WINTER – 15 EXAMINATION

Subject Code: **17406** **Model Answer**

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) (i) The engine in which combustion of fuel takes place inside the cylinder is known as internal combustion engine. 1 mark

Ex.- Automobile vehicles, locomotives etc. 1 mark

(ii) Biomass is an organic matter produced by plants grown on land and water along with their derivatives and animal manure.

As an energy source, biomass can either be used directly via combustion to produce heat or indirectly after converting it to various forms of biofuel.

Biomass can be converted into biofuel by thermal, chemical and biochemical method.

(iii) The properties which do not depend upon the mass of the system, are known as intensive properties.

Properties like temperature, pressure and density are called intensive properties.

(iv) 1) **Boyle's Law-** The law states that the volume of a given mass of a perfect gas varies inversely with absolute pressure when the temperature remains constant.

Let,

P = Absolute pressure of the gas

V = Volume of the gas at pressure P

Then according to this law,

$$V \propto 1/P$$

2) Charles's law: It states that if a perfect gas is heated at constant pressure, its volume varies directly with the absolute temperature.

At constant pressure, $V \propto T$, when P = c

$$\frac{V}{T} = \text{constant}$$

(v) In Isochoric process volume remain constant.

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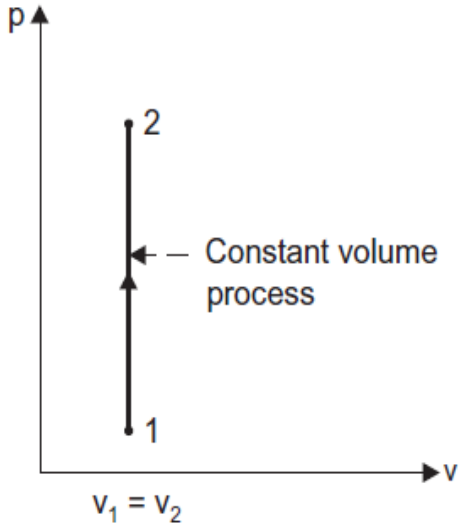

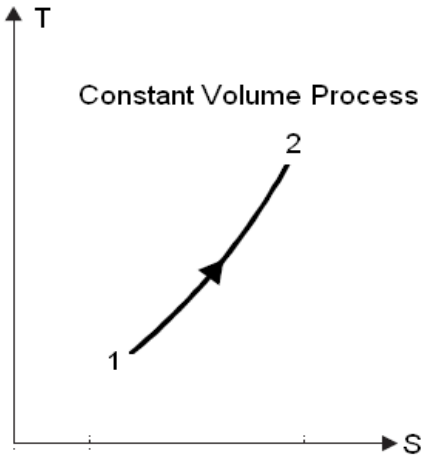

(vi) Following are the applications of compressed air - *(Any Four)* 1/2 mark each

1) To drive air motors in coal mines.
2) To inject fuel in air injection diesel engines.
3) To operate pneumatic drills, hammers, hoists, sand blasters.
4) For cleaning purposes.
5) To cool large buildings.
6) In the processing of food and farm maintenance.
7) For spray painting in paint industry.
8) In automobile & railway braking systems.
9) To operate air tools like air guns.
10) To hold & index cutting tools on machines like milling.

(vii) Classification of air compressor:- *(Any Four)* 1/2 mark each

1) On the basis of Principle of operation	i) Reciprocating	ii) Rotary
2) On the basis of action of air	i) Single acting	ii) Double acting

(viii) Following is the list of different components used in vapour compression cycle

1) Compressors
2) Condenser
3) Expansion device
4) Evaporator

Q.1. b) (i) Classification of I.C engine:

1) On the basis of type of ignition
Battery ignition, compression ignition
2) On the basis of engine cycle
Otto cycle , Diesel cycle , Dual cycle.

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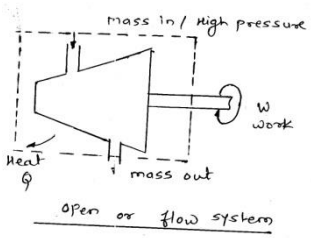
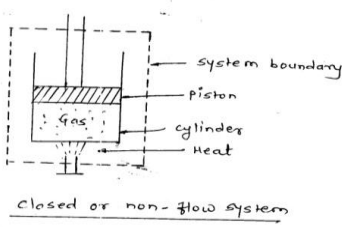
3) On the basis methods of charging the engine-
?Naturally aspirated and supercharged engines
4) On the basis of fuel used
Petrol engine, diesel engine, gas engine

(ii) Differentiation between open and closed system

OPEN SYSTEM	CLOSED SYSTEM
In this system, both mass & energy may cross the boundary.	Only transfer of energy but no mass transfer across the boundary.
	
Ex. Nozzle , compressor, boiler	Ex. Piston cylinder arrangement without valve, refrigeration system.

Q.No. 1 b) iii) (04 marks for equation and 04 for correct answer)
Given : $P_1 = P_2 = 1.5$ bar
$V_1 = 4\ m^3$
$V_2 = 2\ V_1 = 4 \times 2 = 8\ m^3$

For a constant pressure process ,

Workdone during the process = $W_{1-2} = PdV$

$W_{1-2} = 1.5 \times 10\ 5\ (8 – 4)$

$W_{1-2} = 6 \times 10^5$ J/ Kg

The workdone by the gas is equal to 6×10^5 J/ Kg

Q.2. a) Comparison between S.I. and C.I. engine (Each point 1 mark)

	S.I. Engine	C.I. Engine
Basic cycle	Otto cycle	Diesel cycle
Ignition System	Spark ignition	Compression ignition
Compression Ratio	6 - 11	14 - 22
Speed	High	Low

b) Differentiation between conventional and non conventional energy sources (Each point 1 mark)

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	Conventional	Non conventional
Availability	Wide availability	Limited
Harnessing cost	Less	High
Pollution	High pollution	No pollution
Magnitude of power generation	Relatively less	Very High

c) Each definition – 1 mark

i) Heat: Heat is the energy interaction driving forces caused by the temperature difference between the system and surrounding.

ii) Work: In thermodynamics, work is considered as interaction occurring between the system and the surrounding. Work is said to be done by a system if sole effect on things external to the system can be reduced to the raising of a weight.

iii) Internal energy – It is defined as the energy associated with the random, disordered motion of molecules.

iv) Enthalpy – It is the sum of the internal energy of the system plus the product of the pressure and volume of the system.

Q 2 d) Workdone for adiabatic Process :- (04 marks)

$$W = \int_{V_1}^{V_2} P\,dV$$

But $PV^{\gamma} = C$

$$W = \int_{V_1}^{V_2} C\,\frac{dv}{v^{\gamma}}$$

$$W = \frac{dv}{v^{\gamma}} = C\left[\frac{v^{-\gamma+1}}{-\gamma+1}\right]_{V_1}^{V_2}$$

$$= C\left[\frac{V_2^{-\gamma+1} - v_1^{-\gamma+1}}{1-\gamma}\right]$$

$$= C\left[\frac{v_1^{-\gamma+1} - v_2^{-\gamma+1}}{\gamma-1}\right]$$

But $P_1 v_1^{\gamma} = P_2 v_2^{\gamma} = C$

$$\therefore W = \frac{P_1 v_1^{\gamma} v_1^{-\gamma+1} - P_2 v_2^{\gamma} v_2^{-\gamma+1}}{\gamma-1}$$

$$= \frac{P_1 v_1 - P_2 v_2}{\gamma-1} = \frac{R(T_2 - T_1)}{\gamma-1}$$

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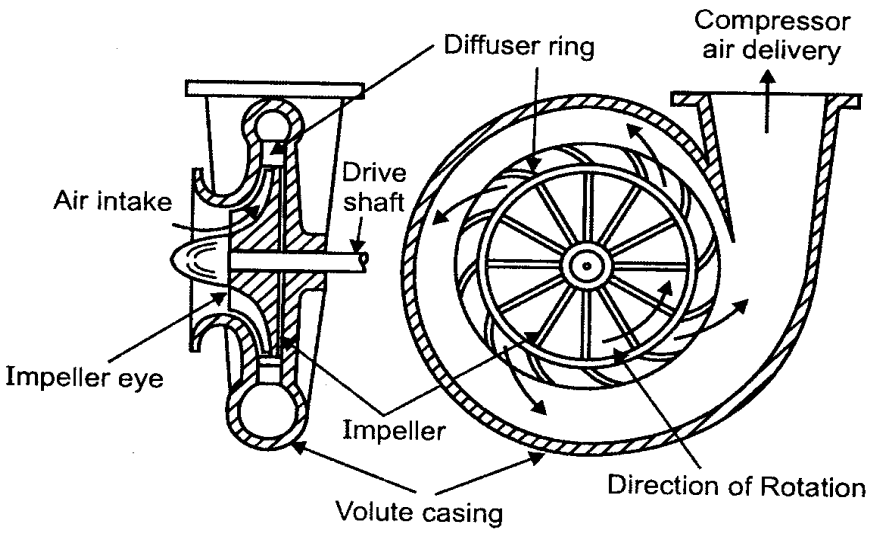
e) Working of Centrifugal Compressor (Working – 2 Marks Sketch – 2 Marks)



Centrifugal compressor consists of a rotating member known as 'impeller wheels' mounted on steel shaft and enclosed in cast iron casing.

The impeller wheel consists of two discs, a hub disc and cover disc with number of blades mounted radially between them. Impeller blades are constructed in stainless steel to avoid corrosion and erosion.

An impeller has rotary vanes, which provides closed radial passage for flow of air. Atmospheric air is sucked in at the center of the impeller called the eye. A diffuser ring, around the impeller, is provided with diffuser vanes. In diffuser vanes the kinetic energy of air changes into pressure energy. The volute casing also provides diffuser passage for further build-up of air pressure.

As the impeller rotates at high speed air undergoes centrifugal action and is accelerated to a high velocity. The air is decelerated in the diffuser and volute casing, to build its pressure. Finally the compressed air leaves through the outlet.

f) Characteristics gas equation is P V = m R T

Where, P is pressure in N/m^2
V is volume in m^3
T is temperature in ^0k
m is mass in kg and
R is characteristic gas constant
Universal gas constant is 8.314 $J/kg.mol.^0k$

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Q.No. 3 a) (04 marks)

By first law of theremodynamics,

dq = dU + dW

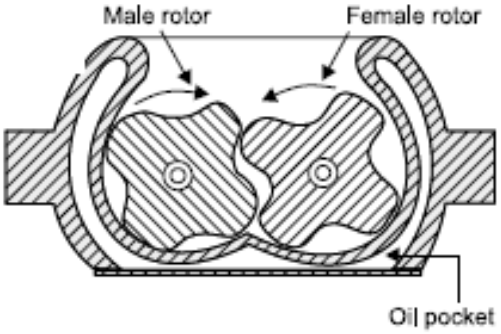
dU = dq – dW

dU = 675-290

dU = 385 J

Q.No. 3 b) Screw Compressor: (02 marks for sketch and 02 for explanation)

Construction and working of screw compressor.



Screw type compressor: Screw type compressor is very much similar to roots blower. These may have two spiral lobed rotors, out of which one may be called male rotor having3–4 lobes and other female rotor having 4–6 lobes which intermesh with small clearance. Meshing is such that lobes jutting out of male rotor get placed in matching hollow portion in female rotors. Initially, before this intermeshing the hollows remain filled with gaseous fluid at inlet port. As rotation begins the surface in contact move parallel to the axis of rotors toward the outlet end gradually compressing the fluid till the trapped volume reaches up to outlet port for getting discharged out at designed pressure. Since the number of lobes is different so the rotors operate at different speed.

Two rotors are brought into synchronization by the screw gears. Thrust upon rotors is taken care of by oil lubricated thrust bearings. These compressors are capable of handling gas flows ranging from 200 to 20000 m3/h under discharge pressures of 3 bar in single stage and up to 13 bar gauge in two stages. Even with increase in number of stages pressures up to 100 bar absolute have been obtained with stage pressure ratio of 2.Mechanical efficiency of these compressors is quite high and their isothermal efficiencies are even more than vane blowers and may be compared with centrifugal and axial compressors. But these are very noisy, sensitive to dust and fragile due to small clearances.

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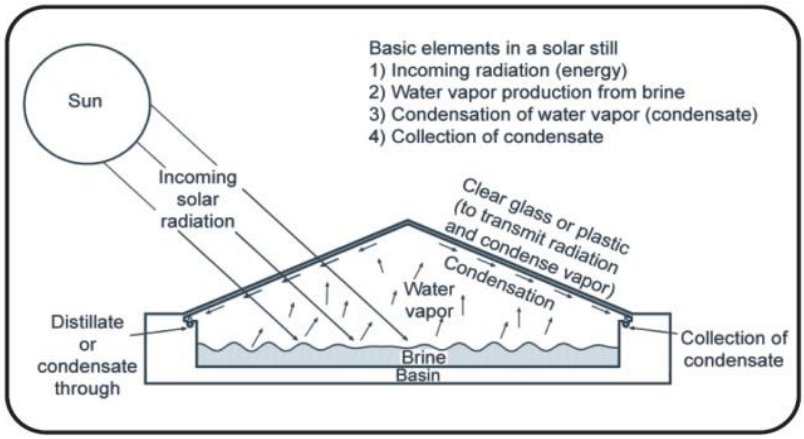
Q.No. 3 c) (02 marks for sketch and 02 for explanation)

Solar distillation plant : figure shows various components of conventional double slope type solar distillation system. It is a air tight basin usually made up of concrete or special fiber with a transparent cover to accept radiation from the sun.

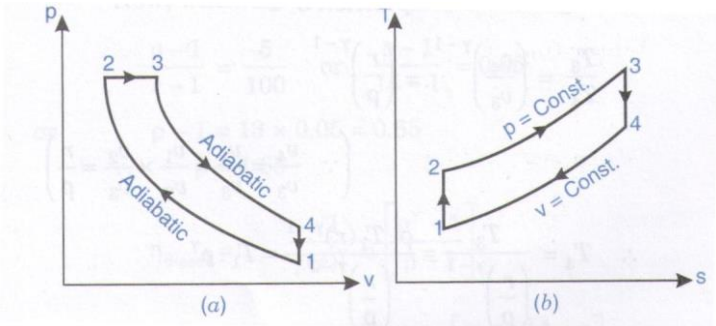
The inner surface of solar still is blackened to absorb maximum solar radiation. The blackened surface is known as basin liner.

The saline water is taken into basin for purification. The depth of the water is around 5 to 10 cms. Solar radiations after going through the still kept absorb by the blackened surface of the basin and thus temperature of water increases. Evaporated water increases the percentage of moisture which later on gets condensed on the cooler underside of the glass and then it is collected by means of condensate channel. in this way with the use of solar energy distillation process is completed.



Q.No. 3 d) (02 marks for diagram 01 for each and 02 marks for equation)

Diesel Cycle on P-V and T-S diagram :



Equation for air standard efficiency diesel cycle

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$$\eta_{diesel} = 1 - \frac{1}{\gamma(r)^{\gamma-1}}\left[\frac{\rho^{\gamma}-1}{\rho-1}\right]$$

Q.No. 3 (01 mark each difference ,any four)

e) Isochoric and Isobaric Process:

ISOBARIC PROCESS	ISOCHORIC PROCESS
1. Here pressure is constant during process (P=C)	1. Here Volume is constant during process (V=C)
2. N= 0	2. Here n=∞
3. Work Done =P(V_2-V_1)	3. work Done = 0
4. Occurs is a piston & cylindrical arrangement	4. Occurs in constant volume vessel
5. Here specific heat at constant pressure is assumed to be constant (Cp).	5. Here sp. Heat at constant volume is assumed to be constant (Cv).

Q.No. 3(01 mark each difference ,any three and 01 mark for example)

f) Differentiation between fire tube type boiler and water tube type boiler

Sr. No	**Fire tube boilers**	**Water tube boilers**
01	Hot flue gases flow in the tubes surrounded outside by the water	Water flows in the tubes surrounded outside hot gases
02	Slower in operation and have low evaporation rates	faster in operation and have low evaporation rates
03	Failure due to Temperature stress causing failure of feed water arrangement is minimum	Failure due to Temperature stress causing failure of feed water arrangement is more
04	It can work upto 20 bar pressure only	It can work upto 200 bar pressure
05	Simple and rigid construction	Complex construction
06	More maintenance and operation cost	less maintenance and operation cost
07	Smaller sizes and hence not suitable for large power houses	Bigger sizes and hence suitable for large power houses
08	Installation is difficult	Installation is easy
09	Requires less floor area	Requires more floor area
10	Ex : Cochran, lacashire etc	Ex.: Babcodk and Wilcox , Beson, Etc

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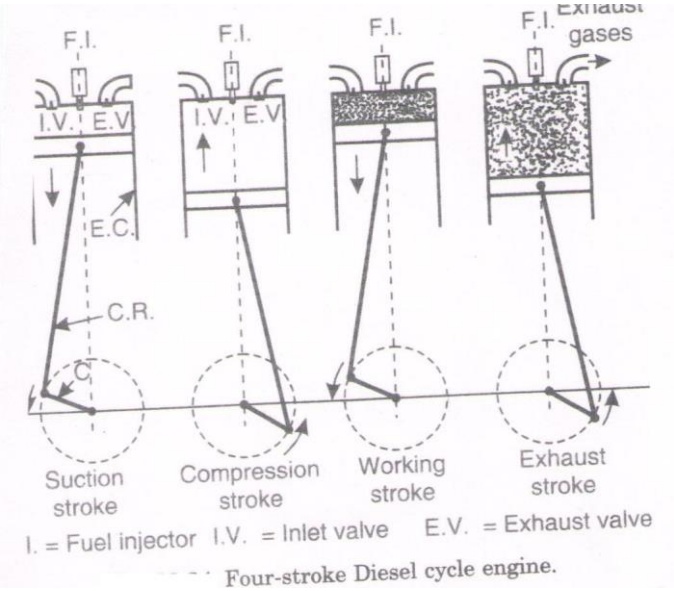
Q.No. 4 a) Summer Air conditioning for Delhi City : (8 marks for proper design)

Complete sensible and heat load calculations and design for a proper equipment for the summer conditions of the cit New Delhi should be carried out.

Q.No. 4 b) (04 marks for sketch and 04 for working)

Four stroke diesel engine :

Working of Four stroke diesel engine:



Four-stroke Diesel cycle engine.

1. Suction stroke: with the movement of the piston from TDC to BDC during this stroke, the inlet valve opens and the air at atmospheric pressure is drawn inside the engine cylinder : the exhaust valve however remains closed. At the end of suction stroke the inlet valve closes.

2. Compression stroke: The air is drawn at atmospheric pressure during the suction stroke is compressed to high pressure and temperature (to the value of 35 bar and 600) C) as the piston moves from BDC to TDC. Both inlet and exhaust valves do not open during any part of the stroke.

3. Expansion or power stroke: As the piston starts moving from TDC a metered quantity of fuel is injected into the hot compressed air in fine sprays by the fuel injector and it starts burning at constant pressure./

During expansion stroke both inlet and exhaust valves remains closed. Thus power is obtained by expansion of products of combustion. Therefore it is also called as 'power stroke'. Both pressure as well as temperature decreases during expansion stroke.

4. Exhaust stroke:

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At the end of expansion stroke the exhaust valve opens, the inlet valve remains closed and the piston moves from BDC to TDC. During exhaust stroke the burnt gases inside the cylinder are expelled out. The exhaust valve closes at the end of the exhaust stroke but still some residual gases remains in cylinder.

Q.No. 4) (01 mark for each difference any eight)

c) Differences between reciprocating and rotary air compressors:

Reciprocating compressor	Rotary compressor
1. Compression of air takes place with help of piston and cylinder arrangement with reciprocating motion of piston.	1. Compression of air takes place due to rotary motion of blades.
2. Delivery of air intermittent.	2. Delivery of air is continuous.
3. Delivery pressure is high i.e. pressure ratio is high.	3. Delivery pressure is low, i.e. pressure ratio is low.
4. Flow rate of air is low.	4. Flow rate of air is high.
5. Speed of compressor is low because of unbalanced forces.	5. Speed of compressor is high because of perfect balancing.
6. Reciprocating air compressor has more number of moving parts.	6. Rotary air compressor has less number of moving part.
7. It needs proper lubrication and more maintenance.	7. It required less lubrication and maintenance.
8. Due to low speed of ration it can't be directly coupled to prime mover but it requires reduction of speed.	8. Rotary air compressor can be directly coupled to prime mover.
9. It is used when small quantity of air at high pressure is required.	9. It is used where large quantity of air at lower pressure is required.

Q.No. 5 a) (02 marks for statement)

i**) Kelvin-Plank Statement of second law of thermodynamics**: " It is impossible to construct a heat engine to work in a cyclic process whose sole effect is to convert all the heat supplied to into an equivalent amount of work

Or

It is impossible to construct 100 % heat engine

ii) (02 marks for statement)

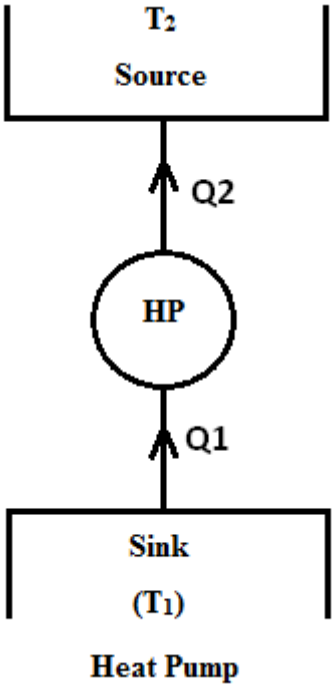
Clausius statement of second law of Thermodynamics:- It states that it is impossible to construct a device working in a cyclic process whose sole effect is the transfer of energy in the form of heat

from a body at a lower temperature (sink) to a body at a higher temperature (source).

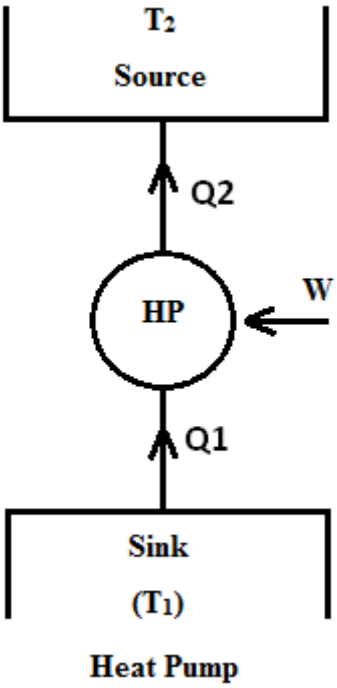
Or

It is impossible for energy in the form of heat to flow a body at a lower temperature to a body at a higher temperature without the aid of external work.

Application to heat pump : (04 marks)



Not possible



Possible

Source T_2 = Higher temperature

Sink T_1 = Lower temperature

Clausisus statement is related to heat pump and it says that it is impossible to construct a heat pump which pumps heat from low temperature to high temperature without input of work.

$$COP = Q2/ W$$

Q.No. 5 b) Babcock and Wilcox boiler. (04 marks for figure and 04 for explanation)

A neat labeled diagram of Babcock and Wilcox boiler is shown with path of water steam & air flue gas.

It is a water tube, natural circulation , multitubular internally fired boiler.

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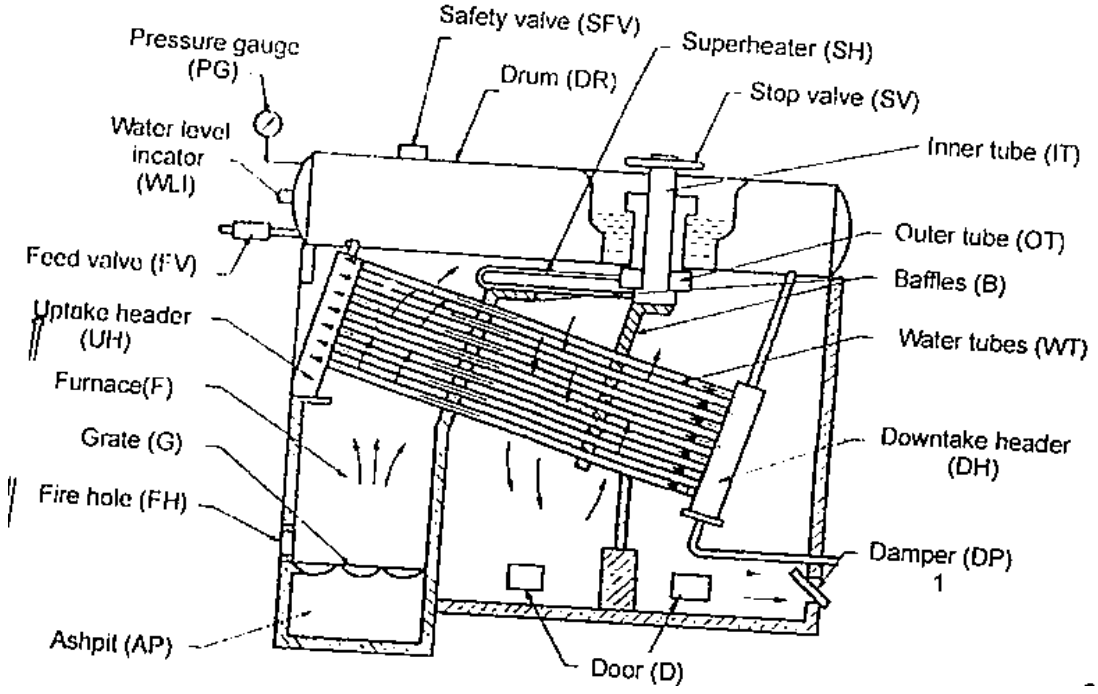
The boiler shell known as drum is made of high quality steel. It is connected by short tubes with the uptake header (UH) and by the large tubes to the down take header (DH). The water level in the drum is slightly above the center. The water tubes are connected to the top & bottom header & are kept inclined at an angle of 15^0 to the horizontal

(02marks)

The furnace is arranged below the uptake header coal is fed to the grate through the fire hole (FH). The battles are arranged in a such manner that the hot gases from the hot gases from the grate (G) are compelled to move in the upward & downward direction. First the hot gases rise upward & then go to down & then rise up again & finally escape to the chimney.

Babcock and Wilcox boiler is used for the generation of power as a stationary boiler in power generation units. (1 Marks)



(3Marks)

Q.No. 5 c) (02 marks for figure, 02 marks for explanation and 02 marks each for PH and TS diagram)

Vapor compression refrigeration System :

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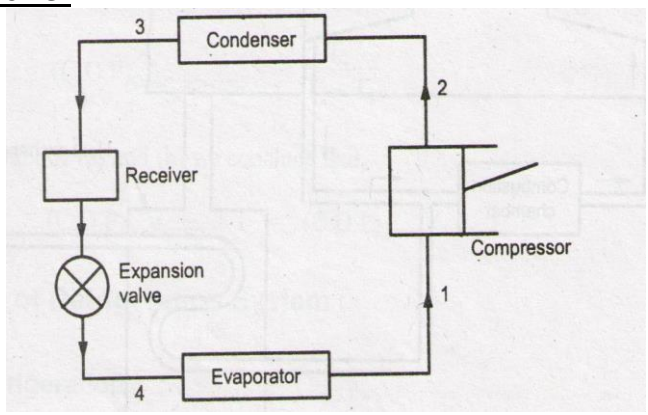

Working:

a) The refrigerant used in cycle is low boiling point organic compound which has two phase behavior during cycle operation. Compressor compressed the refrigerant , condenser cools, expansion device reduces the temperature of refrigerant and evaporator gives the required refrigerating effect.

b) The fairly dry vapor leaves evaporator and enters the compressor at point 1. This low pressure low temperature is compressed isentropically to point 2.

c) During compression pressure and temperature increases, the temperature at point 2 should be greater than the temperature of condenser cooling medium.

d) The vapor at the end of compression is dry saturated or superaheated . These vapors are condensed in condenser where latent heat of condensation is removed and phase change takes place

e) High pressure saturated liquid leaves condenser and enters in expansion valve at point 3 . The expansion 3-4 takes place in expansion device where it passes through a narrow passage. This process is constant enthalpy

f) Due to throttling the pressure of refrigerant is dropped upto 10 times due to which saturation temperature corresponding to this low pressure is very low and refrigerant becomes very cold before entering to evaporator at point 4 vapor enters evaporator where it absorbs latent heat of evaporation and hence refrigeration effect is achieved.

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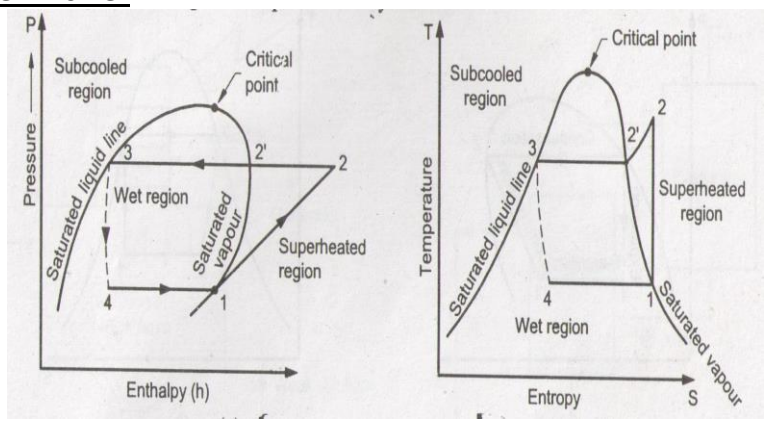


Q.No. 6 a) (02 marks for law and 02 for limitations)

First Law of Thermodynamics: - It states that if a system executes a cycle , transferring work and heat through its boundary, the net heat transfer is equivalent to the net work transfer.

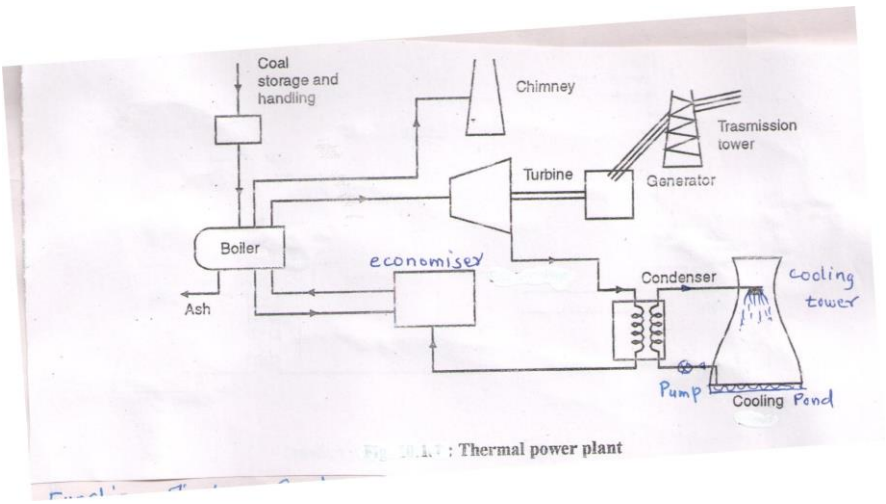
$$\text{or} \qquad \oint dQ = \oint dW$$

where $\oint$ represents the sum for a complete cycle.

Limitations of first law of thermodynamics

1. It is not clear about the direction of heat and work transfer
2. First law does not help whether or not system will undergo change.
3. No restriction on possibility of conversion energy from one form to another.
4. No clarity that how much percentage of one form of energy converted into another form of energy

Q.No. 6 b) Steam power plant : (02 marks for figure and 02 for functions)



: Thermal power plant

Functions of steam condenser :

a) It increases efficiency of the plant

b) It reduces back pressure of steam in turbine

c) More work is obtained because of condenser

d) It reduces temperature of exhaust steam

e) Water required for the plant is lesser

f) Steam heat loss is less

Q.No. 6 : (01 mark each for difference)

c) Differences between heat and work)

Heat	work
It is energy in transition across boundry of system due to temperature difference	It is energy in transition across boundry of system due to travel of force
Enthalpy, entropy are forms of it	Thermodynamic work, mechanical work, shaft work etc are form of work
Heat rejected by system is negative. Heat sypplied to system is positive by convention	Work supplied to system is negative. Workdone by the system is positive by convention
Unit is Joule	Unit is N-m

Q.No. 6 d) (02 marks each)

i) Zeroth law of Thermodynamics**:** It states that if two systems are in thermal equilibrium with third system separately then they are in thermal equilibrium with each other.

Consider three bodies A, B and C. When body A and B are in thermal equilibrium with Body C separately, then body A & B are in thermal equilibrium with each other.

Entropy :

Entropy is a thermodynamics property of a working substance which increases with the addition of heat and decreases with the removal of heat. Entropy means "transformation "and is a measure of extent of irreversibility of the process undergone by the system.

It is denoted by "S" or "ϕ". The units of entropy is kJ/kg -^{o}K

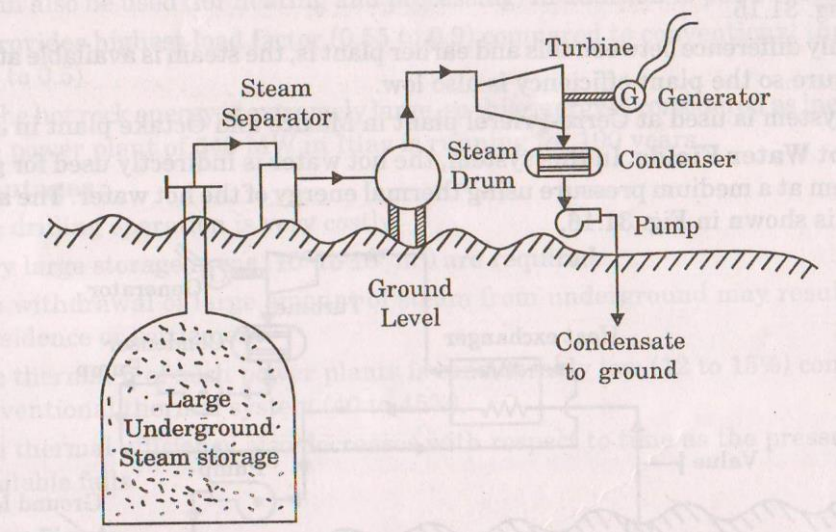
Q.No. 6 (02 marks for figure and 02 for Explanation)

e) Explain working principle of geothermal power plant with neat sketch. (2+2=4)

(02 Mark for description and 02 marks for sketch)

Geothermal power Plant: This is also known as one form of nonconventional energy source. The power plant sketch is as shown in figure. It consists of availability of large amount of steam in the crust of earth. Raw steam from underground is taken into steam separator and dry steam is stored into steam drum. The dry steam is then passed through the turbine. The condenser performs the

function of condensation and the condensate from the condenser is reinjected into the ground. This condensate under the ground absorbs the heat from the rock and again steam is generated.



Q.No. 6 f) Window Air conditioner: (02 marks for figure and 02 for labeling)