Generation of electricity generating Station:-

Types of generating Station:-

(1) Steam Power Station.

(2) Hydroelectric Power Station.

(3) Diesel Power Station.

(4) Nuclear Power Station.

Steam Power System:-

→ A generating Station which converts heat energy of coal combution into electrical energy is known as Steam Power Station or thermal Power Station.

→ A steam Power station basically works on the rankine cycle.

→ A steam ~~Power station was~~ is Produced in the boiler by utilising the heat of coal combution.

→ The steam is then expanded in the Prime over.

→ The steam condens in a condensor to be fed into boiler again.

→ The steam turbine drives the alternator which converts mechanical energy ~~[illegible]~~ into electrical energy.

→ This type of Power station is suitable where coal and water are available in large amount. So, that electric Power is to be generated.

Advantages:-

→ The fuel is used quite cheap.

→ Less initial cost compaire to other generating Station.

→ It can be installed at any Place irrespective of the existance of coal.

→ The coal can be tranported to the side of the Plant by real and road.

→ It is required less Place as compaire to hydro electric Power Station.

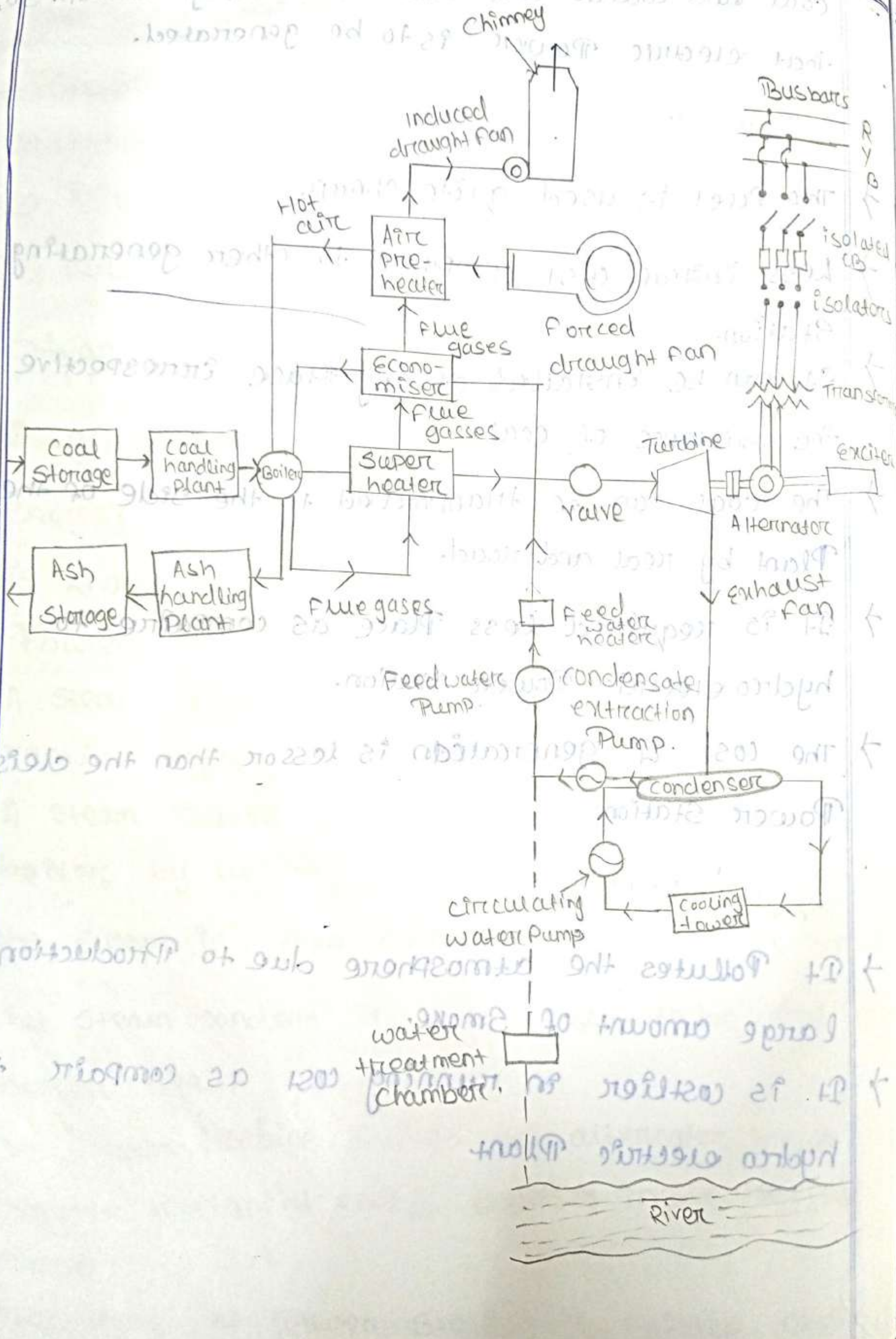
→ The cost of generation is lessor than the deisel Power Station.

Disadvantages:-

→ It Pollutes the atmosphere due to Production of large amount of Smoke.

→ It is costlier in running cost as compair to hydro electric Plant

Schematic arrangement of Steam Power Station.



→ The hole arrangement can be devided into following stages for the sake of simplicity:-

(a) coal and Ash handling arrangement.
(b) Steam generating Plant.
(c) steam turbine.
(d) Alternator.
(e) Feed water
(f) cooling Arrangement.

(a) Coal and ash handling arrangement:-

→ The coal is transported to the Power station by road or rail and is stored in the coal storage Plant.

→ The storage of coal is Premarily of matter of Protection against coal strikes, failure of transportation of system and general and shortages.

→ From the coal storage Plant, coal is delivered to the coal handling Plant where it is Pulverised (i.e; crushed into small Pieces) in order to increase its surface exposure, thus Promoting rapid combustion without using large quantity of excess air.

(b) Steam generating Plant:-

→ The steam generating Plant consists of a boiler for the Production of steam and other auxilliary equipment for the utilisation of flue gases.

The steam generating Plant consist of folowing things.

(i) Boiler.
(ii) Super heater
(iii) Economizer.
(iv) Air Preheater.

Boiler:—

→ The heat of combution of coal in the boiler is utilised to convert into steam at high temp. & Pressure.

→ The flue gasses from the boiler make their journey through superheater, economiser, air Pre-heater and are finally exhausted through the chimney.

→ The steam boiler are two types.

(i) water tube boiler
(ii) fire tube boiler.

Super heater:—

→ The steam Produced in the boiler is wet and is Passed through a super heater where it is dried and superheated(i.e; steam temp. increased above that of boiling Point of water) by the flue gasses on their way of chimney.

→ superheating Provides two Principle benefits. Firstly, the overall efficiency is increased.

→ Secondly too much condensation in the last stages of turbine is avoided.

→ Super heater are two types.

(i) Radian Super heater.

(ii) convention Super heater.

Economiser:-

→ It is a device which heats the feed water. On it's way to the boiler by deriving heat from the flue gasses.

→ This results in raising boiler efficiency, saving in fuel and reduced stresses in the boiler due to higher temp. of feed water.

→ An economiser consists of a large number of closely spaced Parallel steel tubes connected by headers of drums.

→ The feed water flows through these tubes and the flue gases flow outside.

→ A Part of the heat of the flue gasses is transferred to feed water, thus raising the temperature of the latter.

Air Pre-heater:-

→ An air Pre-heater increases the temp. of the air supplied for coal burning by deriving heat from flue gasses.

→ Air is drawn from the atmosphere by a forced draught fan and is Passed through air Preheater before supplying to the boiler furnace.

→ The air preheater extracts heat from flue gasses and increases the temp. of air used for coal combustion.

→ The principle benefits of pre-heating the air are: increased thermal efficiency and increased steam capacity per square of boiler surface.

→ There are two types
  (i) Recuperative type.
  (ii) Regenerative type.

Steam turbine:—

→ The dry and superheated steam from the superheater is fed to the steam turbine through main valve.

→ The heat energy of steam when passing over the blades of turbine is converted into mechanical energy.

→ The electrical O/P from the alternator is delivered to the busbars through transformer, cct breakers and isolators.

Feed water:—

→ The condensate from the condenser is used as feed water to the boiler.

→ Some water may be lost in the cycle which is suitably made up from external source.

→ The feed water on its way to the boiler is heated by water heaters and economiser.

→ This helps in raising the overall efficiency of the plant.

Cooling Arrangement:—

→ In order to improvement the efficiency of the plant, the steam exhausted from the turbine is condensed by means of a condenser.

→ water is drawn from a natural source of supply such as a river, canal or lake and is circulated through the condenser.

→ The circulated water takes up the heat of the exhausted steam and itself becomes hot.

→ This hot water coming out from the condeser is discharged at a suitable location down the river.

→ In case the availability of water from the source of supply is not assured throughout the year, cooling tower are used.

→ The hot water from the condenser is passed on to the cooling towers where it is cooled.

→ The cold water from the cooling tower is reused in the condenser.

Efficiency of Steam Power Station:-

Thermal efficiency

$$\eta_{thermal} = \frac{\text{Heat equivalent of mechanical energy transmitted of turbine shaft.}}{\text{Heat of coal combustion.}}$$

Overall efficiency

$$\eta_{overall} = \frac{\text{Heat equivalent of electrical output}}{\text{Heat of combustion of coal.}}$$

$$\eta_{overall} < \eta_{thermal}$$

$$\boxed{\eta_{overall} = \eta_{thermal} \times \eta_{electrical}}$$

Hydroelectric Power Plant:-

→ A generating station which utilises the potential energy of water at a high level for the generation of electrical energy is know as a hydro electric power plant.

→ Hydroelectric Power stations are generally located in hilly areas for the construction of dams.

→ So, that large water reservoir can be obtained.

→ In hydroelectric Power Station, water head is created by constructing a dam across a river or lake.

→ From the dam, water is led to a water turbine. The water turbine captures the energy in the falling water and changes the hydraulic energy into mechanical energy at the turbine shaft.

→ The turbines drives the alternator which converts mechanical energy into electrical energy.

→ Hydroelectric Power stations are becoming very Popular bcz the reserves of fuels (i.e; coal and oil) are depleting day by day. They have the added importance for flood control, storage of water for irrigation and water for drinking purpose.

Advantages:-

→ It requires no fuel as water is used for the generation of electrical energy.

→ It requires very small running charges bcz water is the source of energy which is available free of cost.

→ It is quite neat and clean as no smoke or ash is produced.

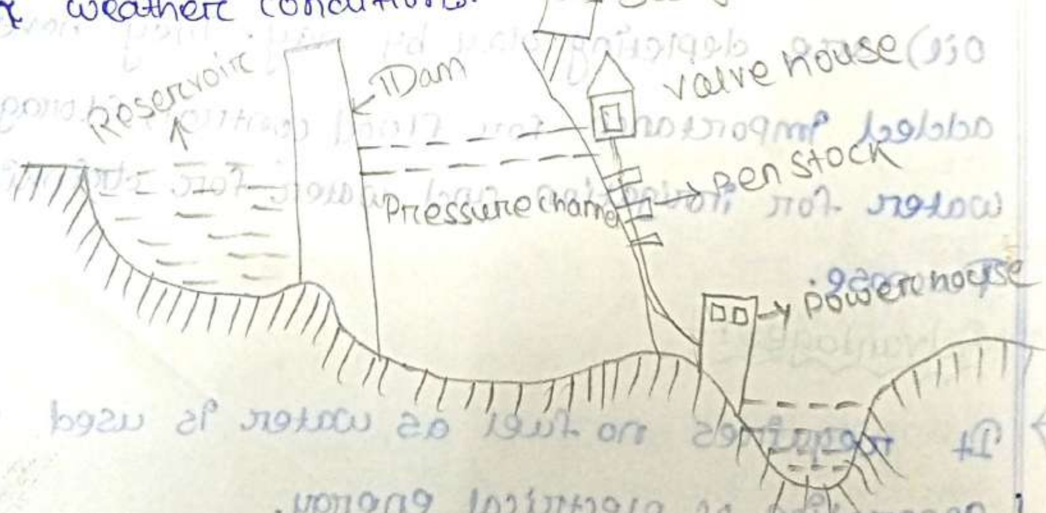
→ It is comparatively simple in construction and requires less maintenance.

Disadvantages:-

→ It involves high capital cost due to construction of dam.

→ Skilled and experienced hands are required to build the plant.

→ There is uncertainty about the availability of huge amount of water due to dependance on weather conditions.



Construction of Hydroelectric Power Plant :-

→ The constituent of hydroelectric Plant are.

(1) Hydroelectric structure.

(2) water turbines

(3) Electrical equipment

1) Hydroelectric structure:-

→ Hydraulic structures in hydro-electric Power station include dam, spillways, headworks, surge tank, penstock and accessory works.

Dam:-

→ A dam is a barrier which stores water and creats water head.

→ Dams are built of concrete or stone mesonary, earth or rock fill.

→ The type and arrangement depends upon the topography of the site.

→ The type of dam also depends upon the foundation conditions, local materials and transportation available, occurrance of earthquakes and the other hazards.

Spill ways:—

- There are times when the river flow exceeds the storage capacity of the reservoir.
- Such a situation arises during heavy rainfall in the catchment area.
- In order to discharge the surplus/excess water from the storage reservoir into the river on the down-stream side of the dam, spillways are used.
- Spill ways are constructed of concrete Piers on the top of the dam. Gates are provided betn these piers and excess water is discharged over the crest of the dam by opening these gates

Head works:—

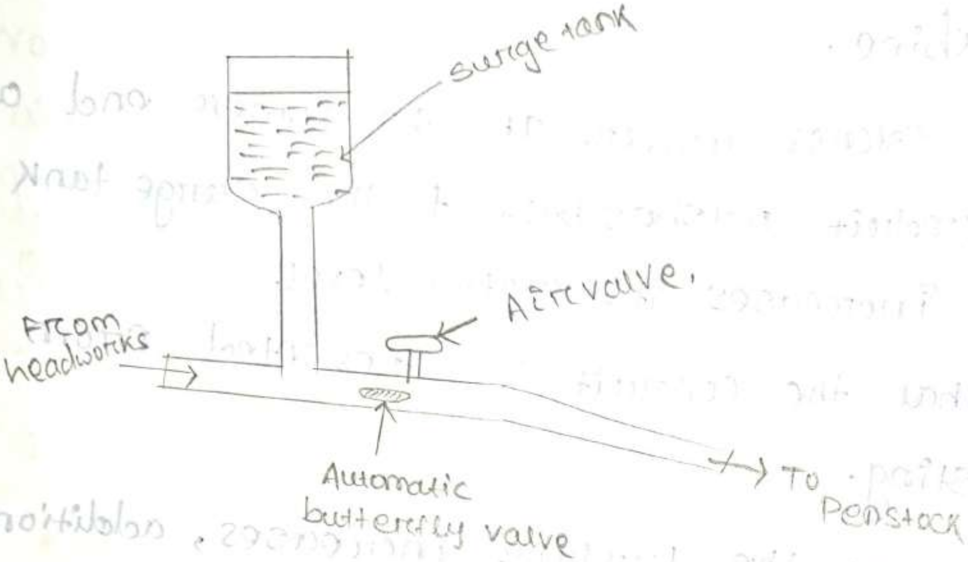
- The headworks consists of the diversion structure at the head of an intake.
- They generally includes booms and racks for diverting floating debris, sluice's for by-passing debris and sediments and valves for controlling the flow of water to the turbine.
- The flow of water into and through headworks should be as smooth as possible to avoid

head loss and cavitation.

Date:- 06.02.2020

Surge tank:-

→



→ A surge tank is a small reservoir or tank (open at the top) in which water level rises or falls to reduce the pressure swings in the conduit.

→ A surge tank is located near the beginning of the conduit.

→ When the turbine is running at a steady state load, there are no surges in the flow of water through the conduit i.e, the quantity of water flowing in the conduit is just sufficient to meet the turbine requirements.

→ However, when the load on the turbine decreases, the governor closes the gates of turbine, reducing water supply to the turbine.

→ The excess water at the lower end of the conduit rushes back to the surge tank and increases its water level.

→ So, that the conduit is prevented from bursting.

→ When on the turbine increases, additional water is drawn from the surge tank to meet the increased load requirement.

Penstocks:—

→ Penstocks are open or closed conduits which carry water to the turbines.

→ They are generally made of reinforced concrete or steel.

→ Concrete penstocks are suitable for low heads (< 30m) as greater pressure causes rapid deteriotation of concrete.

→ The steel Pen stocks can be designed for any head; the thickness of the Penstock increases with head or working Pressure.

→ Various devices such as automatic butterfly valve, air valve and surge tank Provided for the Protection of Penstocks.

→ Automatic butterfly valve shuts off water flow through the Pen stock Promptly if it ruptures.

→ Air valve maintains the air Pressure inside the Penstock equals to outside atmospheric Pressure.

→ when water runs out of a Penstock faster than it enters, a vacume is created which may cause the Penstock to collapse.

→ Under such situations, air valve opens and admits air in the Penstock to maintain inside air Pressure equal to the outside air Pressure.

Water turbines:—

→ water turbines are used to convert the energy of water falling into mechanical energy.

→ The types of water turbine are.

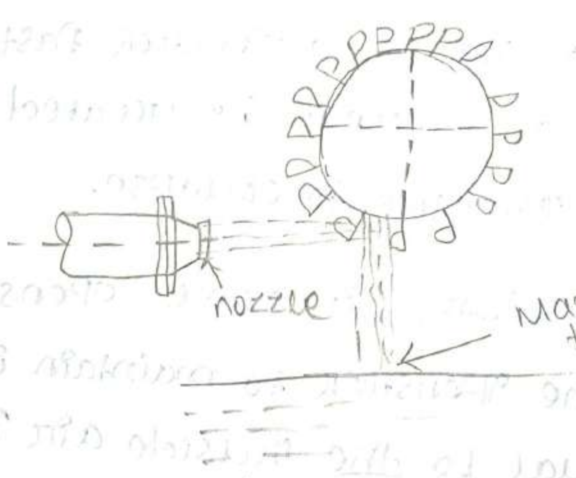
(1) impulse turbine
(2) Reaction turbine.

Impulse turbines:-

→ This types of turbine are used for high heads.

→ In an impulse turbine entire pressure of water converted into kinetic energy in a nozzle and the velocity of the jet drives the wheel.

→ The examples of this type of turbine is the Pelton wheel.



→ It consist of a wheel fitted with eliptical bucket along its periphery.

→ The force of water jet striking the buckets on the wheel drives the turbine.

Reaction turbine :-

→ Reaction turbines are used for low and medium heads.

→ In a reaction turbine, water enters the runner Partly with Pressure energy and Partly with velocity head.

→ The types of reaction turbine are,

(a) Francis turbines (b) Kaplan turbines.

→ A Francis turbines are used for low to medium heads.

→ It consist of an outer ring of stationary guide blades fixed to the turbine casing and an inner ring of rotating blades forming the runner.

→ A Kaplan turbine is used for low heads and large quantities of water.

→ It is similar to Francis turbine except the runner of Kaplan turbine receives water axially.

→ water flows radially in-wards through regulating gates all round the sides, changing dirn in the runner to axial flow.

→ This causes a reaction force which drives the turbine.

Neuclear Power Station:-

Internal

→ In neuclear power station, heavy elements such as uranium or Thorium are subjected to nuclear fission in a special apparatus known as reactor.

→ The heat energy thus released is utilised in raising steam at high temp. and pressure.

→ The steam runs the steam turbine which converts steam energy into mechanical energy.

→ The turbine drives the alternator which converts mechanical energy into electrical energy.

→ The most imp. feature of a nuclear power station is that huge amount of electrical energy can be produced from a ratively small amount of nuclear fuel as compared to other conventional types of power station.

→ It has been found that complete fission 1Kg of uranium (U^{235}) can produce as much energy as can be produced by the burning of

4500 tons of high grade coal.

Advantages:-

- The amount of fuel required is quite small.
- The nuclear PowerPlant requires less space as compared to any other type of the same size.
- It has low running charges.
- This type of plant is very economical for producing bulk power.

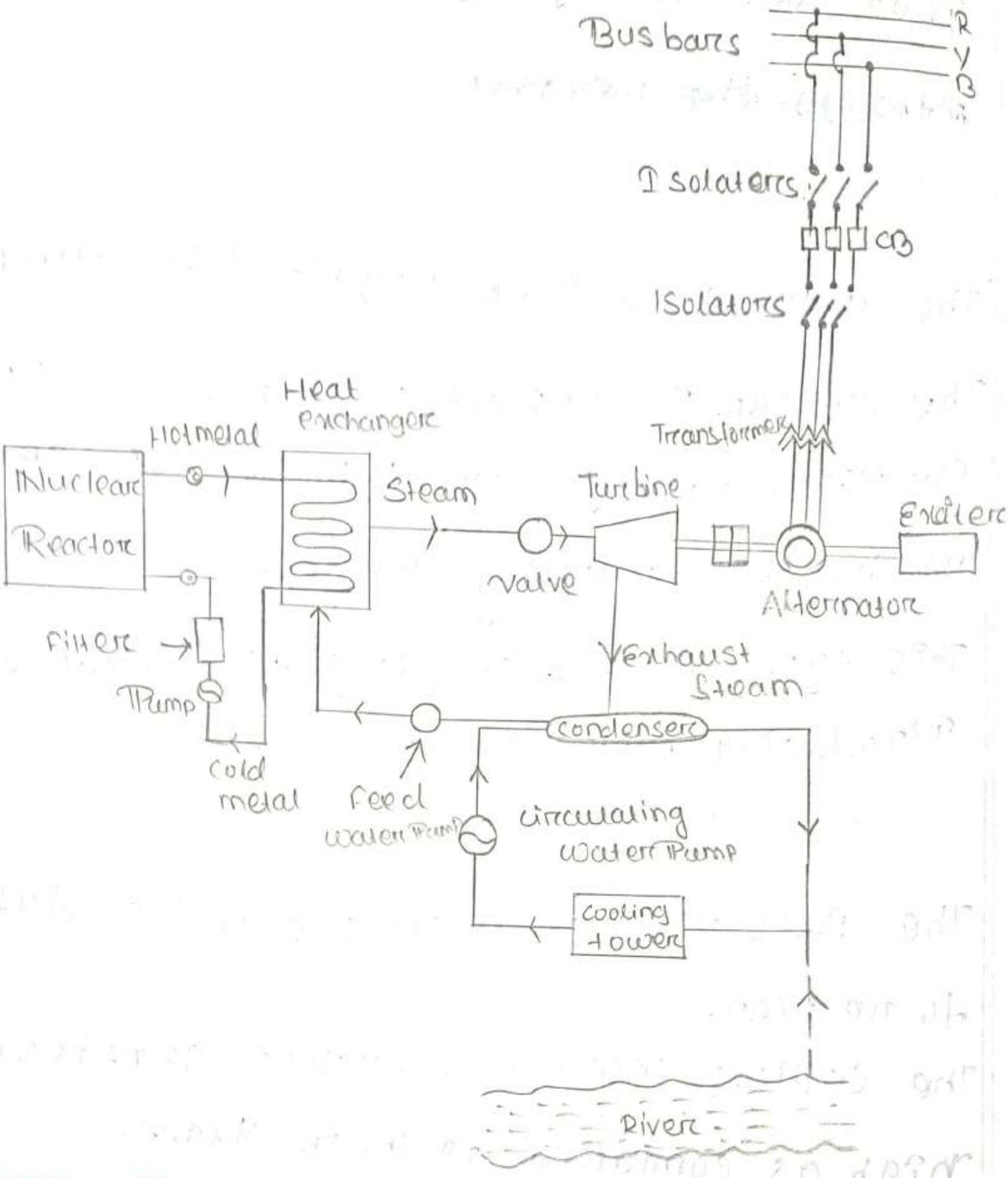
Disadvantages:-

- The fuel used is expensive and is difficult to recover.
- The capital cost on a nuclear plant is very high as compared to other plant.
- The fission by-products are generally radio-active and may cause a dangerous amount of radioactive pollution.

Schematic Arrangement of Nuclear Power station:-

The whole arrangement can be divided into the following main stages.

(i) Nuclear reactor (ii) Heat exchanger (iii) Steam turbine (iv) Alternator



Nuclear Reactor:—

→ It is an apparatus in which nuclear fuel (U^{235}) is subjected to nuclear fission.

→ It controls the chain reaction that starts once the fission is done.

→ If the chain reaction is not controlled, the result will be an explosion due to the fast increase in the energy released.

→ A nuclear reactor is a cylindrical stout pressure vessel and houses fuel rods of uranium.

→ The fuel rods constitute the fission material and release huge amount of energy when bombarded with slow moving neutrons.

→ The moderator slows down the neutrons before they bombard the fuel rods.

→ The control rods are of cadmium and are inserted into the reactor.

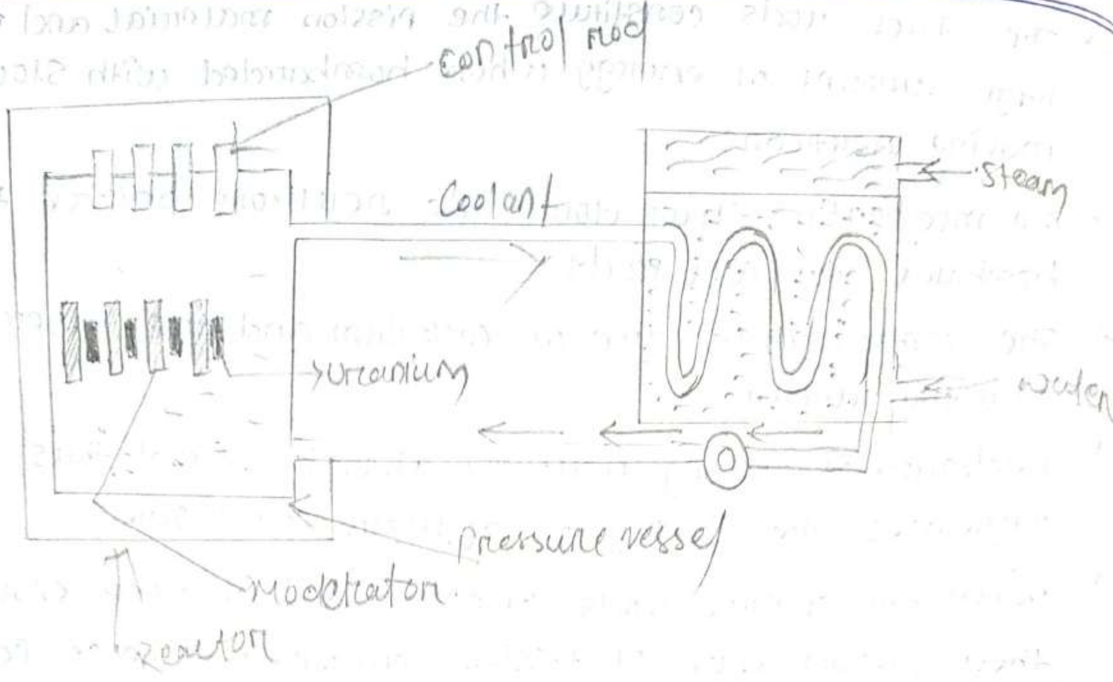
→ Cadmium is strong neutron absorber and thus regulates the supply of neutrons for fission.

→ When the control rods are pushed in deep enough, they absorb most of fission neutrons and hence few are available for chain reaction which, therefore, stops.

→ So, by pulling out the control rods, power of the nuclear reactor is increased, whereas by pushing them in, it is reduced.

→ In actual practice, the lowering or raising of control rods is accomplished automatically according to the requirement of load.

→ The heat produced in the reactor is removed by the coolant, generally a sodium metal.



Heat Exchanger:-

→ The coolant gives up heat to the heat exchanger which is utilised in raising the steam. After giving up heat, the coolant is again fed to the reactor.

Steam turbine:-

→ The steam produced heat exchangers is led to the steam turbine through a valve. After doing a useful work in the turbine, the steam is exhausted to condenser.

→ The condenser condenses the steam which is fed to the heat exchanger through feed water pump.

Alternator:-

The steam turbine drive the alternator which converts mechanical energy into electrical energy.

→ The output from the alternator is delivered to the bus-bars through transformer, circuit breakers and isolators.

—— * ——

-: Transmission of electric Power:-

Active Power:-

→ It is the Power which is consume inactive work done. It is denoted by 'P'.

→ Mathmatically it can be written

$$P = VI \cos\phi$$

→ It is also called real Power

→ It is measured in watt.

Reactive Power:-

→ It is the Power which is required to creat magnetic field inside the system it is neccessary for continous conversion or transmission of Power.

→ Any type of energy can't be directly converted into other form their by the input energy 1st have to converted into magnetic form. then to the respective form.

→ In any system when we do switch on 1st reactive Power will flow then active Power will flow the Path.

Mathematically, it can be written

$$P = VI \sin\phi$$

→ It is measured in VAR (volt ampere Reactive)

Voltage Magnitude :-

→ voltage is a electrical Pressure i.e; required to circulate the current through the circuit.

→ voltage should be in limit.

$$|V|_{min} \leq |V| \leq |V|_{max}.$$

If $|V| \geq |V|_{max}$.

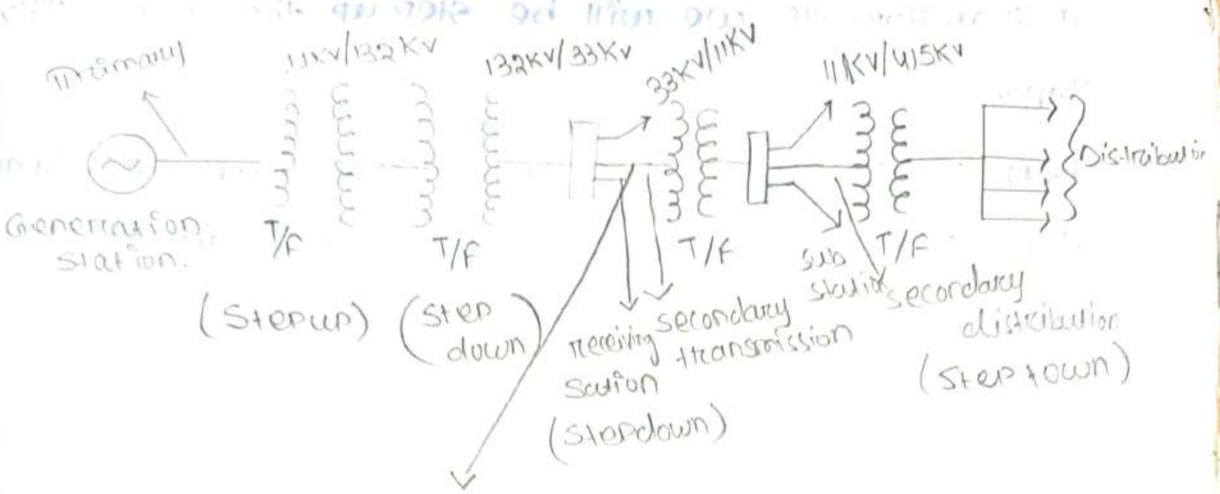
→ It can cause insulation breakdown so that short circuit may develop. It may also damage load.

→ If $|V| \leq |V|_{min}$.

→ It voltage decreases the Power flow will also decrease as P and Q depends on voltage.

Transmission :-

→ Transfer of Power from one end to another end is called transmission. In transmission Power always high voltage transmission is preffer' to reduce transmission loss.



Primary distribution.

→ one line diagram of transmission & Distribution.

→ Electrical Power is normally generated 11KV in a Power station then 11KV step up to 132 KV, 220KV, 400KV or 760KV etc. as per the requirement to reduce the losses.

→ Staping of the voltage is depends upon the distance at which the Power will be transmitted.

→ Length of the conductor with depends the voltage and and the distance.

→ Transmission of voltage consists of
(1) Primary transmission (2) Secondary transmission
(3) Primary distribution (4) Secondary distribution.

Primary Transmission:—

→ In this 11KV which is generated a generating station will be transmitted to reduce the loss through a step.

up transformer we will be step up the voltage 11KV to 132KV.

→ Then 132KV will be transmitted through over head lines to the other coil this is called Primary transducer.

Secondary Transmission:-

→ In this transmission the step up voltage 132KV will be again stepped down to 33KV through a step down transformer at receiving station.

Primary Distribution:-

Again the voltage 33KV will stepped down to 11KV through a stepdown transformer.

Dt:- 18.12.19

Voltage regulation:-

→ For the transmission of reactive Power there most be Potential difference in a such way that or sending and voltage should have higher Potential then receiving end.

→ For the transmission of active Power from Source to the load the source should have certain Phase advansed made overload

→ The voltage regulation of transmission line is defined as the ratio of difference between sending and receiving and voltage of a transmission line.

$$\% \ V.R = \frac{V_S - V_R}{V_R} \times 100$$

Transmission line:-

→ Transmission line is the long conductor with special designed (bundled) to carry bulk amount generated Power at very high voltage from 1 station to another as per variation of the voltage level.

Three Phase circuit:-

→ Polyphase circuits are considered for bulk Power transmission.

→ In the Polyphase system three Phase system mostly Prefferred

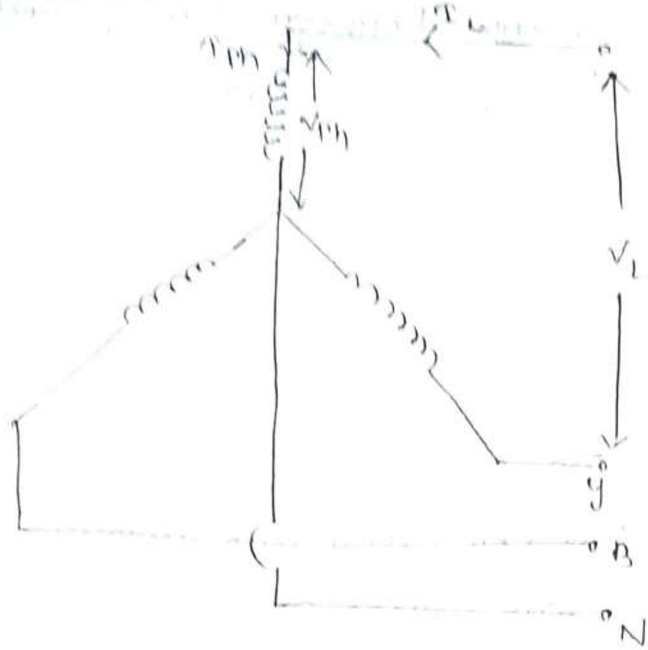
→ Each Phase is kept at a Phase shift of 120°.

→ There are two types 3 Phase connection.

(1) Star connection. (Y)

(2) Delta connection. (Δ)

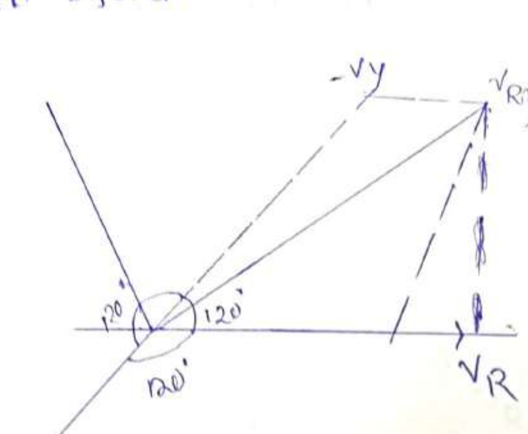
Star connection:



→ In this all starting or finishing ends. Joined together at a common point is called neutral.

→ From the neutral point of a wire is taken out then this circuit is called 3-Phase 4 wire system. Otherwise 3 Phase 3 wire system.

$$\boxed{I_L = I_{ph}}$$



$$V_{ph} = V_R = V_Y = V_B$$

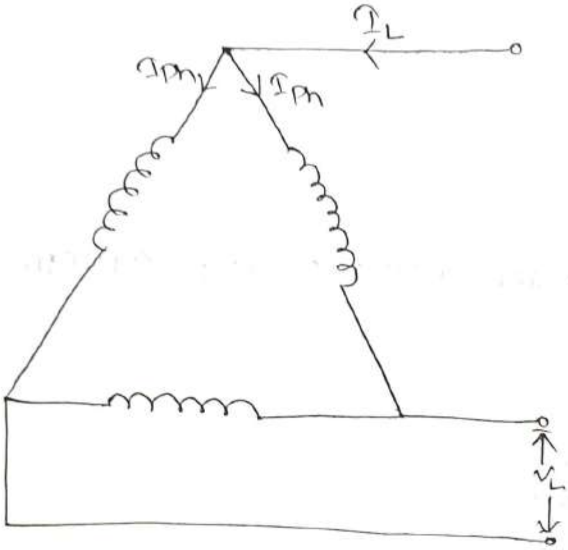
$$V_L = V_{RY} = V_{YB} = V_{BR}$$

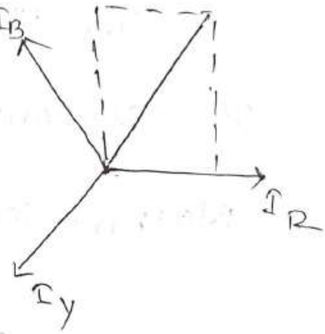
$$V_{RY} = V_R + (-V_Y)$$

$$= \sqrt{(V_R)^2 + (-V_Y)^2 + (2V_R)(-V_Y)\cos 60^\circ}$$

$V_{RY} = V_L = \sqrt{3}\ Ph$ & $I_L = I_{Ph}$

Delta connection:-





$I_L = \sqrt{3}\, I_{Ph}$

$V_L = V_{Ph}$

$I_L = \vec{I}_{Ph} + \vec{I}_{Ph}$

→ In this starting of one coil is connected two finishing of other coil.

→ It forms a closed path like on mesh so that named as delta.

Power:-

$P_{1\phi} = V_{Ph} I_{Ph} \cos\phi$

$P_{3\phi} = 3 V_{Ph} I_{Ph} \cos\phi$

$P_{3\phi}(Y) = \sqrt{3}\, V_L I_L \cos\phi$

$P_{3\phi}(\Delta) = \sqrt{3}\, V_L I_L \cos\phi$

Performance of lines:-

Performance of lines consist of two things

① Efficiency

② Regulation

Efficiency:-

The Performance of a system is considered of efficiency

Mathmatically,

$$\% \eta = \frac{o/p}{i/p} \times 100$$

$$= \frac{o/p}{o/p + losses} \times 100$$

$$= \frac{i/p - losses}{i/p} \times 100$$

→ For the calculation of efficiency losses must be considered.

→ Here, (transmission line) major loss is Ohmic loss. which is more than 95%.

Regulation:-

→ Here in transmission line voltage regulations calculated. Regulation means correction and it is ~~calculated~~ calculated when

(1) Load is Partially (or) totally through of to know the rise in voltage.

(2) To estimate % draw of voltage when the loading is increased from no-load to full-load so that sweetable compensating device can be designed.

Mathematically,

$$\% \text{ Regulation} = \frac{V_{NL} - V_{FL}}{V_{rated}} \times 100$$

→ For the calculation of line regulation we needed to consider full-load value.

→ The receiving and voltage is taken as full-load voltage so,

$$\% \text{ Regulation} = \frac{V' - V_R}{V_R} \times 100$$

where,

V' = Receiving end voltage at no-load

V_R = Receiving end voltage at full load.

$V' - V_R$ = also called impedance drop.

$V' - V_R = IZ$

$V' - V_R = I \angle \pm\phi \; Z\angle\phi$ (+ → leading load, − → lagging load)

$V' - V_R = I\,(\cos\phi \pm j\sin\phi)\,(R + jX)$

$= (I\cos\phi \pm Ij\sin\phi)(R + jX)$

$= (IR + jIX)(\cos\phi \pm j\sin\phi)$

$= IR\cos\phi \pm IRj\sin\phi + jIX\cos\phi \mp IX\sin\phi$

$$\boxed{V' - V_R = IR\cos\phi \mp IX\sin\phi}$$

(− → leading, + → lagging)

So,

$$\% V_R = \frac{V' - V_R}{V_R} \times 100$$

For lagging load = $\dfrac{IR\cos\phi + IX\sin\phi}{V_R} \times 100$

For leading load $= \frac{v_R \cos\phi - v_X \sin\phi}{V} \times 100$

Power factor :

→ Power factor is a measure of how effectively incoming Power is used in electrical system and

→ It is defined as the ratio of real Power to apparent Power.(KVA)

$$KVA = \vec{KW} + \vec{KVAR}$$

→ If load is inductive then the Power factor will be lagging.

→ If load is capacitive then the Power factor will be leading.

→ If load is resistive then the Power factor will be unity.

→ $\cos\phi = 1$ means the Power supplied is being used for Productive work and this is called unity.

Dt:- 09.01.20.

Corona:-

→ The Phenomena of violate glow hissing noise and Production of ozone gas is considered as Corona.

→ The main reason for the occurance of corona is

(i) Excessive voltage:-

This is called ionisation there by radiation are coming out is visual and invisual form.

(ii) Atmospheric condition:-

→ Corona also depends on atmospheric condition

→ Corona also affected by spacing between conductors, roughness of the surface, and shape of the conductors.

→ The air around the conductor is consisting of some deplayed the level of ionisation due to cosmic radiation by sun

→ When the voltage in the line increases the charges will excessively float then the air around it prospot by ionisation.

→ Through the space there is some invisible radiations present, this phenomenon is called as Corona-1.

→ The voltage at this phenomenon is called as critical disrupted voltage.

→ When the operating voltage further increases the radiations are turning into visual forms This is called Corona-2.

→ The voltage at this phenomenon is called as visual critical voltage.

Advantages:-

→ The virtual diameter of conductor increases these called resistance to decreases.

Disadvantages:-

→ this phenomenon causes power loss.

→ Due to realise of ozone the surface make get corroded.

→ Due to continous sparking there may be material injury.

Internal

Kelvin's Law:-

→ The Kelvin's law states that the most economical size of conductor is that for which annual depreciation on the capital cost of the conductor is equal to the annual cost of energy loss.

→ Economy is one of the most important factors while designing any transmission line.

→ Total annual cost can be devided into two parts.

(i) Annual charges on capital out lay:-

It includes depriciation interest; interest on capital cost, maintenance cost.

(ii) Running charges:-

In this the cost of energy loss during the operation is counted in running charges.

imp → If the crosssectional area of the conductor is the decreased. The total capital cost of the conductor decreases but the line losses increases.

→ $R \uparrow = A_c \downarrow \rightarrow I^2R \uparrow \longrightarrow$ ohmice

→ where as if the cross sectional area of conductor increases the linelosses decreases but the total capital cost increases.

So let ① Area of cross-sectional of conductor $= A_c$

② Annual interest and depreciation on capital cost of the conductor $= C_1$

③ Annual running charges $= C_2$

$C_1 \propto A_c$

$\Rightarrow C_1 = K_1 A_c$

and $C_2 \propto \frac{1}{A_c}$

$\Rightarrow C_2 = K_2 / A_c$

where,

K_1 and K_2 = Proportionality constant.

<u>Now</u>

Total annual cost $(C) = C_1 + C_2$

$\Rightarrow C = K_1 A_c + \frac{K_2}{A_c}$

For C to be minimum

$$\frac{dc}{dA_c} = 0$$

So, $\frac{dc}{dA_c} = \frac{d}{dA_c}(C_1 + C_2)$

$$= \frac{d}{dA_c}\left[K_1 A_c + \frac{K_2}{A_c}\right]$$

$$= K_1 - \frac{K_2}{A_c^2}$$

$$\Rightarrow K_1 - \frac{K_2}{A_c^2} = 0$$

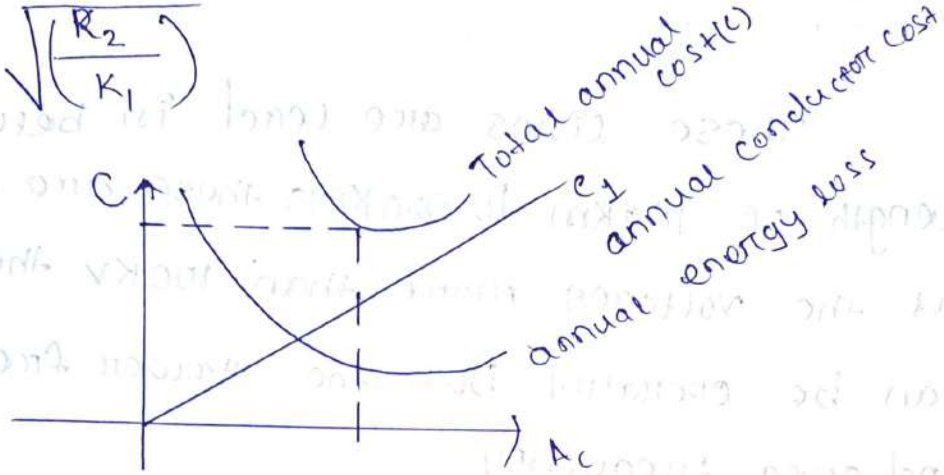
$$\Rightarrow K_1 = \frac{K_2}{A_c^2}$$

$$\Rightarrow K_1 A_c = \frac{K_2}{A_c}$$

$$\Rightarrow \boxed{C_1 = C_2}$$

From the above derivation the economical cross-sectional area can be calculated as

$$A_C = \sqrt{\left(\frac{K_2}{K_1}\right)}$$



Classification OF line:-

→ The transmission lines are classified in 3 types

(I) Short transmission line

(II) medium transmission line

(III) Long transmission line.

(1) Short transmission line:-

These line are lead up to length 80 Kms and operated with the voltage 20 KV these lines are always operated at Power frequency

(2) Medium transmission line:-

These lines are lead in betⁿ lengths of 80Kms to 160 Kms and operated with the voltage in between 20KV to 100 KV. These lines are also operated at Power frequency.

(iii) Long transmission lines:-

These lines are lead in between the length of 160 Km to 280 Kms these are operated at the voltages more than 100 KV those lines can be operated both the Power frequency and area frequency

Power frequency = 50-100 Hz
carrier frequency > 100 Hz

Overhead Lines:- Chapter-3 Date:- 16.01.2020

→ Electric Power can be transmitted or distributed by overhead lines and underground cables.

→ In most of the cases for the transmission of electric power we used overhead lines.

→ underground cables are may be rarely used because the Power is being transmitted to long distance and Proper insulation of the cables will be high as compared to overhead lines.

→ As we know for economic reason electric Power should be transmitted at very high voltage. So, it is very difficult to Provide Proper insulation to underground cables to withstand such a high voltage.

Components of overhead transmission line:-

1. cables or conductors
2. Supports
3. Insulators
4. Cross arms
5. Sag

1. Cables or conductors:-

→ Conductors are the most important component ~~of overhead electrical~~ in the transmission of the electrical Power.

→ As most of the capital outlay is invested for it.

→ Cables or conductors transmitt Powers for sending end to receiving end station.

→ The Proper choice of conductor material and size depends upon following factors.

(a) High electric conductivity

(b) High tensile strength for the support of mechanical aspects.

(C) Low specific gravity. So that weight per unit volume is small.

(d) cost

→ The most commonly used conductor material for the overhead transmission line are copper, Aluminium, steel code aluminium, Galvanised steel and cadmium copper.

→ Generally for overhead transmission line standard conductors used for the flexibility. If there is 'n' no. of layers then the total no. of the individual wires is $3n(n+1)+1$.

Copper:—

→ Copper is an ideal material for overhead transmissi[on] line because its high electrical conductivity and greater tensile strength.

→ Copper has high current density i.e; current carrying capacity of copper per unit of cross-sectional area is large.

→ This has advantages that
Smaller cross-sectional area of conduction is required.

→ Copper can be ideal material for transmition and distribution but to its higher cost and non-availability it is rarely used.

Alluminium:—

→ Al is cheap and light as compared to cu but it has much more smaller conductivity and tensile strength.

→ The conductivity of aluminium is less than cu means the cross-section of alminium conductor will be more then the cu conductor. for the better transmission efficiency.

→ The specific gravity of the aluminium is lower than cu. so, that supporting structure for Al conductors need not to be made so strong.

→ As the Al conductor is the light weight. Hence, it has greater swings so, that larger cross arms are required.

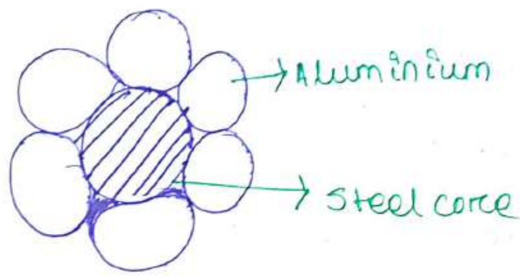
→ ~~Sag~~ Sag of the Al conductor is high as it has lower tensile strength and higher coefficient.

Steel-Cored Aluminium:—

→ Due to low tensile strength Al conductor produce greater sag.

→ This Prohibits there used for longest spans and makes them unsuitable for long distance transmission.

→ So, to increase the tensile strength the Al conductor is reinforced with a core of galvanised steel wires. This is also called as ACSR [Aluminium conductor steel reinforced]



→ Diameter of Al & steel are same.

→ The cross-section of two material in the ratio of 1:6.

Advantages:—

→ ACSR conductors have more tensile strength also keeps the composed it conductor light.

→ ACSR been Produce smaller sag so that for the longer span can be used.

→ when sag is emitter will ACSR the tower of smaller hight can be used.

Galvanised Steel:—

→ Steel has very high tensile strength therefore galvanised steel conductors can be used for extreamely longs span s or four short lines sections exposed to avalable high stress due to climatic change.

→ Due to poor conducting and high resistance of steel. Such conductors are not suitable for transmitting large power over long distance so they having found very suitable in rural areas.

→ It is also unsuitable for use because of poor mechanical strength.

Calcium copper:—

→ cadmium copper is natting but is a copper alloyed with cadmium.

→ An addition of 1% to 2% cadmium to copper about 50% and the conductivity is only reduced by 15% below that of pure copper.

→ Therefore cadmium copper conductor can be useful for long distance transmission.

→ Due to high cost of cadmium such conductor will be economical only for lines of small cross-section that is where the cost of conductor material is comparatively small compaired with the cost of supports.

Line supports :—

→ The supporting structures for overhead line conductors are various types of poles and tower called line supports.

→ Types of line support are used for over head transmission lines are :—

(1) wodden pole (3) RCC poles

(2) Steel poles (4) Lattice steel towers.

→ The choice of supporting structure for a particular case depends upon the line span, x-sectional area, line voltage, cost and local conditions.

1) Wooden Poles :—

→ These are made up of seasoned wood (sal or chir) and are suitable for lines of moderate x-sectional area and of relatively shorter spans, upto 50 meters.

→ Such supports are basically used in rural areas as an economical purpose.

→ Basically double pole structures of the A or H types are used to obtain a higher transverse strength than could be economically provided by means of single poles.

→ **Disadvantages :—**

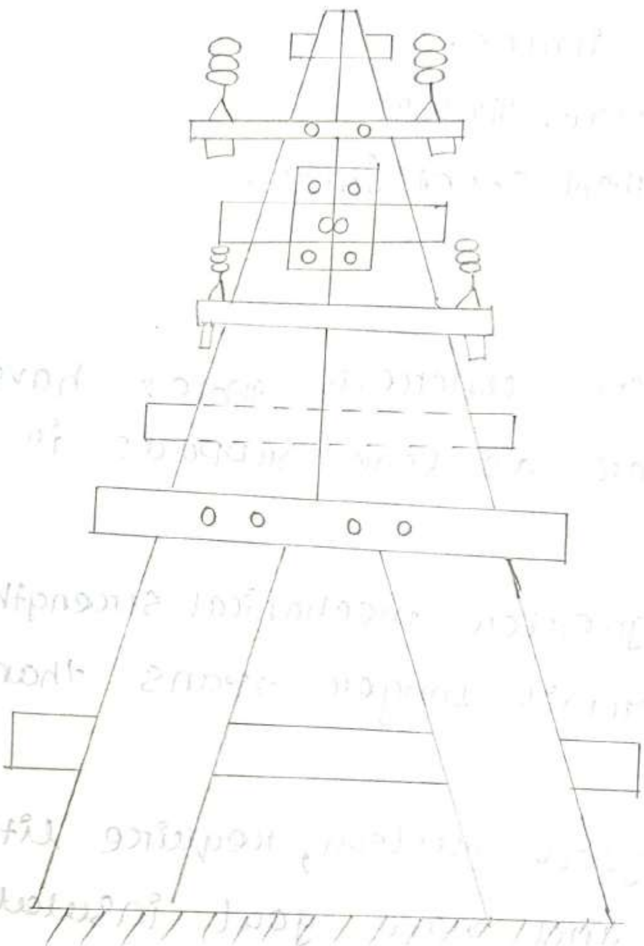
→ Tendency to rot below the ground level.

→ comparatively smaller life (20-25 years)

→ Cannot be used for voltages higher than 20KV.

→ Less mechanical strength.

→ Required Periodical inspection.



2) Steel Poles:—

→ The steel poles are often used as a substitute for wooden Poles.

→ They Possess greater mechanical strength longer life and Permit longer spans to be used

→ Such Poles are generally used for distribution Purposes in the cities.

→ This types of supports need to be galvanised or painted in order to prolong its life.

→ The steel poles are three types.

(i) Rail poles.

(ii) tubular poles

(iii) rolled steel joints.

RCC Poles:—

→ The reinforced concrete poles have become very popular as line supports in recent years.

→ They have greater mechanical strength, longer life and permit longer spans than steel poles.

→ They give good outlook, require little maintenance and have good insulating properties.

→ The main difficulty with the use of these poles is the high cost of transport owing to their heavy weight.

→ Therefore, such poles are often manufacture at the side in order to avoide heavy cost of transportation.

Steel towers:—

→ For long distance transmission at higher voltage, steel towers are invariably employed.

→ Steel towers have greater mechanical strength longer life, can withstand most severe climate conditions and permit the use of longer spans.

→ Tower footings are usually grounded by driving rods into the earth.

→ This minimises the lighting troubles as each tower acts as a lighting conductors.

→ It has basically two types.

(1) single cct tower

(2) Double cct tower.

→ The double cct has the advantage that it ensures continuity of supply, in case there is breakdown of one cct, the continuity of supply can be maintained by other cct.

Insulators:-

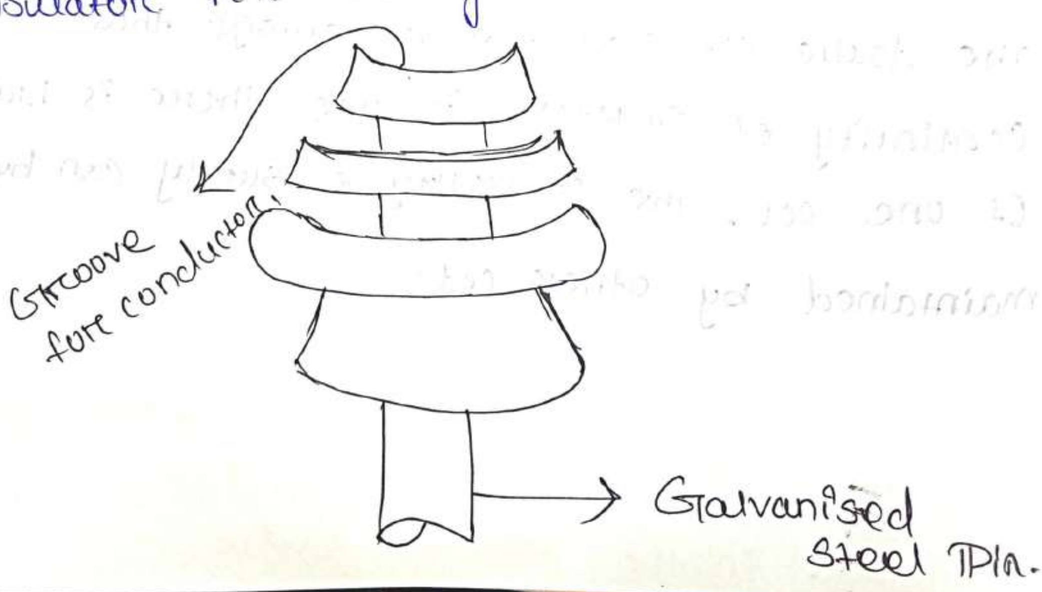
→ The successful operation of an overhead line depends to a extent upon the proper selection of insulators.

→ There are several types of insulators but the most commonly used are (1) Pin type insulator (2) Suspension type.
(3) Strain insulators.
(4) Shackle insulators.

Pin insulators:-

→ The Pin type insulator is secured to the cross arms on the Pole.

→ There is a groove on the upper end of the insulator for housing the conductor.



→ The conductor passes through this groove bound by the annealed wire of the same material as the conductor

→ Pin type insulators are used for transmission and distribution of electric power of voltages upto 33KV.

(2) Suspension type insulators:-

→ For high voltages (> 33 KV) It is usually practice to use suspension type insulators.

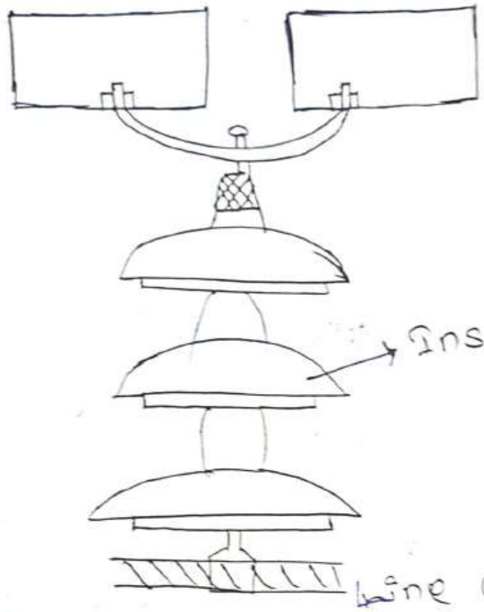
→ They consist of a no. of porcelain disc. connected in series by metal links in the form of a string.

→ The conductor is suspended at the bottom end of the string wire the other end of the string is secured to the cross arms of the tower.

→ Each unit of disc is designed for low voltages, say 11KV.

→ The no. of disc in series would obviously depends upon the working voltage.

→ Ex:— If the working voltage is 66KV then 6 discs are in series will be Provided on on the string.



Advantages:-

→ Suspension type insulator are chief pear than Pin type insulator for voltage beyond 33 KV.

→ If any one disc. is damage the whole string doesn't become useless because the damage disc. can be replaced by another one.

→ The suspention arrangement Provide greater flexibility to the line. The connection at the cross arms is such that insulator string is free to swing in any direction, and can take up the Position where mechanical stress are minimum.

Strain Insulators:—

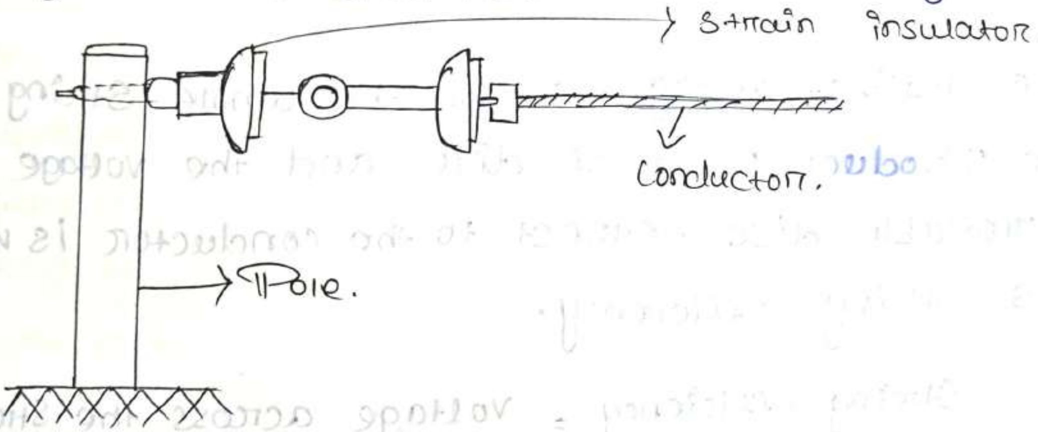
→ when their is a dead end of the line or their is corner or sharp curve the line is subjected to greater tension.

→ In order to relief the line of excessive tension, Strain insulator are, used.

→ For low voltage lines (<11 KV) shackle insulator are used of strain insulator.

→ The discs of strain insulator are used in vertical Plane.

→ when the tension in lines excessively high as an long reverse span two or more string.



Shackel Insulators:—

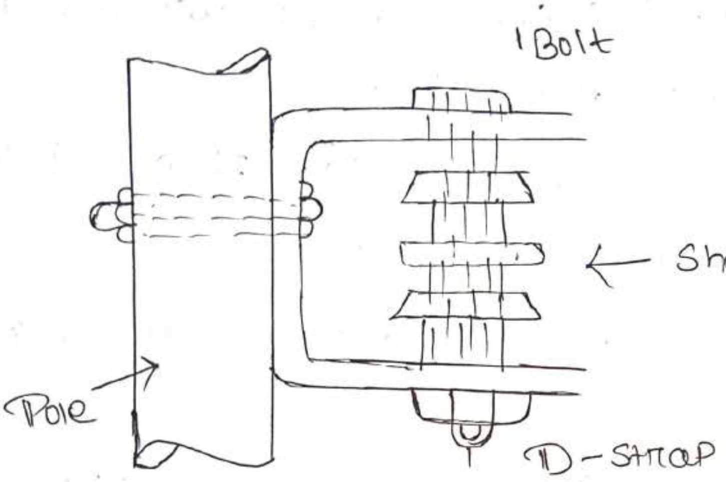
→ This type of insulators are frequently used for low voltage distribution lines.

→ Such insulatores can be used either in horizontal Position on in a vertical Position.

bolt

→ They can be directly fixed to the Pole or to the cross arm.

→ The conductor is fixed in the groove with a soft winding in this type of insulator.



String efficiency:—

→ The ratio of voltage across the whole string to the Product of no. of disc. and the voltage acrossable disc nearest to the conductor is known as string efficiency.

$$\text{String efficiency} = \frac{\text{Voltage across the string}}{n \text{ voltage across disc. nearest to the conductor}}$$

where, n = no. of discs in the string.

Factors to reduce corona:—

→ The phenomenon of corona is more dangerous or disadvantages so it should be reduced by following methods:—

(i) The main reason for the occurrance of corona is excessive voltage so voltage must be maintain constant.

(ii) The spacing b/w the conductors should be sufficientely made.

(iii) By using bundle conductors effect of corona can be reduced.

Sag:—

→ The transmission line due to their heavy weight develops sag the maximum sag specifies the minimum clearance required therefore in desighing the pole height sag calculation is very important

→ Some sag and tension always be a allowed due to temperature deviation in the atmosphere in different seasons.

→ Sag calculations are based on -

(i) Line supports are at same level.

(ii) Line supports are at diff. level.

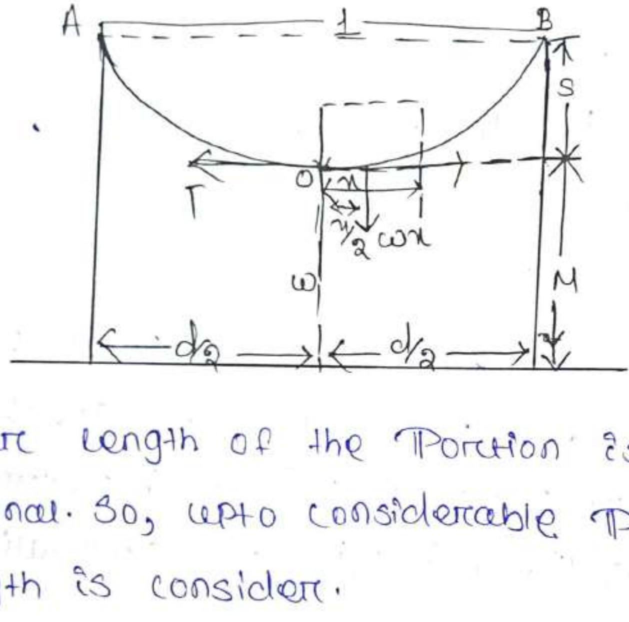
(iii) Sag calculation with effect of wind and ice coating.

Line supports are at same level:-

→ This is the case to be study when the conductor is lead on plain land.

→ In this the span of the conductor almost same the maximum deep is at middle of the span at which the total weight of the conductor consider.

→ For the calculation of sag the portion of conductor to be considered.



→ The linear length of the portion is l/2. But it is not original. So, upto considerable point of linearity the length is consider.

→ Let at point 'P' the coordinates are (x, y.)

→ The weight of the segment 'op' is "wx" is existing at x/2 the tension t is existing in horizontal direction.

→ The segment of conductor 'op' is subjected to one horizontal force 'T' and one vertical force 'wx'.

→ This segment is under equillibrium when the movement developed by both the forces at same.

$$Ty = \omega x \frac{x}{2}$$

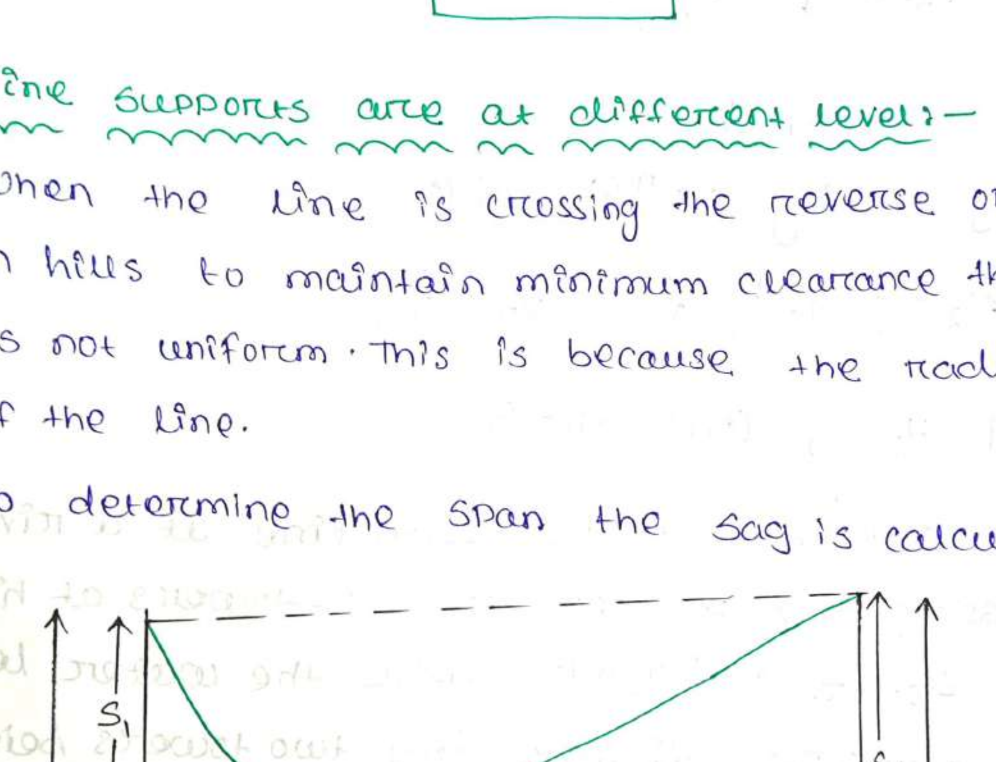
$$y = \frac{\omega x^2}{2T} \qquad \text{at } x = \frac{l}{2},\ y = S$$

$$\boxed{S = \frac{\omega l^2}{8T}}$$

Line supports are at different level :-

→ when the line is crossing the reverse or load on hills to maintain minimum clearance the span is not uniform. This is because the radiant of the line.

→ To determine the span the sag is calculated.



$$\Rightarrow \boxed{S_1 = \frac{\omega x_1^2}{2T}} \qquad \boxed{S_2 = \frac{\omega x_2^2}{2T}}$$

$$x_2 + x_1 = l \quad \text{—— (1)}$$

$$h = H_2 - H_1 = S_2 - S_1$$

$$\frac{w}{2T}(x_2^2 - x_1^2) = h$$

$$wl\,(x_2 - x_1) = 2TH$$

$$x_2 - x_1 = \frac{2TH}{wl} \quad \text{(ii)}$$

$$x_2 + x_1 = l$$

By solving equ^n (1) and (2)

$$x_2 = \frac{l}{2} + \frac{Th}{wl}, \quad x_1 = l/2 - \frac{Th}{wl}$$

$$H = H_2 - S_2 \text{ (or) } H_1 - S_1$$

Problem-1

a) An overhead transmission line at a river crossing is supported from 2-towers at hight top 40mtr and 90mtr above the water level the horizontal distance b/w two towers being if the maximum allowable tension is 2KKg. Find the clearance between the conductor and water at a Point mid-way b/w tower. weight of conductor is 1Kg/meter.

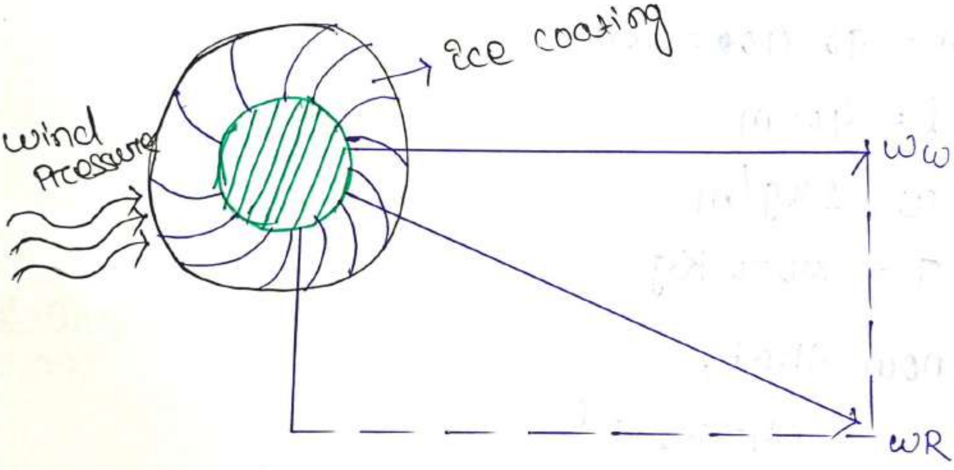
With effect of wind and ice coating:-

→ In hill area the wind Pressure is more, this causes the conductor to move in horizontal direction.

→ In some locations continuos ice fall, the ice coated on the conductor increases its effective way this causes more vertical forceing.

→ The sag render under this condition is calculated on the basic of resultant weight.

→ The sag calculated on the basis of this resultant way is consider as slant sag which can have horizontal as well as vertical components.



$$\theta = \tan^{-1}\left(\frac{w + w_i}{w_w}\right)$$

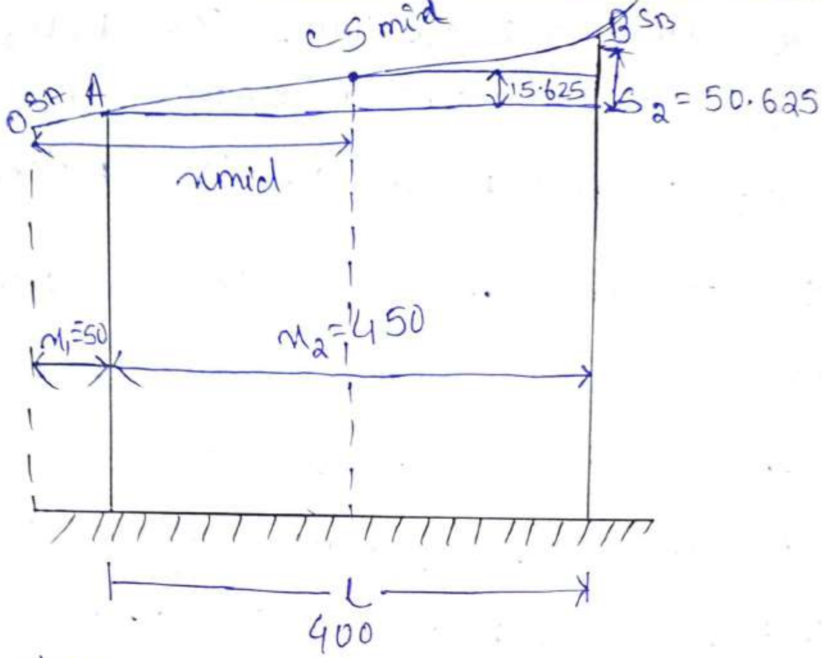
$$w_R = \sqrt{(w + w_i)^2 + w_w^2}$$

$$S_S = \frac{w_R l^2}{8T}$$

$$S_H = S_S \cos\theta$$

$$S_V = S_S \sin\theta$$

Problem-1 (Ans)



Given data,

$h = 90 - 40 = 50m$

$l = 400m$

$\omega = 1 kg/m$

$T = 2000 Kg$

we know that,

$x_1 + x_2 = l$

$\Rightarrow x_1 + x_2 = 400$ —— (1)

and $h = S_2 - S_1 = \frac{\omega x_2^2}{2T} - \frac{\omega x_1^2}{2T}$

$50 = \frac{\omega}{2T}(x_2^2 - x_1^2)$

$50 = \frac{\omega}{2T}(x_2 - x_1)(x_2 + x_1)$

$x_2 - x_1 = \frac{50 \times 2 \times 2000}{400} = 500m$ —— (II)

Solving (1) and (2) we get $x_1 = -50$
$x_2 = 450$

Here in question given that $l = 400m$

Now we know that
$$l = x_1 + x_2$$
$$= (50) + 450$$
$$= 400m$$

Horizontal distance of mid-Point lowest Point 'O' is "x_{mid}"
$$x_{mid} = AO + AC$$
$$= 50 + \frac{400}{2}$$
$$= 250\,m$$

Sag at Point 'C' $S_{mid} = \frac{w x_{mid}^2}{2T}$
$$S_{mid} = \frac{1 \times (250)^2}{2 \times 2000}$$
$$= 15.6\,m.$$

$$S_2 = \frac{w x_2^2}{2T} = \frac{1 \times (450)^2}{2 \times 2000} = 50.6\,m.$$

Height of Point 'B' above mid Point 'C'
$$S_2 - S_{mid} = 50.6 - 15.6 = 35\,m$$
∴ Clearance of mid Point 'C' above water level $= 90 - 35 = 55\,mt$

Problem-2

A conductor of weight 700Kg/m at a span of 200m the ultimate strength is 3000Kg. and the factor of safety is 2. Find the height of the the Pole for the minimum clearance of 10m.

Ans:-

Given data,

$\omega = 700 \, Kg/m$ safty factor = 2

(m.c) clearance = 10m ultimate strength = 3000kg.

$l = 200$

$H.P = m.c + S$

$S = \frac{\omega l^2}{8T}$

$\Rightarrow \omega = \frac{700}{1000} = 0.7 \, Kg/mt.$

we, know safty factor = $\frac{\text{ultimate Strength}}{\text{Tension(T)}}$

$T = \frac{US}{FS} = \frac{3000}{2} = 1500 \, Kg.$

$S = \frac{\omega l^2}{8T}$

$S = \frac{0.7 \, (200)^2}{8 \times 1500} = 2.33 \, mt.$

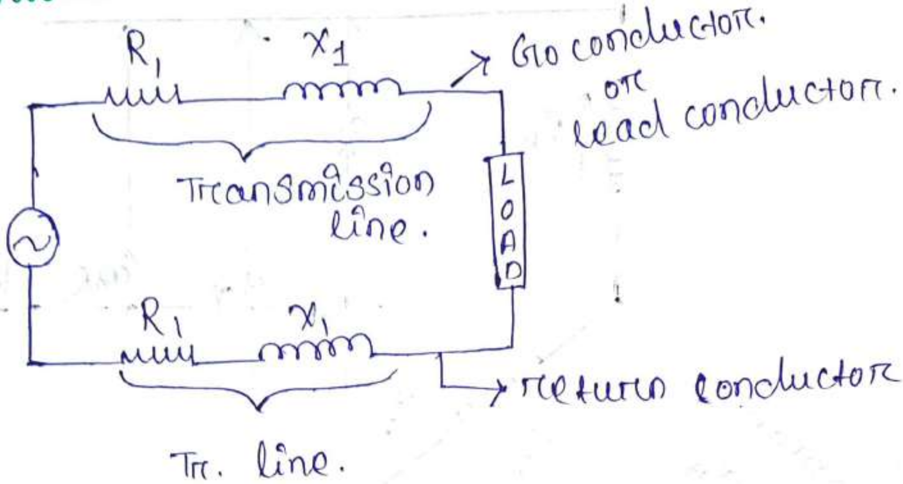
$H.P = 10 + 2.33 = 12.33 \, mt$

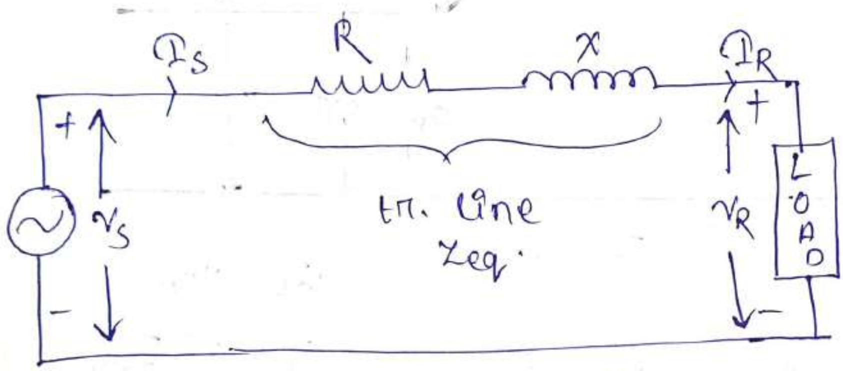
Problem-3

A conductor having span of 500m crossing river. If the effective height of the Pole are 30m. and 90m. the weight of conductor is 155 Kg/Km. If the tension of the conductor 1500kg. find the minimum clearance.

(Chapter-4): Performans of Short & medium lines :-

Performance of short transmission line :-





R = Loop resistance of tranmission line

$(R = R_1 + R_1 = 2R_1)$

x = Inductance $(x = x_1 + x_1 = 2x_1)$

We assume that there in no resistance and inductance in reteren conductor.

Here neglecting capacitance, $I_S = I_R$

V_S = sending end voltage.

V_R = Receiving end voltage.

I_S = sending end current

I_R = Receiving end current.

Here $Z_{eq} = R + jX$ (Z_{eq} = equivalent impendance)

we will write ABCD Parameters.

By appling KVL

$$-V_S + I_R Z + V_R = 0$$

$$V_S = I_R Z + V_R \text{ or } V_S = V_R + I_R Z \quad \text{——— (i)}$$

$$I_S = I_R \quad \text{——— (ii)}$$

(or) $I_S = 0 \cdot V_R + 1 \cdot I_R$

$$\begin{bmatrix} V_S \\ I_S \end{bmatrix}_{2\times 1} = \begin{bmatrix} 1 & Z \\ 0 & 1 \end{bmatrix}_{2\times 2} \begin{bmatrix} V_R \\ I_R \end{bmatrix}_{2\times 1}$$

$$[ABCD] = \begin{bmatrix} 1 & R+jX \\ 0 & 1 \end{bmatrix}$$

Eq (1)

$$V_S = V_R + I_R Z$$

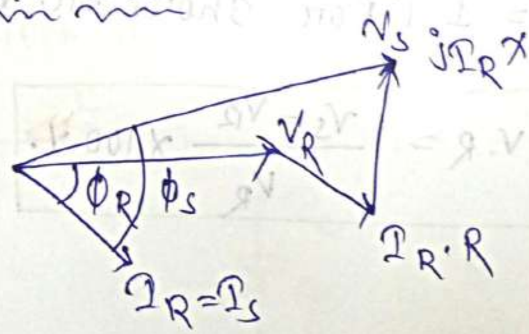
$$V_S = V_R + I_R (R + jX)$$

$$V_S = V_R + I_R R + jI_R X$$

Case 1 Laging P.F load

$\phi_S > \phi_R$

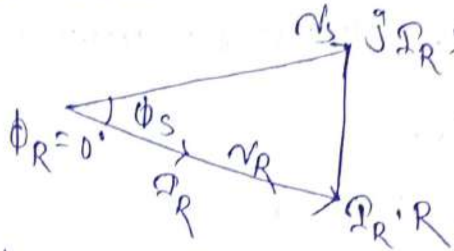
$\cos\phi_S < \cos\phi_R$



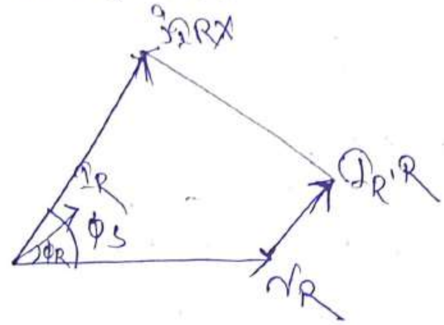
Case-2 : UPF load

$\phi_S > \phi_R$

$|V_S| > |V_R|$



Case-3 Leading P.F



$$\% \; V.R = \frac{V_{NL} - V_{FL}}{V_{FL}} \times 100\%$$

At NL , $I_R = 0$

$V_S = A V_R + B I_R$

$V_S = A V_R$

$V_R = \frac{V_S}{A}$ [no-load voltage]

$$\% \; V.R = \frac{V_S/A - V_R}{V_R} \times 100$$

A = 1 (for short tr. line)

$$\% \; V.R = \frac{V_S - V_R}{V_R} \times 100\%$$

for generalised load.

% V_R for lagging load:—

$$-V_s + I_R \cdot R + I_R\, j\omega L + V_R = 0$$

$$V_s = I_R \cdot R + I_R\, j\omega L + V_R$$

$$\%\ V.R = \frac{|I_R|}{|V_R|}(R\cos\phi + X_L \sin\phi) \times 100$$

% V_R for leading load:—

$$V_R = \frac{|I_R|}{|V_R|}\left[R\cos\phi \pm X_L \sin\phi\right]$$

(+) → Lagging load.

(−) → Leading load.

Performance of medium transmission line:—

⇒ R, L and C lumped model.

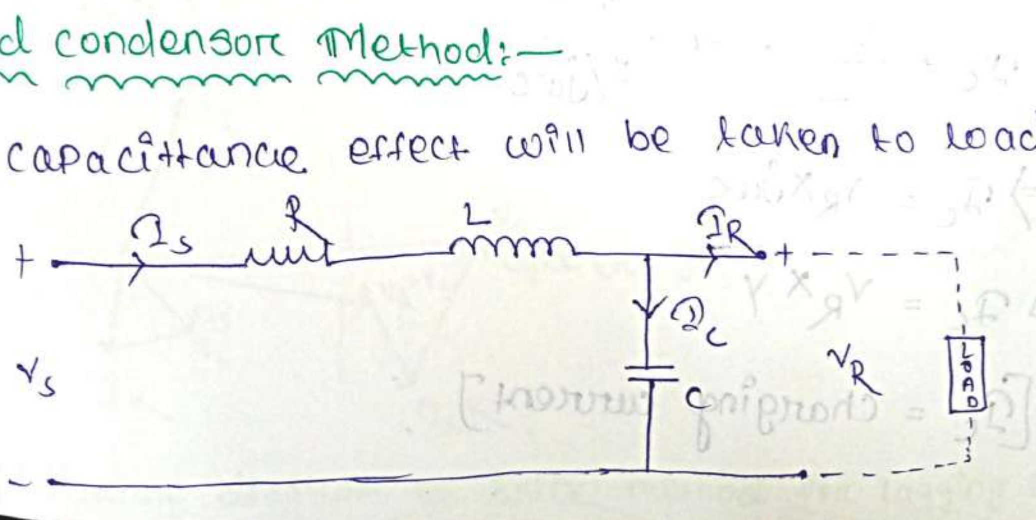
① End condensor method (Load condensor method)

② Nomital T method (middle condensor method)

③ Nominal π method (Split method)

① End condensor Method:—

⇒ capacitance effect will be taken to load side.



ABCD Parameter of any network:-

$$\begin{bmatrix} V_1 \\ I_1 \end{bmatrix} = \begin{bmatrix} A & B \\ C & D \end{bmatrix} \begin{bmatrix} V_2 \\ I_2 \end{bmatrix}$$

$V_1 = AV_2 + BI_2$

$I_1 = CV_2 + DI_2$

Here for the above circuit:-

$$\begin{bmatrix} V_S \\ I_S \end{bmatrix} = \begin{bmatrix} A & B \\ C & D \end{bmatrix} \begin{bmatrix} V_R \\ I_R \end{bmatrix}$$

$V_S = AV_R + BI_R$

$I_S = CV_R + DI_R$

Impendance of capacitance:-

$Z = \frac{1}{j\omega C} = \frac{-j}{\omega C}$ (or) $Y = j\omega C$ ($\because Y$ = admittance)

$I_C = \frac{V_R}{Z}$, $I_C = \frac{V_R}{1/j\omega C}$

$\Rightarrow I_C = V_R \times j\omega C$

$\Rightarrow I_C = V_R \times Y$

[I_C = Charging current]

where there in no-load connected:—

I_R will be 0.

$\Rightarrow I_R = 0$, $I_c = I_s$

$V_s = A V_R$, $I_s = C V_R$ } $V_R = \frac{V_s}{A}$

$I_c = C V_R$ ($\because I_c = I_s$)

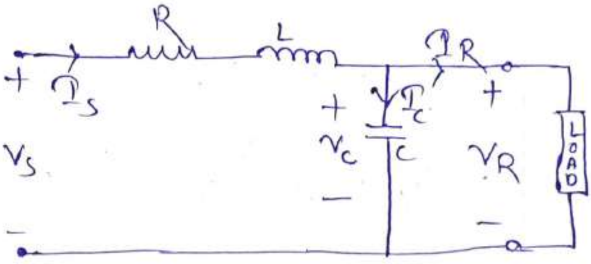
$\Rightarrow \boxed{I_C = C \frac{V_s}{A}}$ (open circuit charging current or capacitor current)

when load will connected:-

① **At lagging load:-**

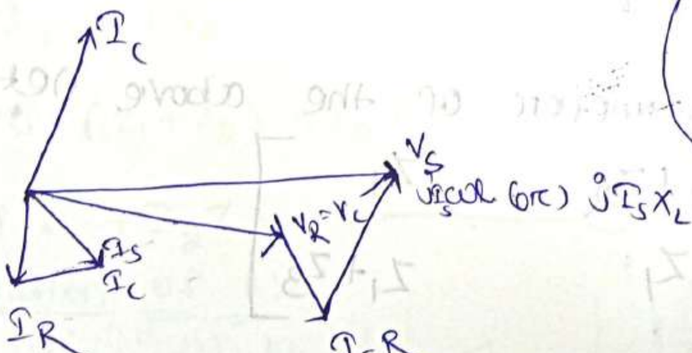
$I_s = I_c + I_R$

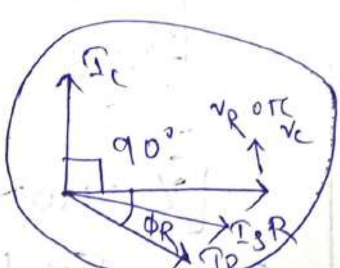
Here voltage across capacitor is V_c ; which is ($V_c = V_R$)



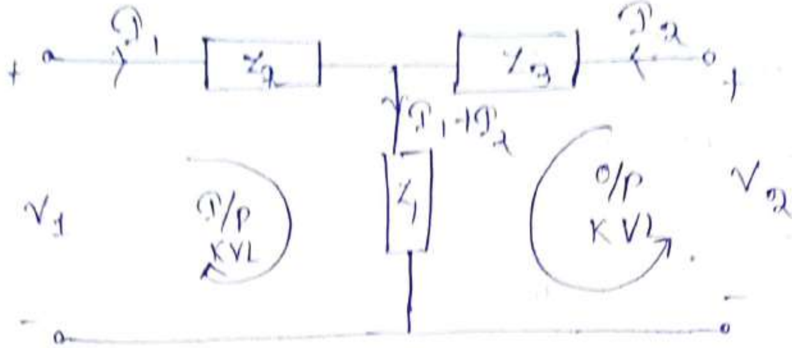
$V_s = I_s(R + j\omega L) + V_R$ (applying KVL)

$V_s = I_s R + j I_s j\omega L + V_R$





[Phasor diagram of END C method for lagging load] lets consider a network.



$$-V_1 + I_2 Z_2 + (I_1 + I_2) Z_1 = 0$$

$$\Rightarrow V_1 = I_2 Z_2 + I_1 Z_1 + I_2 Z_1$$

$$\Rightarrow V_1 = I_1 (Z_1 + Z_2) + I_2 Z_1 \quad \text{——— (1)}$$

$$-V_2 + I_2 Z_3 + (I_1 + I_2) Z_1 = 0$$

$$\Rightarrow V_2 = I_2 Z_3 + I_1 Z_1 + I_2 Z_2$$

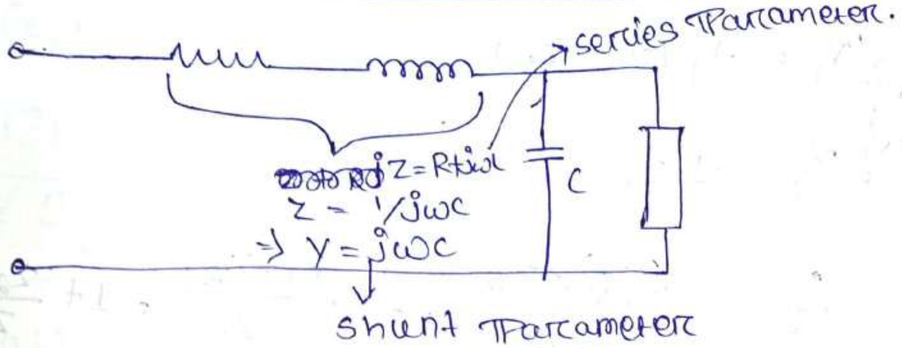
$$\Rightarrow V_2 = I_2 (Z_2 + Z_3) + I_1 Z_1 \quad \text{——— (2)}$$

equ^n (1) and (2) in matrix form

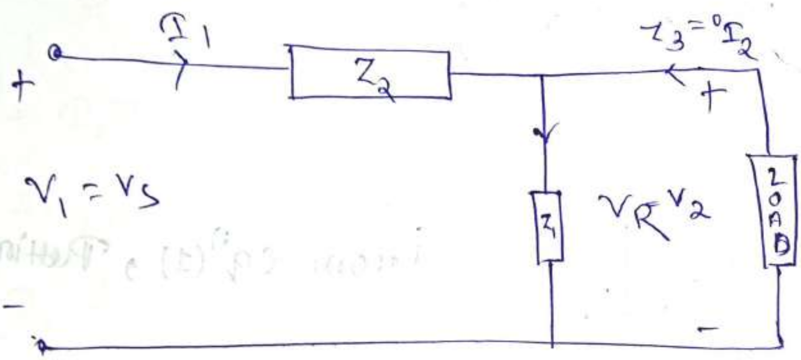
$$\begin{bmatrix} V_1 \\ V_2 \end{bmatrix} = \begin{bmatrix} Z_1 + Z_2 & Z_1 \\ Z_1 & Z_1 + Z_3 \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \end{bmatrix}$$

[Z Parameter of the above network]

$$[Z] = \begin{bmatrix} Z_1 + Z_2 & Z_1 \\ Z_1 & Z_1 + Z_3 \end{bmatrix}$$



converting thin ckt to Z-network.



Here $Z_3 = 0$

Matrix

$$Z = \begin{bmatrix} Z_1 + Z_2 & Z_1 \\ Z_1 & Z_1 \end{bmatrix}$$

now ABCD parameter of network

$$V_1 = AV_2 - BI_2 \quad \text{——— (1)}$$

$$I_1 = CV_2 - DI_2 \quad \text{——— (2)}$$

$$V_1 = I_1 (Z_1 + Z_2) + I_2 Z_1 \quad \text{——— (3)}$$

$$V_2 = I_1 Z_1 + I_2 Z_1 \quad \text{——— (4)}$$

Calculation of A:-

$$A = \left. \frac{V_1}{V_2} \right|_{I_2 = 0} \quad [\text{From equ}^n \ 1, \text{ Putting } I_2 = 0]$$

when $I_2 = 0$ $\begin{cases} V_1 = I_1 (Z_1 + Z_2) \\ V_2 = I_1 Z_1 \end{cases}$

$$\frac{V_1}{V_2} = \frac{\cancel{I_1}(Z_1+Z_2)}{\cancel{I_1} Z_1} = \frac{Z_1+Z_2}{Z_1} = 1 + \frac{Z_2}{Z_1}$$

$$\boxed{A = \frac{V_1}{V_2} = 1 + \frac{Z_2}{Z_1}}$$

Calculation of B :-

$$B = \left. \frac{-V_1}{I_2} \right|_{V_2 = 0}$$ [From eqn (1), Putting $V_2 = 0$]

$\Rightarrow 0 = I_1 Z_1 + I_2 Z_1$

$\Rightarrow -I_1 Z_1 = I_2 Z_1$

$\Rightarrow -I_1 = I_2$

$V_1 = I_1 (Z_1 + Z_2) + I_2 Z_1$

$V_1 = -\cancel{I_2} Z_1 - I_2 Z_2 + \cancel{I_2} Z_1$

$\Rightarrow V_1 = -I_2 Z_2$

$$\Rightarrow \boxed{Z_2 = \frac{-V_1}{I_2} = B}$$

Calculation of C :-

$$C = \left. \frac{I_1}{V_2} \right|_{I_2 = 0}$$ [From equn (2) Putting $I_2 = 0$]

$$V_1 = I_1(Z_1 + Z_2)$$

$$V_2 = I_1 Z_1$$

$$\boxed{\frac{1}{Z_1} = \frac{I_1}{V_2} = C}$$

Calculation of D:-

$$D = \left.\frac{-I_1}{I_2}\right|_{V_2=0}$$

$$0 = I_1 Z_1 + I_2 Z_1$$

$$\Rightarrow -I_1 Z_1 = I_2 Z_1$$

$$\Rightarrow -I_1 = I_2 \Longrightarrow \boxed{\frac{-I_1}{I_2} = 1 = D}$$

So, $[ABCD] = \begin{bmatrix} 1 + \frac{Z_2}{Z_1} & Z_2 \\ 1/Z_1 & 1 \end{bmatrix}$

$$\begin{bmatrix} V_1 \\ I_1 \end{bmatrix} = \begin{bmatrix} 1 + Z_2/Z_1 & Z_2 \\ 1/Z_1 & 1 \end{bmatrix} \begin{bmatrix} V_2 \\ -I_2 \end{bmatrix}$$

now for tr. line:-

$$\begin{bmatrix} V_S \\ I_S \end{bmatrix} = \begin{bmatrix} (1+Z)Y & Z \\ Y & 1 \end{bmatrix} \begin{bmatrix} V_R \\ R \end{bmatrix}$$

$A \neq D$

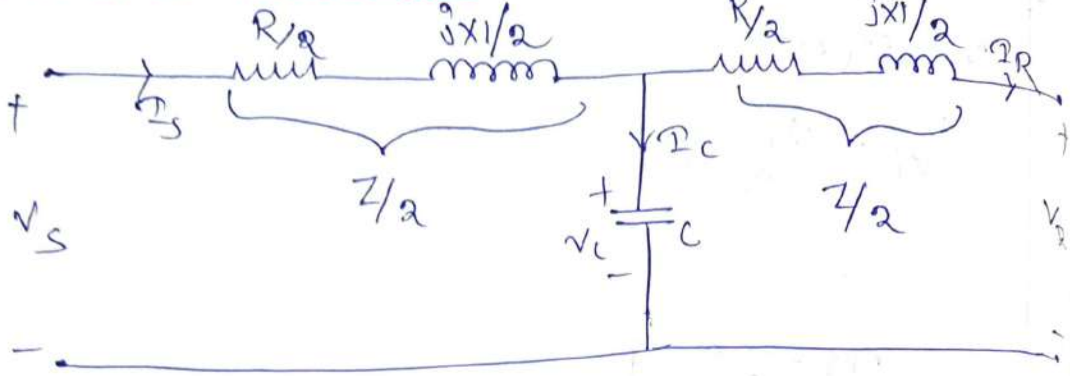
not symmetrical.

$\left[1 + \frac{Z_2}{Z_1} = 1 + Z_2 \cdot \frac{1}{Z_1} \right.$

and we know

$\left. \frac{1}{Z_1} = Y \right]$

(2) Nominal T-method:-



(Here capacitance taken into middle by breaking impendance in two halfs)

Total Resistive freee $= \frac{I_S R}{2} + \frac{I_R R}{2}$

" Reactive " $= \frac{jI_S X_L}{2} + \frac{jI_R X_L}{2}$

" Impendance " $= I_S \frac{Z}{2} + I_R Z/2$

here, $V_C \neq V_R \neq V_S$

$V_C = V_S - I_S R/2 - \frac{jX_L I_S}{2}$ (By appling KVL)

$-V_R = -V_C + I_R \frac{R}{2} + I_R \frac{jX_L}{2}$

$V_C = V_R + I_R \frac{R}{2} + I_R \frac{jX_L}{2}$

$V_S = V_C + I_S R/2 + I_S \frac{jX_L}{2}$

$[ABCD] = \begin{bmatrix} 1+ZY & Z \\ Y & 1 \end{bmatrix}$ (Generalized)

$$[ABCD] = \begin{bmatrix} 1 & Z/2 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 \\ Y & 1 \end{bmatrix} \begin{bmatrix} 1 & Z/2 \\ 0 & 1 \end{bmatrix}$$

$$= \begin{bmatrix} 1 + \frac{ZY}{2} & Z/2 \\ Y & 1 \end{bmatrix} \begin{bmatrix} 1 & Z/2 \\ 0 & 1 \end{bmatrix}$$

$$[ABCD] = \begin{bmatrix} 1 + \frac{XY}{2} & \left[1 + \frac{ZY}{2}\right]\frac{Z}{2} + Z/2 \\ Y & \frac{1 + ZY}{2} \end{bmatrix}$$

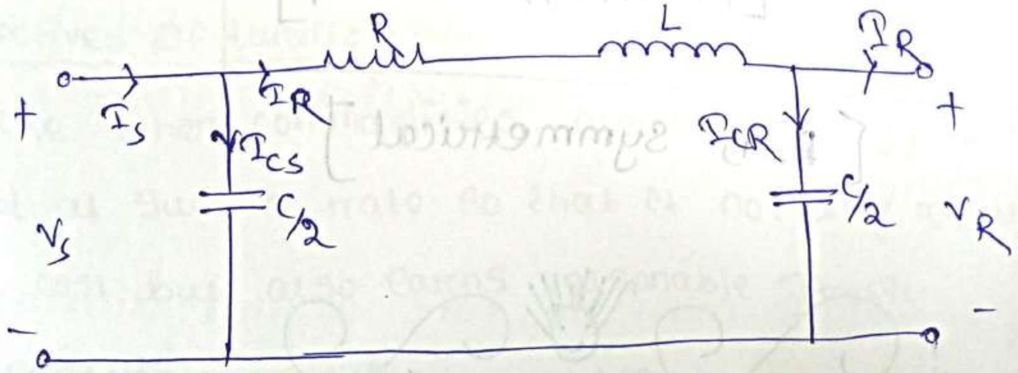
$$Z\left[\left(1 + \frac{ZY}{2}\right) \cdot \frac{1}{Z} + \frac{1}{Z}\right]$$

$$Z\left[\frac{1}{Z} + \frac{ZY}{4} + \frac{1}{Z}\right] = Z\left(1 + \frac{ZY}{4}\right)$$

$$[ABCD] \quad \begin{matrix} 1 + \frac{ZY}{2} & Z\left[1 + \frac{ZY}{4}\right] \\ Y & 1 + \frac{ZY}{2} \end{matrix}$$

here $A = D$ [Symmetrical]

Nominal π Method:-



[here capacitor devided]

$$I_S = I_{CS} + I_{TL}$$

$$I_{TL} = I_{CR} + I_R$$

$$-V_S + I_{TL} R + I_{TL} jX_L + V_R = 0$$

$$\Rightarrow V_S = V_R + I_{TL} R + I_{TL} jX_L$$

$$[ABCD] = \begin{bmatrix} 1+ZY & Z \\ Y & 1 \end{bmatrix} \text{ (generalized)}$$

Here $Z = \frac{1}{j\omega C/2}$, $Y = 2/j\omega C$

$$[ABCD] = \begin{bmatrix} 1 & 0 \\ Y & 1 \end{bmatrix} \begin{bmatrix} 1 & Z \\ 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 \\ Y & 1 \end{bmatrix}$$

$$[ABCD] = \begin{bmatrix} 1 & Z \\ Y & 1+YZ \end{bmatrix} \begin{bmatrix} 1 & 0 \\ Y & 1 \end{bmatrix}$$

$$[ABCD] = \begin{bmatrix} 1+ZY & Z \\ Y+Y(1+ZY) & 1+ZY \end{bmatrix}$$

[A = D symmetrical]

(Chapter-5) :- EHV Transmission :-

6. Extra High voltage:-

→ Extra high voltage cables require the power network to go underground due to continuous increase of energy demand, larger transmission capacity, reliability of energy supply and safety.

→ Lutech engineering offers electrification soln covering extra high voltage cabling works.

→ EHV transmission utilize increasingly higher voltages for the transmission of electric power from 'high voltage' transmission at 100, 138, 161 and 230KV to "extra high voltage" transmission at 345, 400, 500, and 765KV.

→ The higher the voltage, the lower the losses. In addition, by being able to move more power across one line, fewer overall lines are needed for transmission.

. The reasons for adopting of EHV/UHV range for transmission purposes are given below:

1. Reduction of electrical losses, increase in transmission efficiency, improvement of voltage regulation and reduction in conductor material requirement.

2. Line losses are reduced since line losses are inversely proportional to the transmission voltage, EHV transmission efficiency increases because of reduction in line losses.

3. Generating stations (steam, hydro and nuclear power stations) are located in remote areas (far away from load centers) because the reasons of economy, feasibility and from the point of view of safety and environmental conditions.

4. The cost of transmission line and terminal equipment also increases with the increase in the transmission voltage but in general these costs are proportional to the transmission voltage rather than the square of the transmission voltage.

Limitations:—

1. Current carrying capacity:—

The loading of overhead line conductors does not depend on the thermal considerations. However, for overhead transmission lines operating at voltage up to 220 kV.

2. Ferranti Effect:—

The capacitive load on the line the reciering end voltage is higher than the sending end voltage.

3. Surge impendance loading:—

Surge impendance loading (SIL) of a transmission line is defined as the load at the receiving end which is transmitted through one end and and also called natural load.

4. Mechanical vibration and oscillations:—

The electrostatic and electromagnetic fields produced by EHV/UHV transmission lines induce currents and voltages.

5. Audible Noise:—

EHV transmission lines and substation also produce audible noise.

- Corona loss and radio interference.
- Heavy supporting structures and errections difficulties.
- Insulation Requirements.
- Suitability considerations.
- Ferranti effect.

• Environmental and biological aspects.

Heavy supporting structures and erection difficulties

• E.H.V lines carry large mechanical loadings on towers due to bundle conductors.

• With increase in the voltage of transmission, more ~~distance~~ ~~is~~ clearance is required between conductors and ground. Hence higher tower are with increase in the voltage transmission, more distance is required betⁿ the conductors. Therefore cross arms should be long.

• For the erection of E.H.V lines, Problems of transportation and erection aries as the supporting structures are to be transported over long distances, moreover a high standard workmanship is required.

Insulation Requirement:-

• The required line insulation level depends upon the magnitude of likely voltage surges which are caused due to internal causes (switching operations) or due to external causes (atmospheric disturbance like lightning)

- Switching surges, especially those due to arc restriking in circuit breakers are dangerous as they may cause over voltage of 24 times the normal operating voltage.

Ferranti Effect :-

- It is a known fact that when a line is lightly loaded, its receiving end voltage exceeds the sending end voltage.
- Furthermore, whenever the load on the generator is thrown off suddenly, there is a rise in the receiving end voltage. care needs to be taken from these aspects in case E.H.V AC. transmission system.

Environmental and biological aspects :-

→ The recent researches in this field show that E.H.V and U.H.V lines generate electrostatic and electromagnetic fields. These fields can induce current and voltage in animals, human beings and birds. However, fortunately these effects are minimum and within tolerate limits.

→ In E.H.V range, transmission lines also produce audible noise in line conductor, however, these noise do not exceed the satisfactory noise level up to 500KV.

→ The term HVDC refers as high voltage direct current system.

→ HVDC is used to transfer bulk Power over long distance. because it is less expensive and low loss for long transmission.

→ To transmit dc Power first AC Power is converted into dc. by rectifier at sending end and again DC Power is converted in AC Power by inverter at receiving end.

Due following advantages of HVDC over HVAC it is more suitable for transmission of bulk Power:-

1. Corona loss are less in DC system compair to AC System.
2. There is no effect of line inductor and capacitor in DC system.
3. Saving of copper material as there is 2 wire System is used in DC compared to 3 wire AC System.

4. There is no skin effect in DC system so loss due to skin effect are reduced.

5. As there is no charging capacitance in DC system no Ferranti effect in DC system.

6. As bulk power can be transmitted by HVDC system it improves system stability.

7. There is no reactive power. So transmission losses are reduced.

8. In case of faults, power levels on HVDC system can be controlled electronically.

9. HVDC has minimum audible noise as well as minimum radio TV interference.

HVDC system has following disadvantage:-

1. DC voltage can not be step up and stepdown by transformer so inverter and rectifiers are needed at sending and receiving end, which is costly.

2. Converters control is quite complex.

3. Additional filters are required at various stages of HVDC transmission system. So its lead to high installation cost.

Limitations of HVDC:-

1. Since DC (Direct current) current has no natural zero, its difficult to quench arc during current interruption.

2. Since DC has no frequency, inductance = 2xPix0xL So during some faults there is no reactance to limit fault current. only resistance is there in such case to limit fault current.

3. For transmission distance lesser that breakeven distance (around 500-800 Km) HVDC is non-economical.