thermal Equilibrium:- When a system existing in mechanical and chemical equilibrium is seperated from its surrounding by a diathermal wall (which allows heat to flow), and there is no spontaneous change in any property of the system the system, the system is said to exist in a state of thermal equilibrium.
Example:- a tea cup with tea kept in a room.

(iv) Degree of Superheat :-

The temperature through which the steam is heated beyond dry saturated state to superhead condition.

Degree of superheat = $T_{sup} - T_{sat}$.

(v) Enthalpy of Superheated steam ;-

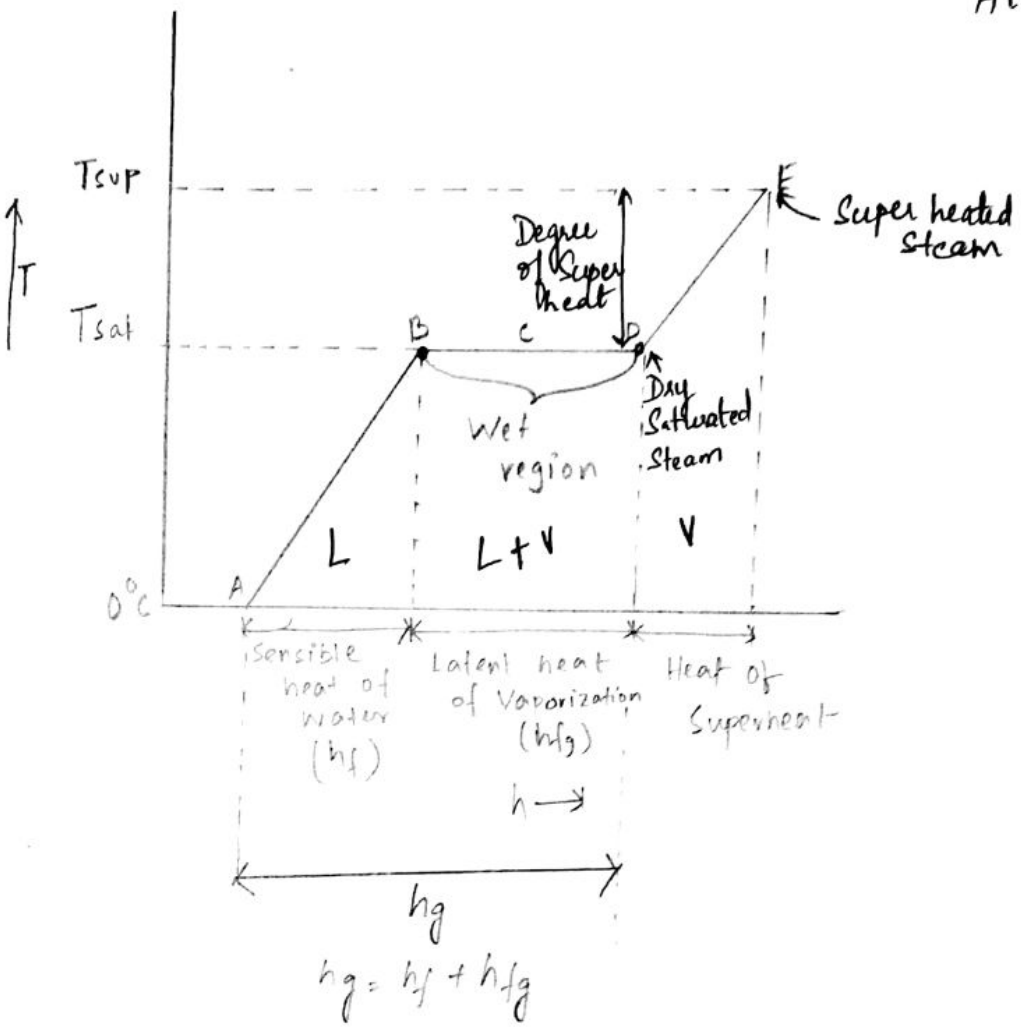
Entropy of steam superheated to temperatures above saturation point.

Q2. (a) With the help of T-h diagram, explain the generation of steam from water at 0°c at constant pressure ?

At B ; $x = 0$.

C ; $x = 0.5$

D ; $x = 1$



Formation of steam explanation :-

Consider a piston and cylinder arrangement having 1kg of water at 0°c (point A). Let a weight 'W' be added on top of the problem to maintain the pressure constant throughout the process.

Let this water be heated. The enthalpy of the system increases and the temperature starts to rise till the saturation temperature (boiling point) of the water is reached (point B).

If further heat is added to the system at point B, all of the heat will be used up to change the phase of water from liquid to steam (at point D). The temperature will remain constant during the phase change.

Between the points B & D, is the wet region, where not-

all the water at saturation temperature is converted into dry saturated steam. The steam in this region is called as wet steam which is characterized by suspension of water molecules in the steam.

Steam at any point (c) between B and D is known as wet steam.

The steam at point D is called as dry saturated steam (which is completely dry and doesnot have any water molecules suspended in it).

If further heat is added to dry saturated steam the temperature of steam starts increasing.

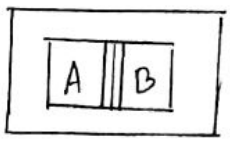
The steam beyond point (D) is called as superheated steam (point E).

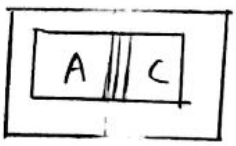
The temperature at which the superheated steam exists is called as Temperature of superheated steam (Tsup)

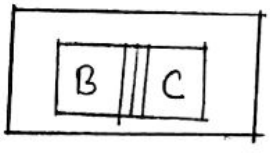
As the heat supplied to the system is at constant pressure, the amount of heat supplied will be eaual to increase in enthalpy of the system.

Q3. (a) State Zeroth law, first Law and second law of thermodynamics.

Ans Temperature is associated will the ability to distinguish hot from cold. when two bodies at different temperatures are brought into contact after sometime they attain a common temperature and are then said to exists in thermal equilibrium. Reference body used to determine temperature is called thermometer.



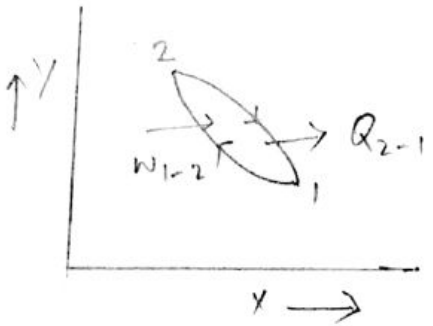




Zeroth law of thermodynamics states that when a body (system) A is in thermal equilibrium with a body B and also separately with a body C, then B and C will be in thermal equilibrium with each other.

FIRST LAW OF THERMODYNAMICS :

Energy which enters a system as heat may leave as work or energy which enters the system as work may leave as heat, Heat and work are different forms of energy which conserved



For a system which executes a cycle, where a definite amount of work and heat is transformed to and form the system or vice versa, it has been found that W_{1-2} is always proportional to Q_{2-1}. The constant of proportionality is called as joules equivalent or mechanical equivalent of heat.

$$\therefore (\Sigma W)_{cycle} = J(\Sigma Q)_{cycle}.$$

This is the first law of thermodynamics for a closed system undergoing a cycle.

SECOND LAW OF THERMODYNAMICS :-

The Second laws of thermodynamics provides the criterion for the probability of various processes which is not given by the first law. The second law gives information on the direction of energy transfer. For example, heat always flows from

a body at higher temperature to a body at lower temperature.

Q4.(a) Explain heat, work, internal energy, enthalpy and entropy.

Ans Heat is form of energy that is transformed across a boundary by virtue of a temperature difference.

Temperature difference – cause
Heat Transfer – effect.

The Modes of heat transfer are:–

(i) Conduction. – The transfer of heat between two bodies in direct contact is called conduction.

(ii) Radiation – Heat transfered between two bodies seperated by empty space or gases through electromagnetic radiation.

(iii) Convection – The transfer of heat between a wall and fluid system in motion.

WORK: Work is done by a force as it acts upon a body moving in the direction of the force.

In thermodynamics, work transfer is considered as occuring between system & its surrounding. work is considered positive when the work is done by the system and work is considered negative when work is done on the system.

INTERNAL ENERGY:- In thermodynamics, the internal energy of a system is the energy contained within the system excluding the kinetic energy of motion of the system as a whole and the potential energy of the system as a whole due to external force fields. It keeps account of the gains and losses of energy of the system that-

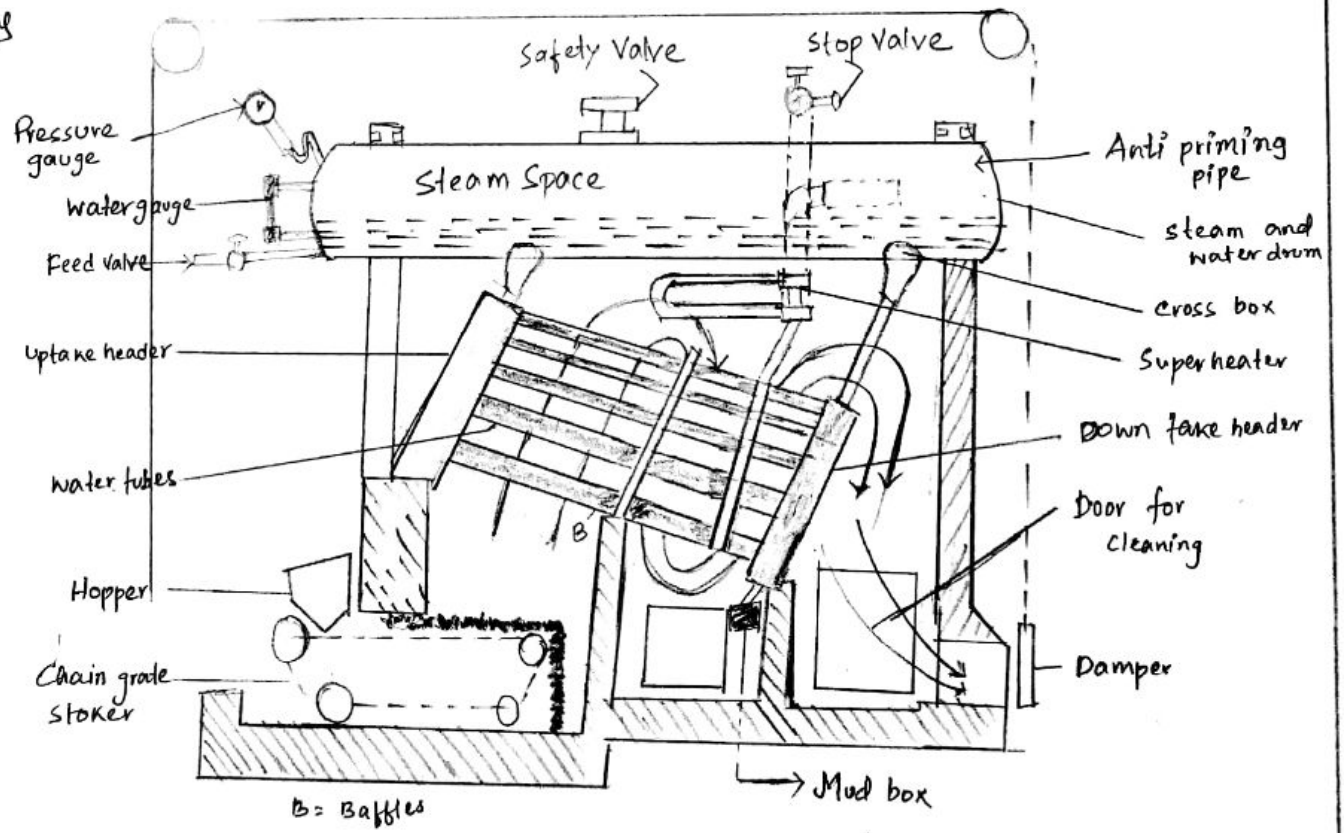
are due to changes in its internal state.

ENTHALPY:- Enthalpy is a property of a thermodynamic system. The Enthalpy of a system is equal to the system's internal energy plus the product of its pressure and volume. For processes at constant pressure, the heat absorbed or released equals the change in enthalpy.

ENTROPY: In statistical mechanics, entropy is an extensive property of a thermodynamic system. It is closely related to the number of microscopic configuration that are consistent with the macroscopic quantities that characterize the system (such as its volume, pressure and temperature).

Q5.(a) Write a net sketch, explain the construction and working of any one water tube boiler.

Ans



BABCOCK AND WILCOX BOILER.

CONSTRUCTION:-

- Babcock and wicox water tube boiler mainly consists of four parts :-
  1. water and steam drum.
  2. water tubes.
  3. chain Grate stoker.
  4. Superheater tube.
- The water and steam drum is suspendend from iron girders resting on iron columns.
- A number of inclined water tubes at a very low inclination of maximum upto 15° are connected at right angles to the end boxes or tubes called as headers.
- The header shown at the right end of the water tube is called down take header and the other shown at the left end of the water tube is called uptake header.
- Each set of the headers are intern connected to the boiler drum.
- A mud box is provided just below the downtake header.
- Sediments in water due to its heavier specific gravity settles down in the mudbox as is taken out through a blow off pipe.
- The moving grate is provided at the front end below the uptake header
- Boilers of higher capacity are usually provided with a chain grate bar. The coal fed at the front end of the grate is burnt on the moving grate in the furnace and the residual ash falls at the other end of the grate into the ash pit.
- Boiler is fitted with a superheater which is placed in the combination chamber underneath the boiler drum.

WORKING :-

- The water is introduced into the boiler drum through the feed valve.
- A constant water level is maintained in the boiler drum.
- The water descends at the rear end into the downtake headers and in the tubes connecting the uptake header and drum.

- During combustion, the hot gases from the furnace grate move upwards around the water tubes.
- There are baffle plates which guide the path of the flue gases in a particular direction as shown in the figure in order to have maximum coverage.
- It finally passes out of the boiler through the exit door and chimney.
- During this path of hot flue gases, the hottest gases emerging directly from the grate come in contact with the hottest portions of the water tubes near the uptake header.
- The water in these portions of the water tubes get vapourized.
- The water and steam mixture ascends or moves upward through the uptake headers to the boiler drum.
- Due to this flow, a continuous rapid circulation of water is established between the drum and water tubes.
- Eventually, the steam generated gets seperated from water as it is lighter than water. The steam occupies the steam space in the boiler drum.
- The wet steam is then made to flow through the anti-priming device which seperates the moisture making it as a dry saturated steam.
- This dry steam is then made to flow through the superheater present in the combustion chambers.
- The superheated steam is then passed to its point of application through the steam stop valve.

Q6. (a) List and explain the functions of boiler mountings and accesories.

Ans :- Boiler mountings are the fittings or devices necessary for the safety and smooth operation of the boilers.

- The boiler mountings are listed as follows :-

① Safety Valve :-

location :- Fitted directly on the top of the boiler shell.

Function:- To main a safe pressure inside the boiler. In case the pressure inside the boiler increases, the excess steam will automatically be released through the safety valves, thereby preventing the explosion of boiler.

② Water Level Indicator

Location:- Fitted outside the boiler shell for clean inspection.

Function:- To indicate a safe water level inside the shell to avoid damage due to overheating in case of low water level.

③ Fusible plug

Location:- Fitted above the crown of the furnace.

Function: To protect the boiler from explosion in case of overheating due to low water level. When the water falls below the minimum level, the plug melts and allows the water to extinguish the fire in the furnace and the steam to escape through the plug hole.

④ Pressure Gauge

Location: Fitted infront and at the top of the boiler shell for clear inspection.

Function: To indicate the pressure of the steam inside the boiler

⑤ Feed check Valve:

Location:- Fitted on the feed water pipeline very close to the furnace.

Function:- To feed water into the boiler continuously. It has to regulate the rate of flow of feed water and prevent the back flow of water from the boiler.

⑥ Blow off Valve

Location:- Fitted at the lowest part of the boiler.

Function: To empty the boiler whenever necessary for cleaning, repair or inspection and to discharge the accumulated mud and sediments in the feed water at the bottom of the boiler.

⑦ Steam stop Valve :-

Location : fitted at the highest part of the boiler shell.

Function : To regulate the flow of steam from the boiler to the required place and to stop whenever not required.

BOILER ACCESSORIES :-

① Steam superheater

Location : fitted in the path of the hot flue gases outside the boiler shell.

Function : To absorb heat from the flue gas and superheat the dry saturated steam coming out of the boiler shell.

② Anti-priming Device.

Location : fitted inside the boiler shell in the steam space.

Function :- To prevent the water particles to be carried in the steam stop before it enters into the steam stop valve. As the wet steam passes through it, the water particles condense and fall back into the shell.

③ chimney

Location : Built at the exit end of the boiler.

Function : To expell the products of combustion to the atmosphere and to draw the hot gases from the boiler.

④ Economizer

Location : fitted near the chimney.

Function : To heat the feed water using the heat of the exhaust hot flue gases.

⑤ Feed Pump

Location : fitted to the feed water pipeline.

Function : To pump the water into the boiler.

⑥ Steam seperator

Location : fitted very close to the application (engine or turbine) point on the main steam supply pipe.

Function : To seperate the water particle from the steam flowing into the steam pipeline before it enters the engine or turbine.

⑦ Steam Trap

Location : Fitted to a small bypass pipe which branches from the main steam pipeline.

Function : To drain off the condensed water accumulated in the steam pipe or from the steam seperator without allowing the steam to escape through it.

⑧ Air preheater

Location : Fitted between economiser and chimney.

Function : To transfer heat from the flue gases to the air that is fed into the furnace for combustion. Thus, It is used to produce a high furnace temperature and to accelerate the combustion.

⑨ Fan draught

Location : Fitted near the grate.

Function : To supply air artificially to the grate. Also called as artificial draught.

Q7.(a) A mixture of saturated water and saturated steam at a temperature of 250°c is contained in a closed vessel of 0.1 m^3 capacity. If the mass of the saturated water is 2kg, find the mass of the steam in the vessel. Also find the pressure, specific volume, dryness fraction and the enthalpy of the mixture.

Sol^n :- $T_s = 250°c$, $V = 0.1\ m^3$, $m_f = 2kg$

using steam table

when $T_s = 250°c$

$p = 3.9762$ MPa

$= 39.7$ bar

$V_f = 0.00125173\ m^3/kg$

$V_g = 0.050083\ m^3/kg$

$$V = V_f + V_g$$

$$0.1 = m_f V_f + m_g V_g$$

$$= 2(0.00125173) + m_g(0.050083)$$

$$m_g = 1.946 \text{ kg}$$

$$V = \frac{V}{m} = \frac{V}{m_f + m_g} = \frac{0.1}{2 + 1.946} = 0.0253 \text{ kJ/kg}$$

Dryness fraction

$$x = \frac{m_g}{m} = \frac{1.941}{2 + 1.946} = 0.4932$$

$$= 49.32\%$$

Enthalpy :- $h = (h_f + x h_{fg}) \times 3.95$ $\left[h_{mix} = h/kg \times \text{mass of mixture}\right)$

$$= (1085.8 + 0.49316 \times 1715.2) \times 3.95$$

$$= (1931.37 \text{ kJ/kg}) \times 3.95 = 7628.91 \text{ kJ}.$$

Q8.(a) A stationary mass of gas is compressed without friction from an intial stage of 0.3 m^3 and 0.105 Mpa to a final state of 0.15 m^3, the pressure remaining constant. There is a transfer of 37.6 kJ of heat from the gas during the process. How much does the internal energy of the gas change?

Sol^n: Given :- $V_1 = 0.3 \text{ m}^3$, $V_2 = 0.15 \text{ m}^3$, $P = 0.105 \text{ Mpa} = 105 \text{ kpa}$.

$$Q = -37.6 \text{ kJ}$$

$$W = P \int dV$$

$$W = P(V_2 - V_1)$$

$$W = 0.105(0.15 - 0.3)$$

$$W = -15.75 \text{ kJ}.$$

$\therefore$ Internal energy

$$Q = \Delta U + W$$

$$-37.6 = \Delta U + (-15.75)$$

$$\Delta U = -37.6 + 15.75$$

$$= -21.85 \text{ kJ}.$$