÷ Unit-2 ÷ Chapter-4 ÷

÷ Heat transfer ÷

Heat transfer is a process in which energy in the form of heat is transfer from one place to ansther.

→ In the terms of thermodynamics the transfer of heat from one medium to another is done by two way either by bomdry wall or by surrounding.

→ The difference in temperature b/w the two end of medium is called heat flux.

÷ Mechanism of heat transfer ÷

The mechanism of heat transfer is done by three methods.

1) Conduction.
2) Convention.
3) Radiation.

1) Conduction ÷ Conduction is the transfer of heat through solid or stationary material.

2) Convention ÷ In this method the transfer of heats done by the motion of fluids the woorm fluid is replaced by the cool fluid.

3) Radiation :- Radiation is the transfer of heat by the means of electron magnetic wave or rays.

:- Objective of heat transfer :-

i) By the study of heat transfer the loss of heat and loss of energy can be reduced.

ii) Heat is transfer in to surrounding is the waste of heat and it can be reduced by using adiabatic process.

Application of heat transfer :-

The study of heat transfer can be applied into following process.

[A] :- Evaporation :- By the use of heat the liquid is present in material is evaporation.

Ex - Extraction of vegetables.

B) Distillation :- By distillation process the different liquid of diff. boiling point is seprated.

C) Drying :- The removal of water content or maisture from the sample is called drying and it is done by applying the heat.

D) Crystallisation :- The saturated solution can be convert into super saturated solution and again into crystals by applying heat.

E) Sterilization:- By autoclave and hot air oven micro organisms are killed.

:- Heat transfer :-

Conduction:- Conduction is the transfer of heat through a stationary solid or stationary fluid.

→ The conduction of heat can be experienced by touching the object.

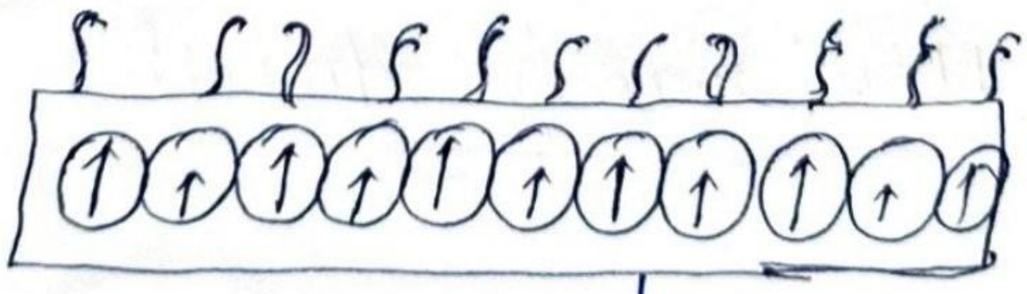
→ The mechanism of conduction is explain by two mechanism latice vibration and particles collesion.

Lattice-Vibration:- This mechanism is based on the temp gredient b/w two particles.

→ When there is a difference b/w temp then heat transfer from high temp to low temp and by such mechanism the heat is transfer to the end.

Particle Collesion:- This mechanism is seen in stationary fluids. when the particles absoob energy then they started to vibrate and transfer their energy to next particle.

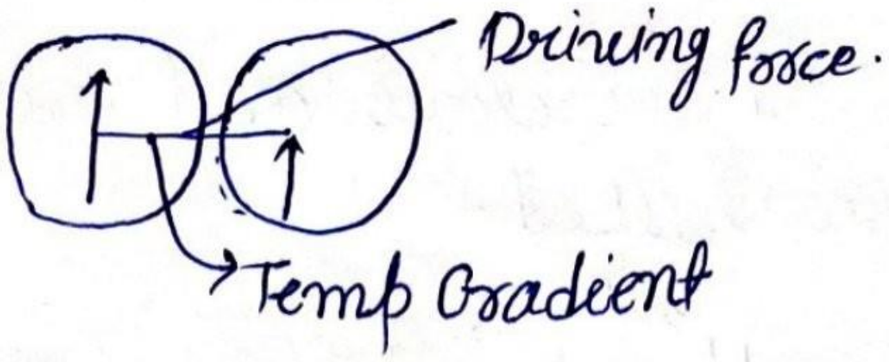
→ How next particle is vibrate and transfer their energy to next particle.



mech < Lattice vibration
Particle collesion.

Stationary solid or fluid

The rate of condonction can be determine by using driving force is temp is temp gredient and the resistance.



$$\text{Rate} = \frac{\text{Driving Force}}{\text{Resistance}}$$

Fourier's law:- Fourier gives a mathmetical expression from the rate of conduction.

→ If any object have area 'A', temp gredient 'dt' and the length is 'dl' then -

$$\frac{dQ}{d\theta} = -\frac{KAdt}{dl}$$

Where- $\frac{dQ}{d\theta}$ = Rate of Conduction

K = Constent

A = Surface Area of object

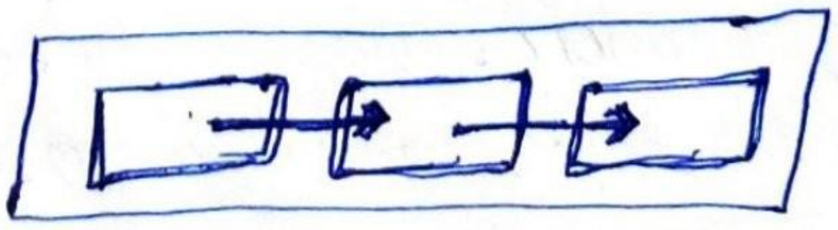
dt = Temp gredient

dl = length.

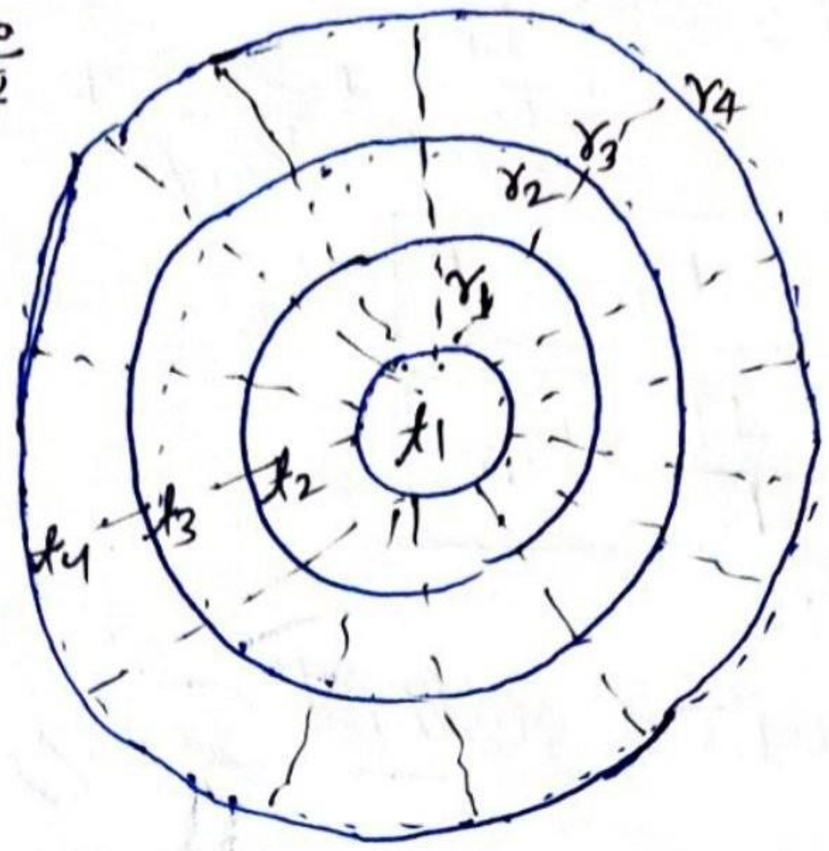
According to fourier's law the rate of conduction is directly proportional to the surface area and temperature difference of the particle and inversaly proportional to the length of object.

:- Heat trans for through :-

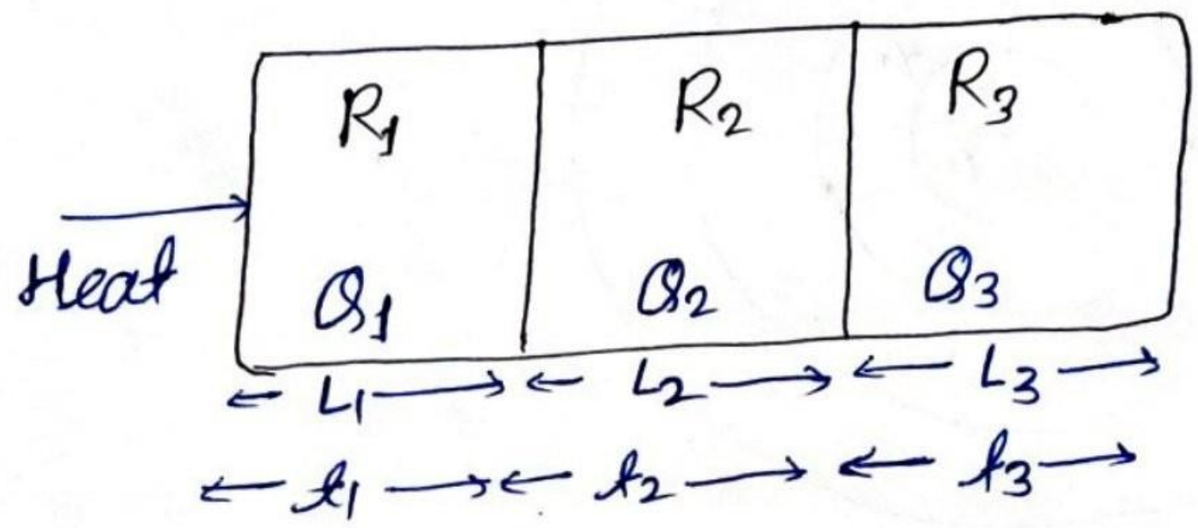
A) A series :-



b) A cyllender :-



i) Heat transfer through a compaund Resistance in series :-



$$\Rightarrow \quad \Delta t = t_1 + t_2 + t_3$$

$$\Rightarrow \quad Q = Q_1 + Q_2 + Q_3$$

$$\Rightarrow \quad Q = \frac{KA\,dt}{dl}$$

$$\Rightarrow \quad t = \frac{Q \times L}{K_m \times A}$$

$$\Rightarrow \quad t_1 = \frac{Q_1 \times L_1}{K_m \times A}, \quad t_2 = \frac{Q_2 \times L_2}{K_m \times A}, \quad t_3 = \frac{Q_3 \times L_3}{K_m \times A}$$

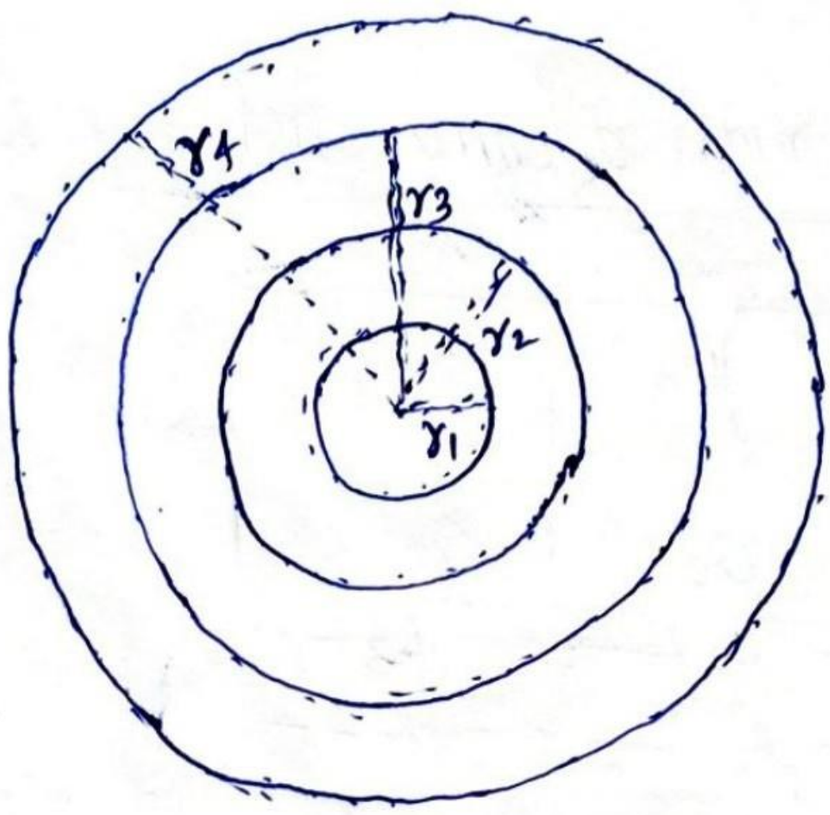
$$\Rightarrow \quad \Delta t = \frac{Q_1 L_1}{K_m \times A} + \frac{Q_2 L_2}{K_m A} + \frac{Q_3 L_3}{K_m A}$$

$$\Rightarrow \Delta t = Q\left(\frac{L_1}{K_m A} + \frac{L_2}{K_m A} + \frac{L_3}{K_m A}\right)$$

$$\boxed{\Delta t = K_m \cdot Q \cdot R}$$

$$\boxed{Q = \frac{\Delta t}{R} \times K_m}$$

(ii) Heat flow through a cylender :-



$$\Rightarrow Q = \frac{K dt A}{dr}$$

$$\Rightarrow Q = \frac{K dt \cdot 2\pi r \cdot N}{dr}$$

:- After integration :-

$$\boxed{dt = \frac{2\pi \cdot N / K_m}{\log r_1/r_2}}$$

Convention :- Convention is a mode of heat transfer b/w a solid or liquid surface and its Adjacent liquid or gas which is in motion.

- it involves the combind effect of conduction and fluid motion.

Types of convention

It is of two type

i) Forced convention: When the liquid is forced to flow over the surface by external means such as pump, wind.

ii) Natural convention / Free convention: When liquid flow is caused by buoyan force that are induced by density different due to variation of temp of fluid.

Radiation

Radiation is the transfer of energy process in which heat is transfer through space by means of electromagnetic waves.

→ It is also k/a thermal Radiation and it is very effective across perfect vaccume or air.

→ The amount of thermal energy Radiated increase with temp.

→ There are diff types of emitters. which Radiate the energy. IR temp, UV, Ceramic Rod.

Fundamental concept of Radiation: Radiation follow two laws.

i) It travels in straight line.

ii) It reflects from the surface.

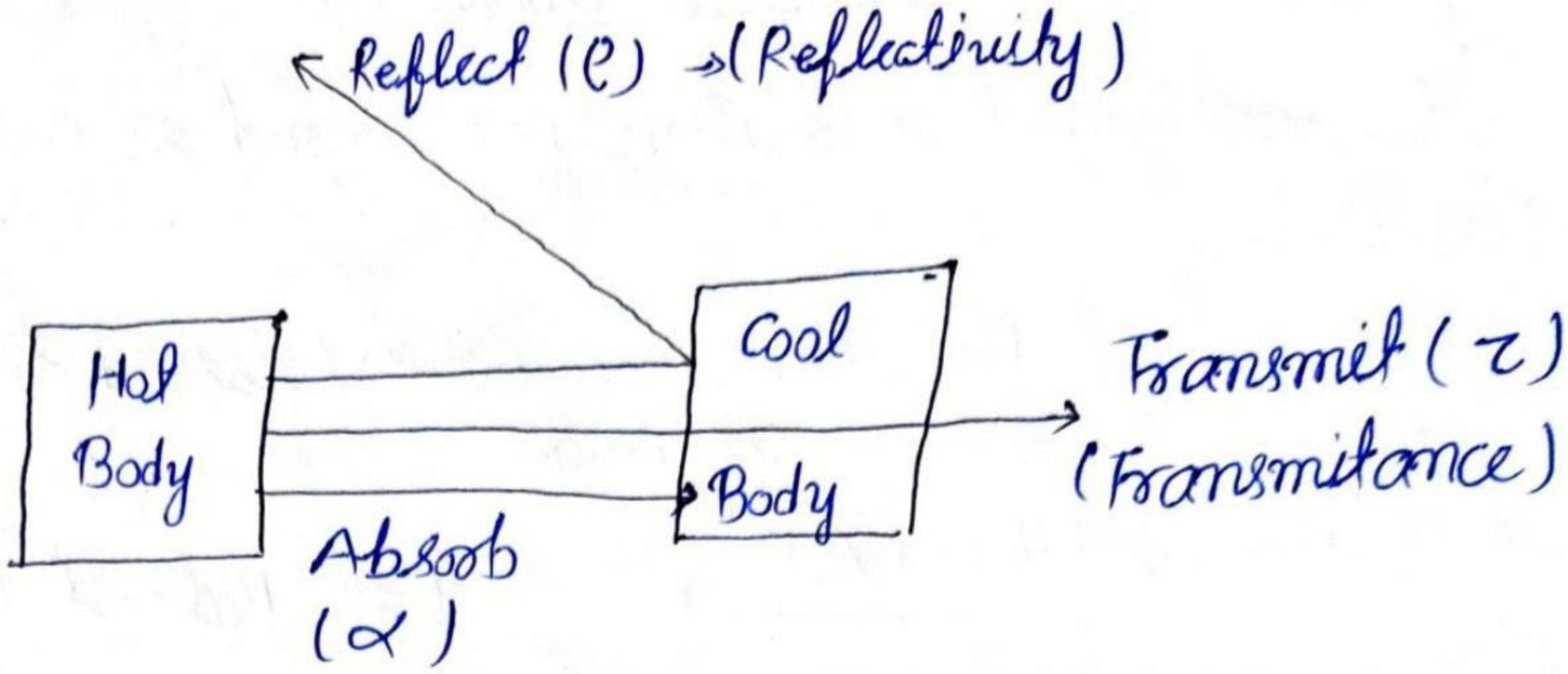
→ Suppose a cold substance is placed near to the hot body then hot body emitte the Radiation which is absorb by the cool body.

→ Some amount of Radiation is absorb by the cool body this is call absorbility (α)

→ Some amount of Radiation is transmitte from the cool body. this is called transmitance (τ).

→ And some Radiation is Reflect called Reflectivity (ρ).

→ The total Radiation emitted by the hot body is deals to the some of absorbivity, transmitance Refectivity.



$$\text{Total Radiation} = \alpha + \tau + \rho$$

$$1 = \alpha + \tau + \rho$$

Black body :- All other solid hot body Radiate the energy at the temp above the absolute zero and with not some rate, but the black body emitte the Radiation absolute zero temp and with some rate.

→ Black body is defind as a Radiant surface which releases maximum amount of Radiation a given temp.

→ In theory black body is considered to be inclosed space with a small opening and the temp of inclosed surface should be consfent.

→ The black body is made from a tube of carbon and a bath end are plucked with a small hole the centre

→ The black body is works on principle that a good observer is a good conductor.

→ Black color absorb all the light Radiation so it emitte maximum amount of energy.

÷ Rate of Radiation ÷

The emition of radiation per second is called rate of Radiation.

→ The rate of Radiation can be expressed by stefan Baltzman law -

$$q = bAT^4$$

q = Rate of Radiation (Jule/Sec)

b = Constant

A = Surface Area of Radiating body (m^2)

T = Absolute temp (K)

$$b = \frac{q}{AT^4}$$

$$b = \frac{\text{Jule/Sec}}{m^2 \times \text{Kelvin}}$$

The value of 'b' for 'a' black body is $5.67 \times 10^{-8} \frac{J/S}{m^2 \times K}$

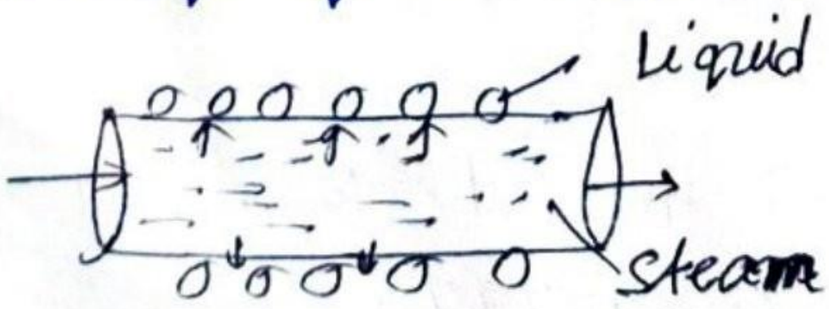
÷ Grey body ÷

Grey body or those colored surface whose absorbtivity is constent at all temp.

÷ Heat exchanger ÷

Heat exchanger is a device in which the heat is exchange b/w two diff mediums. steam to liquid. or liquid to air.

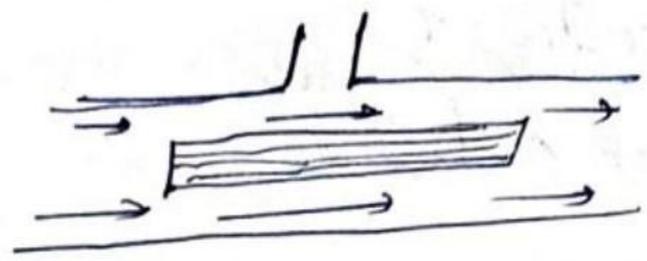
→ When any liquid is flow from the surface of steamline then heat is transfer from hat steam to cald liquid.



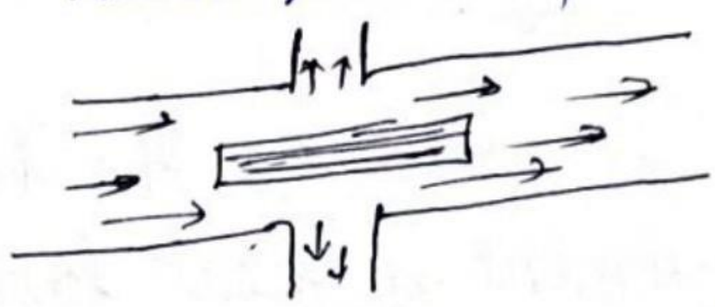
on the basis of structure heat exchanger is of four type.

i) Counter flow :- The liquid is pass over steam in one direction.

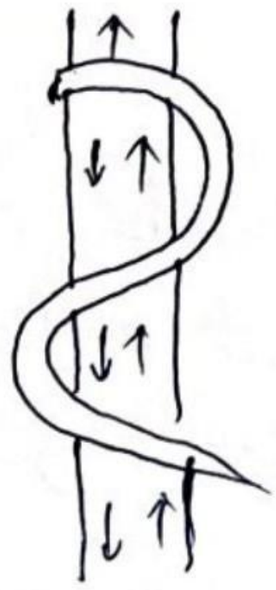
2) Concurrent flow :- The liquid is pass over steam in two direction.



3) Cross flow :- The liquid is pass over steam in four direction.



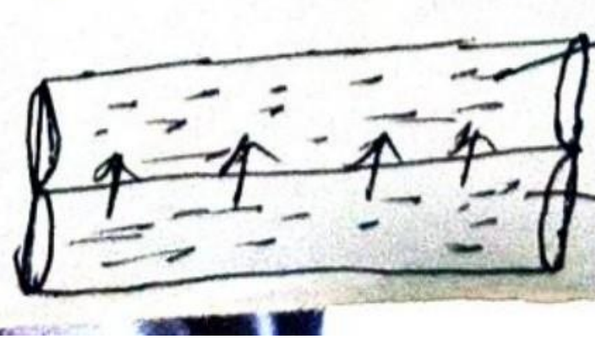
4) Cross Counterflow :- In this type of heat exchanger the liquid flow in one direction but the steam is pass in all direction through coil.



% Heat Interchanger %

Heat interchanger is a device in which the heat is pass b/w to same medium from hot liquid to cool liquid or from hot air to cool air.

→ The transfer of heat is across the metal tube or metal wall.



⁂ Classification heat exchanger ⁂

On the basis of construction heat exchanger is of four type.

i) Shell & Tube heat exchanger.
2) Plate heat exchanger.
3) Regenerative Heat exchanger
4) Adeabatic wheel Heat exchanger
5)

1) Shell and tube heat exchanger:-

Principle:- The liquid is pass b/w the heat exchanger tube and by the movement of heat from hot to cool. surface heat is exchange.

→ In this exchanger the heat transfer coefficent is affect the rate of heat transfer.

Construction:- The shell and tube exchanger is made up of bundle of paraller heat exchanger tube held in Place with tube seat and placed into a shell.

→ In the structure of this exchanger diff imp component are present.

1) U-Tube or Straight tube.
2) Baffels.
3) End channel
4) Inlet and outlet nozzle.
5) Tube bundle.

Working: The coal liquid is fill into shell inlet and the hot steam into tube inlet the direction of both steam and liquid in opposite direction. the steam is moove from down to top and liquid is move from top to bottom

→ With help of baffles the tube header are rotated after the heat exchanging process the hot liquid is collected from shell outlet.

Advantage: It is also expensive and easy process.

→ Large heating tube can be placed into small area.

DisAdvantage: It is slow process because the velocity of liquid is slow.

→ Large amount of heat is loss from tube sheet.

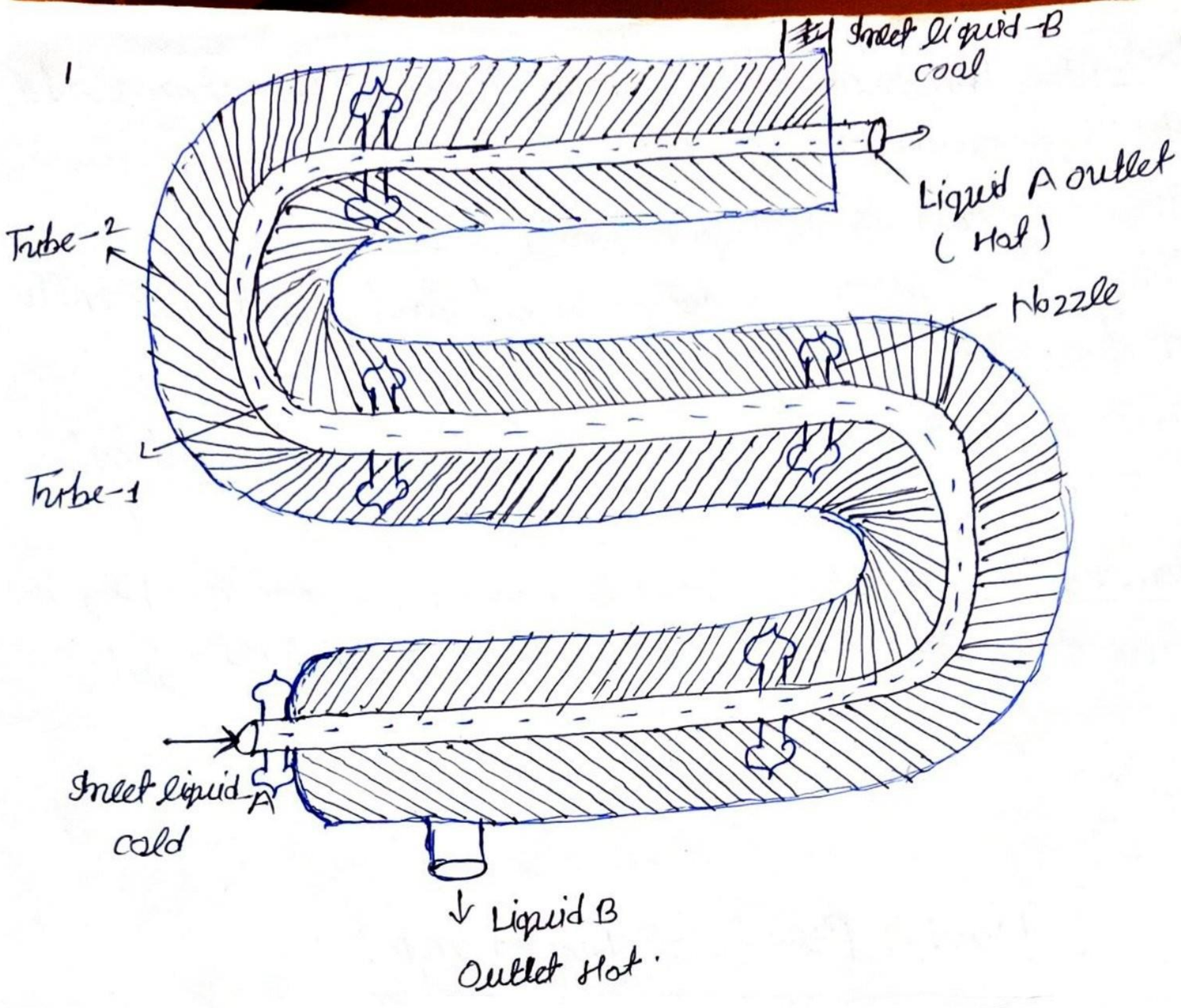
:- Floating Head heater :-

Principle :- The floating head heater is based on the heat exchanger principle, when hot steam is pass over the cool liquid then the heat is exchanger b/w steam and liquid.

→ And two floating head heater are independent to flow to the ends.

:- Constructing :- Its construction is similar to the shell and tube exchanger but in then to pass floating heads is present.

→ In them some tubuler heater is also present.



Working :- First of all the cool liquid is fill in the tube.

→ Now pass the hot liquid from next tube and allow to comes out from outlet.

→ In this process the pipe get heated and the hot liquid losses its temp.

→ The same liquid continuous to flow and finally leave the interchanger through outlet.