UNIT - I

THERMAL POWER PLANT

(or)

STEAM POWER PLANT

The invention of steam engine for obtaining mechanical energy and electric generator Completely replaced the non Convertional (or) non renewable methods ie., Wind, tidal, geothermal.

The Size of the thermal plants grew from a few kw to more than 1000 MW as of today.

The thermal power plants uses Coal as fuel therefore for a 400MW Capacity plant requires about 5000 to 6000 tons of Coal every day.

SELECTION Of SITE:

To get maximum efficient power generation we need a perfect place to be selected so there are few important factors should be taken into Consideration.

Generally the plant having Capacity of 1000 Mw are called Super thermal power plant.

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POWER SYSTEM - I.

Power system is collection of equipments designed for desired purpose ie., supplying Uninterrupted and continous power supply to consumers according to their requirements

Thus power system is categorized into three parts i) Generation system.
ii) Transmission system.
iii) Distribution system.

Generation System of power system deals with the generation of electrical energy.

Electrical energy is most used form of energy because i) less costly i.e., electrical energy can be provided in economical way.
2) Transportation is very easy and comfortable.
3) flexibility is more in interconversion of almost 1H forms of energies into electrical form and Vice Versa.

Types of ~~Enger~~ Energies are generally of two types

i) Renewable energies → Eg: Solar, Wind, Hydro etc
ii) Non Renewable energies → Eg: Coal, petrol, nuclear etc

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-factors for the selection of site for thermal power plant are discussed below:

1) Supply of fuel:-

The power station should be located as close as possible to the coal mines. The other way is to find suitable location so that cost per unit of received energy is minimum taking both the transmission and transportation charges into account.

2) Ash Disposal facility:-

The ash content of coal should be as low as possible. Unfortunately, Indian coal has ash content of 20 to 40%. This creates problems of air pollution and non-effective operation of boiler if it is not removed regularly and effectively.

A large space should be available near the plant for ash disposal. Presently the ash from the plant is used for many industrial processes ie., cement factories. and therefore, its disposal to sea (or) river is not desired that even threatens the acquatic life.

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3) Availability of water :-

Huge quantities of water are required for condenser, for disposal of ash and as feed water to the boiler and drinking water for working staff. It is therefore desirable to locate the plant near the bank of river or canal so as to have continous supply of water.

Land Requirement :-

The average land requirement is 3 to 4 acres per MW capacity. As per economical point of view land selection should be done away from the heart of city. The selected site should have good bearing capacity so as to withstand the dead load of plant and forces transmitted to foundation due to plant Operation.

Transport facilities :-

If the plant is to be located away from the fuel centers here it is Coal mines, then rail and road transport facilities should be available.

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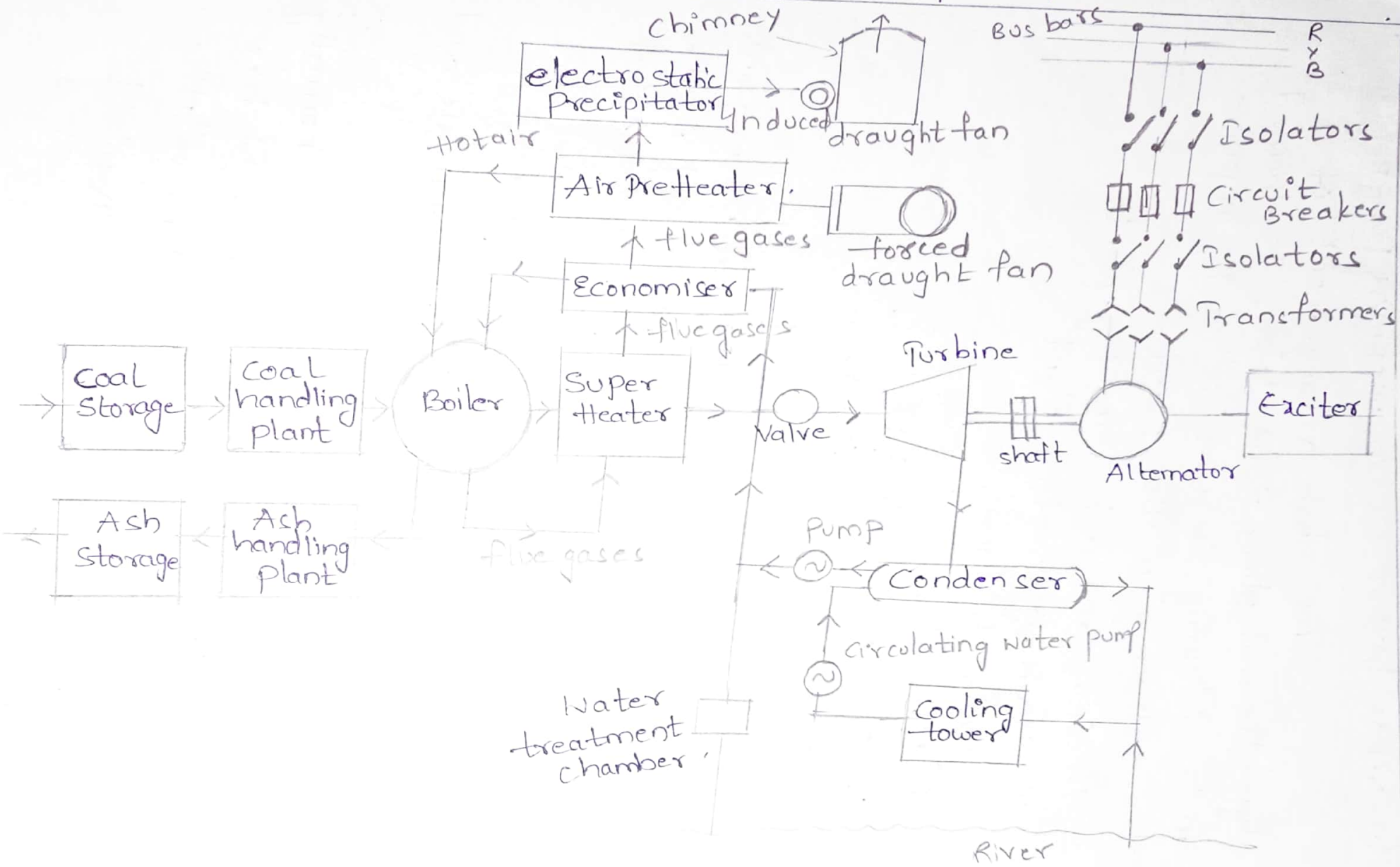
A TYPICAL LAYOUT OF THERMAL POWER PLANT.



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General Layout Of A Thermal Power Plant.

The whole arrangement of a thermal power plant layout is divided in to following Sections so as to improve the efficiency of the plant.

1) Coal and ash handling plant.
2) steam generating plant.
3) steam turbine.
4) Alternator.
5) feed water Circuit.
6) Cooling water Circuit.

Coal Handling plant:

Most of the thermal power plants use coal as fuel. Coal is classified in the following manner in increasing Order of heat value.

i) peat ii) Lignite iii) Bitominous
iv) Sub bitominous v) Semi bitominous and
vi) Anthracite.

Semi bitominous Coal is normally Used in thermal power stations. It has low percentage of moisture, ash, volatile matter and has percentage of available hydrogen.

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It is desired that the coal handling plant should be simple and units should be located centrally so that inspection and maintenance is easier.

Ash Handling plant:

In thermal power plant, ash has great nuisance value for designers of plant and residential areas around the plant.

In indian coal in average 20-40% of ash content is present. The ash contains poisonous gases like CO, CO_2 & SO_2. This high content of silica mixed with water produces corrosive acids which leads to corrosion of boiler material thus in turn reduces the boiler efficiency.

Thus removal of ash from the boiler regularly is necessary for proper burning of boiler and coal. So to run thermal power plants efficiently and economically with low grade of coal proper ash handling systems are suitably designed.

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The modern ash handling systems are classified into following groups.

i) Mechanical System :-

This system is normally used for low capacity power plants. In this method the ash falls on the belt conveyor and is carried continously to the dumping site.

ii) Hydraulic system :-

It is a popular method. due to its simplicity, clean & low cost operation. In this method some hydraulic machines are used in collection of ash and the dumped to site.

iii) Pneumatic system :- → (Used for small & large capacities)

Abrasive ash and fine dust can be very sucessful handled by system. The ash and dust from all discharge point is picked up by a high velocity air stream created by an exhauster at discharge end. & carried to point of delivery.

iv) Steam jet system:

In this method pressuried steam is passed through a pipe at sufficiently high velocity such that it is capable of carrying dry

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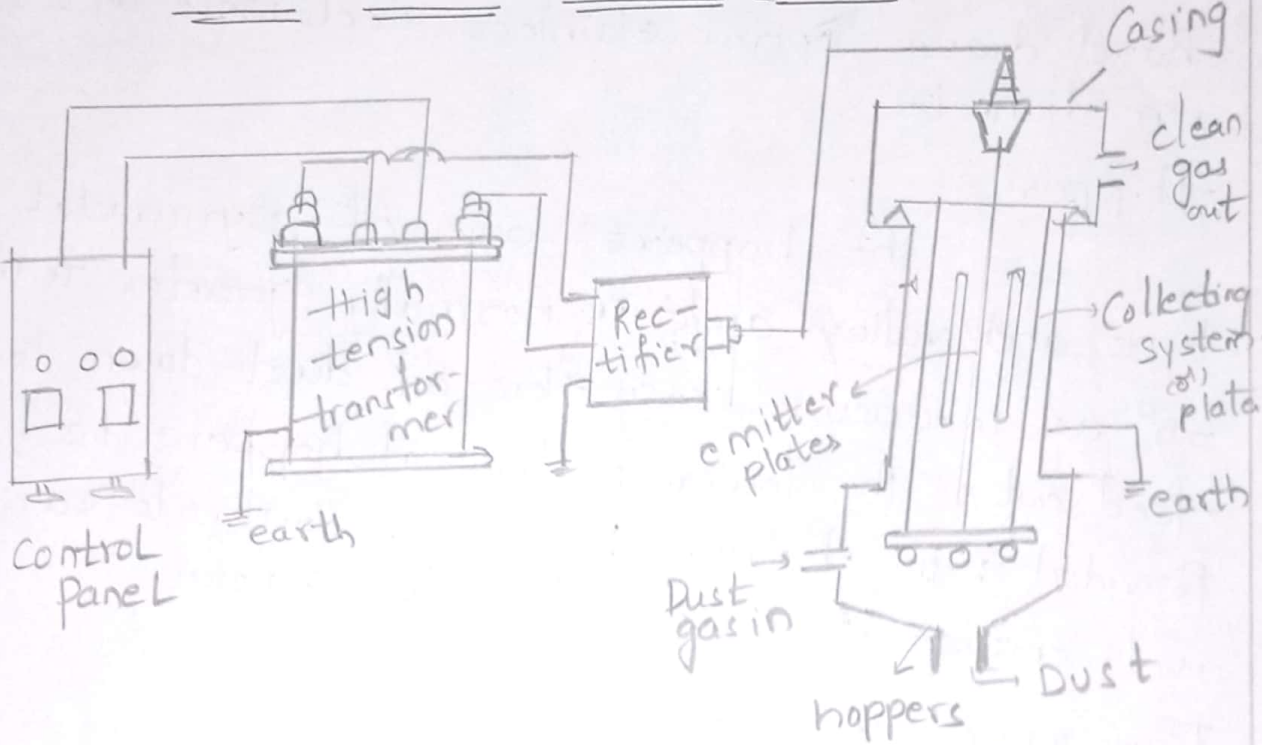
Solid particles of Considerable Size alongwith it. The pressure of steam is greater than that of the atmosphere. Space requirement is less. The operation of system is noisy.

ELECTROSTATIC PRECIPITATOR:



The main components of an electrostatic precipitator are.

Casing :- It is an all welded steel structure assembled from prefabricated wall and roof panels. The electrodes supported by Casing should be perfectly aligned so that gas temperature & pressure & also wind loading do not cause flexing of Casing.

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Collecting System :-

The upper edge of the collecting plates are provided with hooks hung from support angles welded to roof structure.

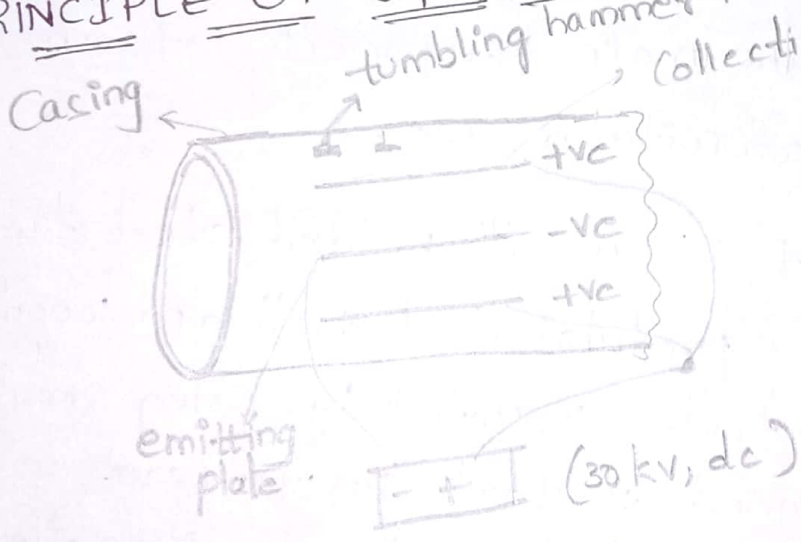
Emitting System :

The emitter electrode consists of hard drawn spiral stainless steel wire of 2.5 mm diameter.

Hopper :-

The hoppers are of pyramidal type and valley angle is normally greater than 55° as to ensure easy flow of dust down to feed out. The lower portion of hoppers is provided with electrical heaters & controls so as to ensure flow of ash into disposal.

PRINCIPLE Of OPERATION :-



Flue gases which comes out of boiler contains fly ash, CO & SO which contains hazardious gases that damages respiratory system.

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To control (or) handle fly ash electro static precipitator is used. The electro static precipitator is used for pollution control device.

As the voltage applied and spacing between electrodes are adjusted such that a strong electric field is created between the electrodes such that when gas carrying dust particles passed between oppositely charged conductors the gas gets ionised. Thus dust particles gets negatively charged and are attracted towards the positive charged plates. Thus the deposited dust particles are removed from the collecting plates by tumbling hammers and is collected in dust hoppers.

The electrostatic precipitator has following advantages are.

i) It can remove dust particles as small as 0.01μ in size.

ii) The operation is simple.

iii) The efficiency of the electro static precipitators is 99.5% to 99.9%.

The only disadvantage is that it is relatively costlier.

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Steam Generating plant :

The steam generating plant consists of a boiler for production of steam and other auxilliary equipments for utilization of flue gases so that the overall efficiency is increased.

BOILER :- A boiler is a device wherein water is converted into steam by utilizing the heat of combustion.

Steam boilers are broadly classified as fire tobe and water-tobe types.

FIRE TUBE :

The hot combustion gases pass through the tubes and tubes are sourrounding by water. In case of fire tube boilers since water and steam are held in drum, an increase in working pressure necessitates use of thicker plates sections and hence these boilers put a limitation on working pressure.

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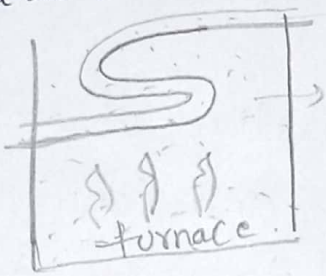
Water tube type:

In case of water tube boilers, the water flows through the tube and hot combustion gases flow over these tubes.

Water tube boilers are used universally for such plants.

The unique features of water tube boilers are

i) Method of water circulation.
ii) improved method of heating.
iii) less space requirement
iv) safer operation and better efficiency of plant.



SUPER HEATER:

A super heater is a device which raises the temperature of steam much over the boiling point of water., which results in higher efficiency of the plant.

A super heater made up of a group of tubes of special alloy steel such as chromium molybednum.

These tubes are heated by heat of flue gases, when they pass from the furnace to the chimney.

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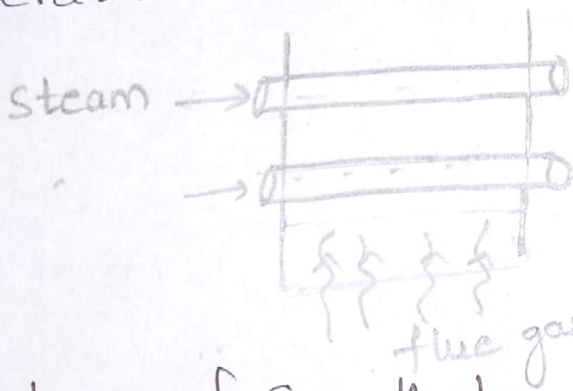
The classification is based on the method of heat transfer from flue gases to steam.

i) Radiant type ii) Convection type.

A Radiant Superheater is normally located in furnance between the furnance water walls and absorbs heat from the burning fuel through radiation.

A Convection Superheater uses heat in the flue gases to heat the saturated steam through a convective heat transfer process.

A Combination of two superheaters ie, the radiant type and Convection type in a steam plant is used to give constant superheat temperature at all loads.



Advantages of Superheater:

→ Without Superheater if the steam produces in boiler is feed to turbine then the moisture Content remained in steam may cause Corrosion to turbine blades hence if the

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steam is heated in super heater before it reaches turbine such that the moisture content is nullified then efficiency of turbine operation will be increased.

2) To increase the velocity of steam passing to turbine i.e., by increased temperature of steam the gas particles becomes light weighted hence velocity of particles are increased.

ECONOMISERS :-

An economiser heats the feed water on its way to boiler by utilising heat from the flue gases thus raising the boiler efficiency and economising on the fuel used ie., the amount of coal used for steam production is reduced as water is preheated in economiser.

This also reduces the stresses in the boiler.

An economiser consists of a large number of thin walled small diameter closely packed parallel tubes. the tubes are finned to increase surface area.

The water to be feed to boiler flows inside the tubes and flue gases flow outside the feed water should be pure so as to avoid scaling and internal corrosion.

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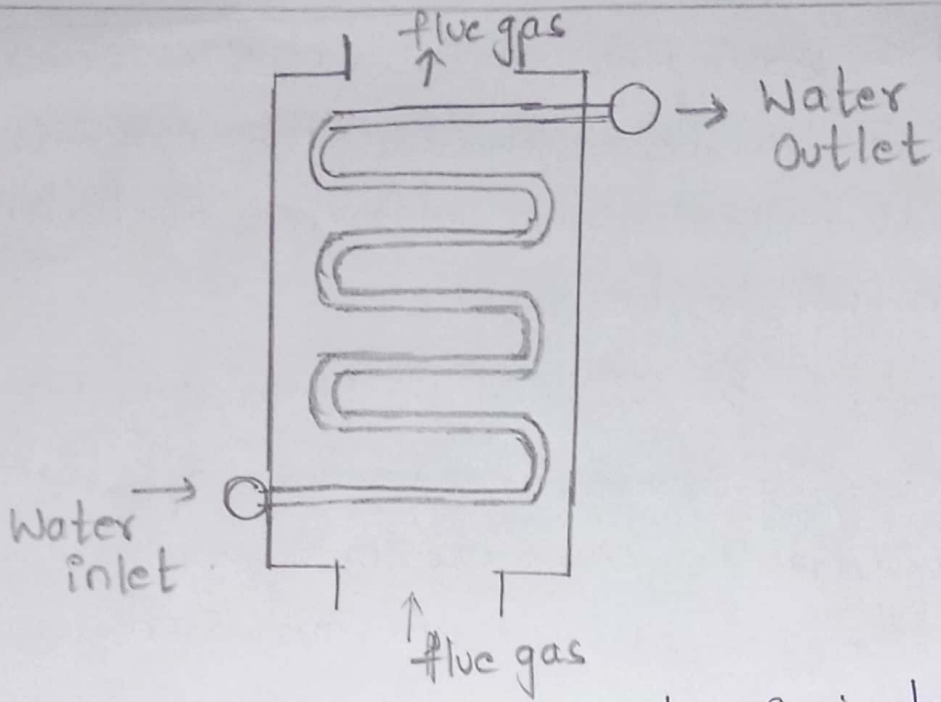

The economisers are expensive in installation and maintanance also hence economisers are used whenever the boiler pressure exceeds 70 kg/cm^2.

AIR PREHEATERS :-

The heat of flue gases cannot be extracted completely by superheater and economisers, the air preheaters are used to recover some of the heat escaping with these gases.

The air preheaters extract heat from the flue gases and give it to air being supplied to furnace for coal combustion. This results in higher furnace temperature and increased efficiency of plant.

The classification is based on method of transfer of heat from flue gases to air

i) Recuperative type.

ii) Regenerative type.

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Recuperative type has a group of steel tubes flue gases pass through the tube where as air flows external to tube, thus heat of flue gases is transfered to the air.

Regenerative type.

It Consists of slowly moving drum made of Corrugated metal plates. The flue gases passes continously on one side of drum and air on other side.

Regenerative type is often prefered due to its Compactness, reduced weight and high efficiency.

STEAM TURBINE:

Steam turbine is nothing but engine which converts steam energy into mechanical energy. there are basically two types of steam turbines.

i) Impulse turbine 2) Reaction turbine.

In both these turbines, at first the heat energy of steam, at high pressure, is converted into kinetic energy by passing steam through the nozzles.

In Impulse turbine, the steam Coming out, at a very high velocity through the fixed nozzles, impinges on blades, fixed on the periphery of rotor. The expansion of steam thus take place in nozzles.

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The blades changes the direction of steam flow without changing its pressure. The resulting motive force, due to change in momentum, gives the rotation to turbine shaft.

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

The Combination of one Impulse, two reaction type turbines are also used Called Compounding type turbines. in large Capacity power plants.

CONDENSER:

Power plants use Condensers to provide vaccum so that the expansion of steam in turbine takes place to a very low pressure. This improves the power plant efficiency.

The condensed steam in the Condenser can be recovered for use as feed water to the boiler, thereby reducing the water softening plant load to a Considerable extent. The two types of Condensers.

i) Jet type ii) Surface type.

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Jet type Condensers:

In this type, cooling water and steam are mixed together and the stream of warm water, so produced is withdrawn.

Surface type Condensers:-

In this type, steam and cooling medium are seperated by metal surface, steam flowing on one side of metal surface and cooling medium on the other.

Surface condensers are most commonly used in power plants.

Alternators:-

The generators coupled directly to the steam turbines are called turbo alternators and those coupled to water turbines are known as water wheel alternators.

All high capacity machines are 2 pole and hence for supply of 50 Hz, their speed is 3000 rpm. The rotors of alternators may be cylindrical (or) salient pole type.

The turbo alternators have cylindrical rotors, smaller in diameter and longer in length, as compared to salient pole machines which are used for slow speed operation. the air gap of turbo-alternator is longer as compared to salient pole

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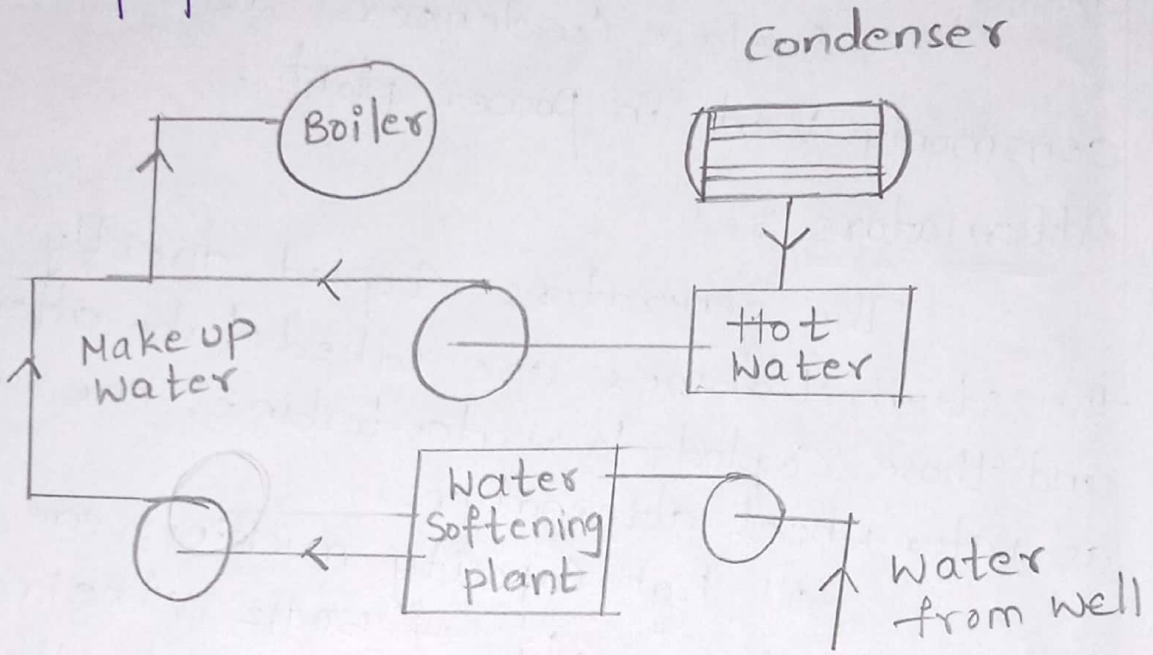
FEED WATER CIRCUIT:

The condensate from condenser is used as feed water into boiler. Some water is lost throughout the cycle from blow down leaks etc. The loss varies from 1 to 3% during normal operation and 5% during start up period.



A 400 MW plant requires 100 to 150 tons of water per hour as make up water. A seperate water softening plant is required to supply this water from river, a well or a lake. The water supplied by water softening plant is of very high quality The impurities causes corrosion and erosion of boiler tubes, turbine blades, condenser

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tobes and blockage in boiler tobes resulting tobe failure due to overheating.

COOLING WATER CIRCUIT:

The water used for cooling the exhaust steam in condenser into condensate is circulated from lake (or) river, by means of circulating water pumps and is returned back into source.

If sufficient quantity of water is not available, it should be cooled and used again.

It is then pumped into condenser where it absorbs latent heat from exhaust steam becomes hot and hot water is pasced to cooling tower.

A cooling tower is structure usually made of concrete. Corrugated surfaces, troughs (or) baffle are provided inside tower for uniform distribution of water in tower.

The hot water from condenser is fed to tower from top and allowed to tickle in smaller quantities. practically of size of drops.

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for large capacity power plants, Cooling towers are classified as.

1) INDUCED DRAFT COOLING TOWER.

In this case, the fan is located at top of tower. The air enters through the lower side, is drawn up and discharged to atmosphere through the fan casing.

Advantages: The induced draft fan costs less initially, provides cooling through wide range requires less space.

2) Forced draft Cooling Towers.

In case, the fan is located at base of tower and air is blown up by fan, through descending water and is discharged to atmosphere.

Advantages: The forced draft fan is more efficient, vibration and noise are minimum and blade erosion is avoided.

Disadvantages.

Power requirement is higher and fan size is limited.

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