UNIT-1

THERMAL POWER STATION

Generating station :- [place at which we are producing huge amount of electricity]

Definition :-
Bulk electric power is produced by special plants known as generating station (or) power plants

Depending upon the form of energy converted into electrical energy the generating stations are classified as

* Steam power station
* Nuclear power station
* hydral electric power station
* Diesel power station

Steam power station :- A generating station which converts heat energy of coal combustion into electrical energy is known as steam power station

Advantages of SPS :-
* The fuel used is cheap
* less initial cost as compared to other generating stations
* It can be installed at any place irrespective of the existence of coal. The coal can be transported to the site of the plant by road (or) railways
* It requires less space as compared to hydro electric power station.
* The cost of generation is lesser than that of diesel power station

Disadvantages of SPS :-
* It pollutes the atmosphere due to the production of large amount of smoke and fumes
* It is costlier in running cost as compared to hydro electric power plant
* Maintainence cost is high
* Requirement of water is huge quantity
* handling of coal & disposal of ash is quite

selection of site for SPS :-

* The following points should be considered while selecting a site for a steam power station [SPS]

i. Supply of fuel :-

The steam power station should be located near the coal mines so that transportation cost of fuel, is minimum. However if such a plant is to be installed at a place where coal is not available then care should be taken that adequate facilities exist for the transportation of coal

ii. Availability of water :- A huge amount of water is required for the condenser therefore such a plant should be located at the bank of the river or head a canal to ensure the continous supply of water.

iii. Transportation facilities :- A modern steam power station requires transportation of material and machinery therefore plant should be well connected to other parts of the country by road (or) railways etc

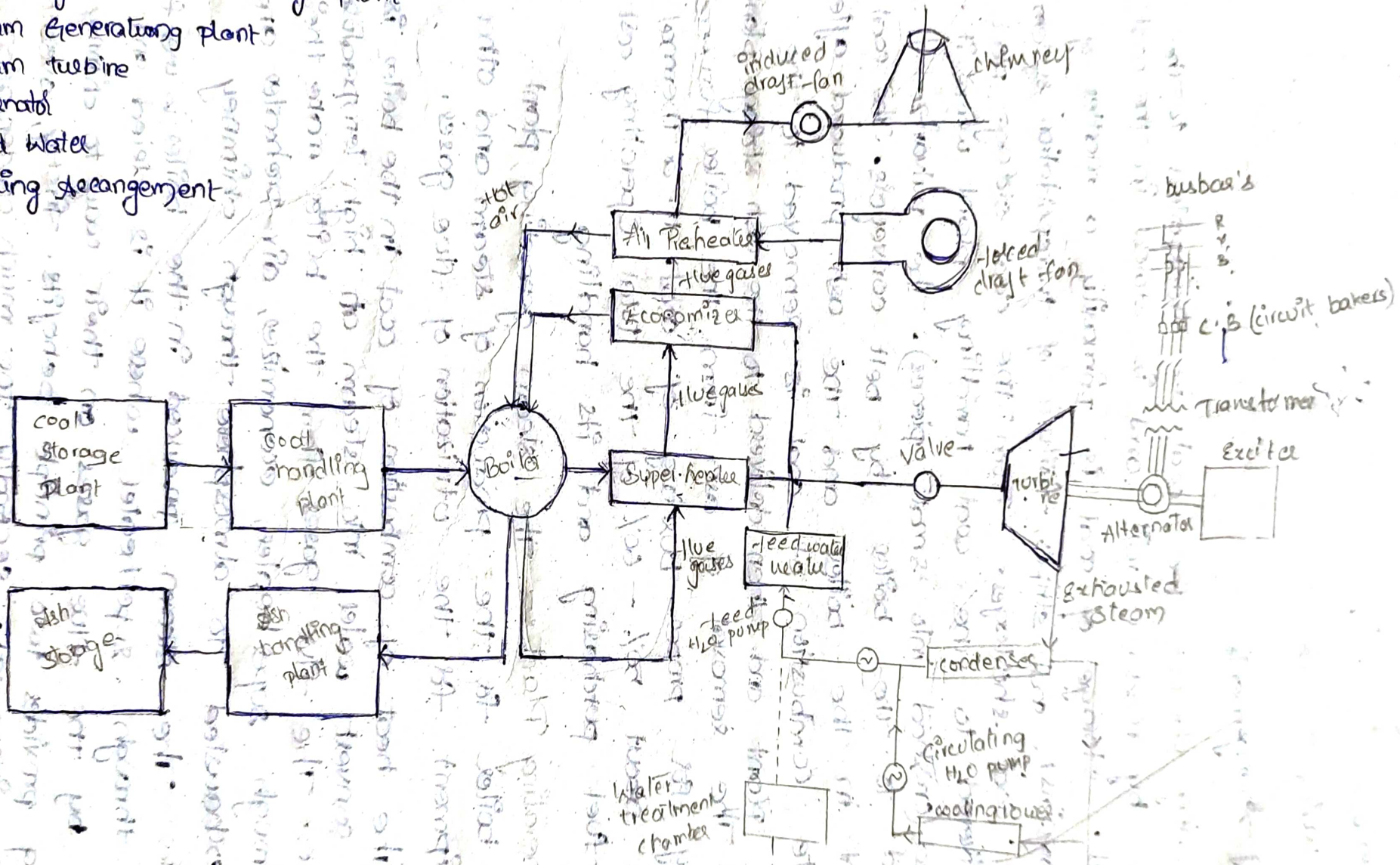
iv. cost and type of plant The steam power station should be located at a place where land is cheap and further extension if necessary is possible. The bearing capacity of the ground should be adequate. so that heavy equipment should be installed.

v. Nearness to load centres :- In order to reduce the transmission cost, the plant should be located near the centre of the load.

vi. Distance from populated Area :- As huge amount of coal is burnt in a steam power station. Therefore smoke & fumes pollute the surrounding area. Due to this the plant should be located at a considerable distance from the populated areas

1. coal storage & coal handling plant
2. Steam Generating plant
3. Steam turbine
4. Alternator
5. feed water
6. Cooling Arrangement

Schematic Arrangement of Steam Power Station



- It is worked on the basis of Rankine Cycle / Vapour power cycle

whole arrangement of steam power station can be divided into following stages for the sake of simplicity

i) coal & ash handling plants
ii) Steam generating plant
iii) Steam Turbine
iv) Alternator
v) feed water
vi) Cooling Arrangements

Coal & Ash handling plants:- The coal is transported to the power station by road (or) rail and is stored in the coal storage plant. storage of coal is primarily a matter of protection against coal stripes, failure of transportation system and general coal shortages. From the coal storage plant coal is delivered to the coal handling plant where it is pulverised (crushed into small pieces). The pulverized coal is fed to the boiler by belt conveyors. The coal is burnt in the boiler and the ash produced after the complete combustion of coal is removed to the ash handling plant and then delivered to the ash storage plant for disposal. The removal of ash from the boiler furnace is necessary for proper burning of coal. In a thermal power station about 50% - 60% of the total Operating cost consists of fuel purchasing and its handling

ii) Steam Generating Plant:- the steam generating plant consists of boiler for the production of steam and other auxilary equipment for the utilization of flue gases.

a) Boiler:- The heat of combustion of coal in the boiler is utilized to convert water into steam at high temperature and pressure. The flue gases from the boiler make their journey through superheater, economizer, air-preheater and are finally exhausted to atmosphere through chimney

b) Superheater:- The steam produced in the boiler is wet & is passed through superheater where it is dried and superheated by the flue gases on their way to chimney. Super heating provides two principle benefits. Firstly, overall effeciency is increased. secondly, too much condensation in the last stages of the turbine is avoided. The

superheated steam from the superheater is fed to steam turbine through main valve

c) Economizer :-

An economizer is essentially a feed water heater and derives heat from the flue gases for this purpose. The feed water is fed to the economizer before supplying to the boiler. The economizer extracts a part of heat of flue gases to increase the feed water temperature.

d) Air preheater :-

An Air pre-heater increases the temperature of the air supplied for coal burning by deriving heat from flue gases. Air is drawn from the atmosphere by a forced draft fan and is passed to air pre-heater before supplying to the boiler furnace. The air pre-heater extracts heat from flue gases and increase the temperature of air used for coal combustion. The principle benifits the pre-heating of air are increased thermal efficiency & increased steam capacity for square meter of boiler surface.

Steam turbine :-

The dry and superheated steam from the super heater 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. After giving heat energy to the turbine, the steam is exhausted to the condenser which condenses the exhausted steam by means of cold water circulation

Alternator :-

The steam turbine is coupled to alternator. The alternator converts mech. energy of turbines into elec. energy. The electrical output from the alternator is delivered to the busbars through transformers, circuit breakers and isolators

Feed water :- The condensate from the condenser is used as feed water for the boiler. Some water may be lost in cycle which is suitably made up from external source. The feed water on its way to the boiler is heated by water heater and economizer. This helps in raising the overall efficiency of the plant

Cooling Arrangement :- In order to improve the efficiency of the plant the steam exhausted from the turbine is condensed by means of a condenser. water is drawn from a natural

Efficiency of steam power station:-

thermal efficiency ($\eta_{thermal}$) = $\frac{\text{Heat equivalent of mech. energy Transmitted to turbine shaft}}{\text{Heat of combustion of coal}}$

thermal efficiency of steam power plant is 30%

Overall efficiency = $\frac{\text{heat equivalent of electrical output}}{\text{heat of combustion of coal}}$

the overall efficiency of steam of steam power station is about 2
It may be seen that the overall efficiency is less than Thermal efficiency is due to some losses occured in alternator
the following relation exists among the various efficiencies

Overall efficiency = thermal efficiency × electrical efficiency

Note:-

The overall efficiency steam power station is quite low due to mainly two reasons firstly a huge amount of heat is lost in the condenser & secondly heat losses occur at various stages of the plant

equipment of steam power station:-

The most important equipment of steam power station are

1. steam generating equipment
2. Condenser
3. Prime mover
4. Water treatment plant
5. Electrical equipment

i) steam generating equipment:- this is important part of steam power station. It is concerned with the generation of super-heated steam and includes different devices such as boiler, boiler furnace, superheater, economizer and air preheater

a) Boiler:- A boiler is a closed vessel in which water is converted into steam by utilizing the heat of coal combustion steam boilers are classified into following 2 types

1. water tube boiler 2. Fire tube boiler

1. In water tube boiler, water flows through the tubes & hot gases of combustion flow over these tubes. In case of fire tube boiler the hot products of combustion pass through the tubes surrounded by water. Water tube boilers have more advantages over fire tube boilers. They are require less space, smaller size of tubes & drum; high working pressure due to smaller drum; less liable to explosion. Therefore due to this advantages water tube boilers are commonly used in steam power station.

b) boiler furnace:- A boiler furnace is a chamber in which fuel is burnt to liberate the heat energy. In addition it provide support to the combustion equipment. The boiler furnace walls are made of refracting materials such as fire clay, silica, kaolin..etc. These materials have the property to resist change of shape, physical properties at high temperatures. There are 3 types of construction of furnace walls.

i) Plane refractory wall

ii) Hallow Refractory walls with an arrangement for air pulling

iii) Water walls

The plane refractory walls are suitable for small plants where the furnace temperature may not be high. However in large plants the furnace temperature is high consequently the refractory material may get damaged. In such cases

refractory walls are made hallow and air is circulated through hallow space to keep the temperature of furnace walls low. The recent development is to use water walls. These consists of plane tubes arranged side by side and on the inner face of the refractory walls. The tubes are connected to the upper & lower headers of the boiler. The boiler water is made to circulate through this tubes. The water walls absorb the radiant heat water in the furnace which would otherwise heat up the furnace walls

c) Superheater :- It is a device which superheats the steam. This increases the overall efficiency of the plant. A superheater consists of group of steel tubes. These tubes are heated by the heat of flue gases during their journey from the furnace to chimney. The steam produced in the boiler is applied to the superheater where it is superheated by the heat of flue gases. superheaters are classified into 2 types according to the system of heat transfer from the flue gases to steam.

i) radiant superheater
ii) Convection superheater

→ The radiant superheater is placed in the furnace between the waterwalls and receives heat from the burning fuel through radiation process. It has 2 disadvantages. Firstly, due to high furnace temperature it may get overheated and requires careful design. secondly, The temp of superheater fall with increase in steam output. Due to these limitations radiant superheater is not used.

→ A convection superheater is placed in the boiler tube bank and receives heat from flue gases entirly through convection process it has the advantage that the temperature of superheater increases with increase in steam output. For this reason, this type of super heater is commonly used

d) Economizer :- It is a device which heats the feed water and the way to boiler by deriving heat from the flue gases this results in raising boiler efficiency. and An economizer consists of large no: of closely spaced parallel steel tubes connected by headers of drums. The feedwater flows through this tubes and the flue gases flow outside. A part of the heat of flue gases is transfer to feed water, thus raising the temperature of water.

e) Air Preheater :- superheaters and economizer generally cannot fully extract the heat from flue gases. Therefore, preheaters are used which recover some of the heat in the escaping gases. the function of air preheater is to extract heat from the

flue gases and give it to the air being supplied to the furnace for coal combustion. This raises the furnace temperature and increases the thermal efficiency of the plant. Depending upon the method of transfer of heat from flue gases to air, air preheaters are divided into 2 types (i) Recuperative Type (ii) Regenerative type.

→ The recuperative type air pre-heater consists of group of steel tubes. The flue gases are passed through the tubes while the air flows externally to the tubes. Thus heat of flue gases is transfer to air.

→ The regenerative type air pre-heater consists of slowly moving drum made of corrugated metal plates. The flue gases flow continously on one side of the drum and air on the other side. This action permits the transference of heat of flue gases to the air being supplied to the furnace for coal combustion

Condensers:- A condenser which condenses the steam at the exhaust of turbine. It serve two important functions. Firstly, it creates very low pressure at the exhaust of the turbine, the permitting expansion of steam in the prime mover to a very low pressure. This helps in converting heat energy of steam into mechanical energy in the prime mover. Secondly, the condensed steam can be used as feed water to the boiler. There are two types of condensers.

1. Jet type condenser
2. Surface type condenser

* In the jet type condenser, cooling water and steam are mixed together and the stream of warm water, so produced is with drawn. Incase of surface type condenser, steam and cooling medium are seperated by metal surface, steam flowing on one side of the metal surface and the cooling medium on the other side. Jet type condensers are not used — steam mixes with cooling water and the condensate can't be used as feed water.

* Surface condensers are most commonly used in power plants.

Prime movers:- The prime movers convers steam energy into mech. energy. They are 2 types of steam prime movers They are (i) steam engines (ii) steam turbine.

* steam turbine has several advantages over steam engine as a prime mover high efficiency, simple construction high speed, less floor area requirement and low maintainace cost. Therefore all modern steam power stations used steam turbine as prime mover. There are 2 types of steam

turbines according to the action of steam on moving
i. Impulse turbine ii, Reaction turbine

* An impulse turbine, the steam expands completely in the stationary nozzles (fixed blades). The pressure over the moving blades remains constant. In doing that steam attains high velocity & force against the moving plates. This results in the impulsive force and the moving plates which sets the turbine rotating.

* In reaction turbine the steam is partially expanded in the stationary nozzles the remaining expansion takes place during its flow over the moving blades. The result is that the momentum of the steam causes a reaction of force on the moving blades which sets the turbine in motion.

4. Water treatment plant:-

Boilers requires water treatment plant They require clean & soft water for longer life and better efficiency. However, the source of boiler feedwater is generally river (or) lake which may contain suspended and dissolved impurities, dissolved gases..etc. Therefore it is very important that water is first purified and softened by chemical treatment and then delived to the boiler. Water from the source of supply is stored in storage tanks, the suspended impurities are removed through sedimentation, coagulation and filteration. Dissolved gases are removed by degasification and aeration. The water is then softened by removing temperoy and permanent hardness through different chemical processes. The pure and soft water, thus available is fed to the boiler for steam generation

5. Electrical Equipment:- The most important electrical equipment i, Alternator:- The alternator is coupled to a steam turbine and converts mech. energy of the turbine into elec. energy

ii, transformers:- A generating station has different types of transformers

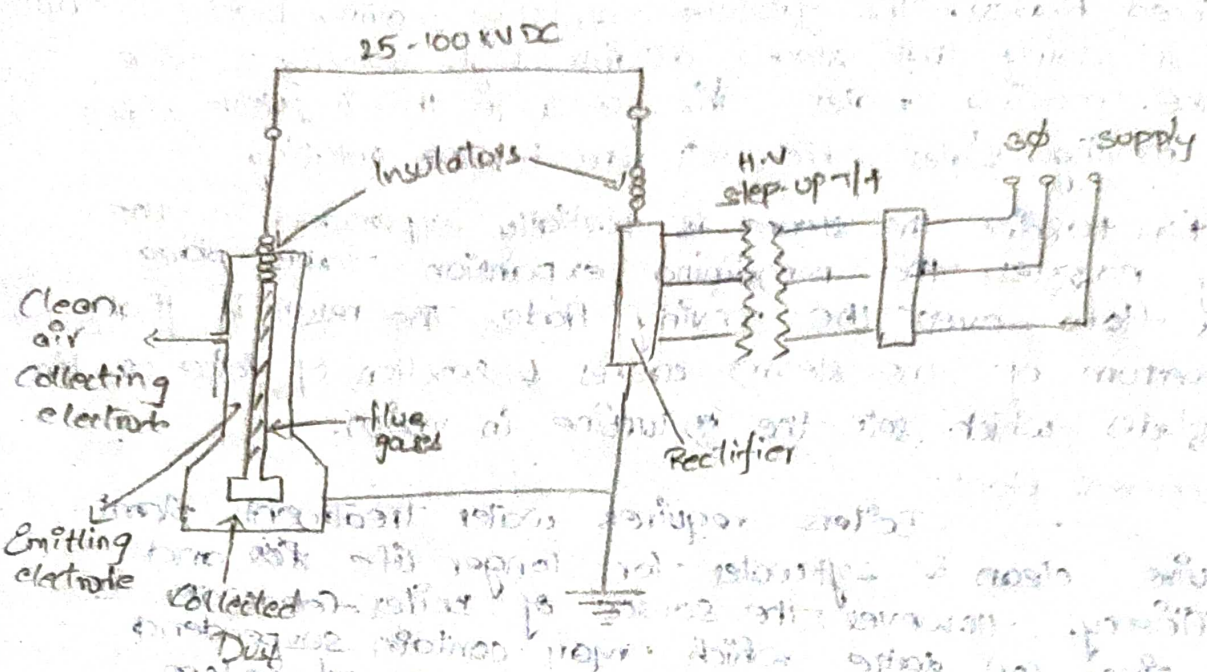
a) main step up transformers:- which stepup the generation voltage for transmission of power

b) station transformers:- which are used for general service (lightening)

c) Auxiliary transformers:- which supply to individual unit auxiliaries

iii) Switch gear:- It consists of such equipment which locates the fault on the system and isolate the faulty part from the healthy section. Contains circuit breakers, relays, switches and other control devices

Electrostatic precipitator :-



It essentially consists of two sets of electrodes which are completely insulated from each other and high voltage electro-static field is maintained across them. One set is called the emitting (or) discharge electrode, is in the form of thin wires and the other set is called the collecting electrode. The emitting electrodes are placed in the centre of a pipe in case of tubular type precipitator and are connected to negative polarity of high voltage D.C source. While the collecting electrodes are connected to the positive polarity of the source and are earthed. High electro static field thus set up between the 2 sets of electrodes create corona discharge and ionize the gas molecules as the flue gas flows through the tube (or) in between the plates. The dust particles in the gas acquire negative charge and are attracted to the electrodes connected to the +ve polarity (collecting electrodes) and get deposited there. The deposited dust is made to fall off the electrodes when rapped mechanically.

The electrostatic precipitator may be

i) plate (or) tubular type
ii) Horizontal flow (or) vertical flow type
iii) Dry (or) wet type

Advantages:-

→ It has the advantages of high efficiency, low pressure drop easy removal of collected particles and capacity of handling large volume of flue gases.

Limitations:-

High capital and Operating Cost & Require more space