UNIT 2: CONVENTIONAL ENERGY SOURCES

SELECTION OF SITE, WORKING OF THERMAL POWER PLANT, SCHEMATIC DIAGRAMS & COMPARATIVE ADVANTAGES/ DISADVANTAGES.

THERMAL POWER PLANT

Thermal energy is the major source of power generation in India. More than 60% of electric power is produced by steam plants in India. India has large deposit of coal (about 170 billion tonnes), 5th largest in world.

A thermal power station basically works on the Rankine cycle. Steam is produced in the boiler by utilising the heat of coal combustion. The steam is then expanded in the prime mover (*i.e.* steam turbine) and is condensed in a condenser to be fed into the boiler again. The steam turbine drives the alternator which converts mechanical energy of the turbine into electrical energy. This type of power station is suitable where coal and water are available in abundance and a large amount of electric power is to be generated.

SELECTION OF SITE FOR THERMAL POWER PLANT

• **Nearness to the load centre**: The power plant should be as near as possible to the load centre to the centre of load .So that the transmission cost and losses are minimum. This factor is most important when Dc supply system is adopted. However in the case of AC supply when transformation of energy from lower voltage to higher voltage and vice versa is possible power plants can be erected at places other than that of load provided other conditions are favorable.

• **Water resources**: For the construction and operating of power plant large volumes of water are required for the following reasons (i) To raise the steam in boiler. (ii) For cooling purpose such as in condensers (iii) As a carrying medium such as disposal of ash. (iv) For drinking purposes. This could be supplied from either rivers or underground water resources. Therefore having enough water supplies in defined vicinity can be a factor in the selection of the site.

• **Availability of Coal**: Huge amount of coal is required for raising the steam. Since the government policy is to use the only low grade coal with 30 to 40 % ash content for power generation purposes, the steam power plants should be located near the coal mines to avoid the transport of coal & ash.

• **Land Requirement**: The land is required not only for setting up the plant but for other purposes also such as staff colony, coal storage, ash disposal etc.

Eg: For 2000MW plant, the land requirement may be of the order of 200-250 acres. As the cost of the land adds up to the final cost of the plant, it should be available at a reasonable price. Land should be available for future extension.

• **Transportation Facilities**: The facilities must be available for transportation of heavy equipment and fuels e.g near railway station.

• **Labour supplies**: Skilled and unskilled laborers should be available at reasonable rates near the site of the plant.

• **Ash Disposal**: Ash is the main waste product of the steam power plant and with low grade coal, it may be 3.5 tones per day , some suitable means for disposal of ash should be though of. It may be purchased by building contractors, or it can be used for brick making near the plant site. If the site is near the coal mine it can be dumped into the disused mines. In case of site located near a river,sea or lake ash can be dumped into it.

• **Distance from populated area**: The continuous burning of coal at the power station Produces smoke, fumes and ash which pollute the surrounding area. Such a pollution due to smoke is dangerous for the people living around the area. Hence, the site of a plant should be at a considerable distance from the populated area.

DEFINITION (STEAM POWER STATION)

A generating station which converts heat energy of coal combustion into electrical energy is known as a steam power station.

BASIC PRINCIPAL OF STEAM POWER PLANT

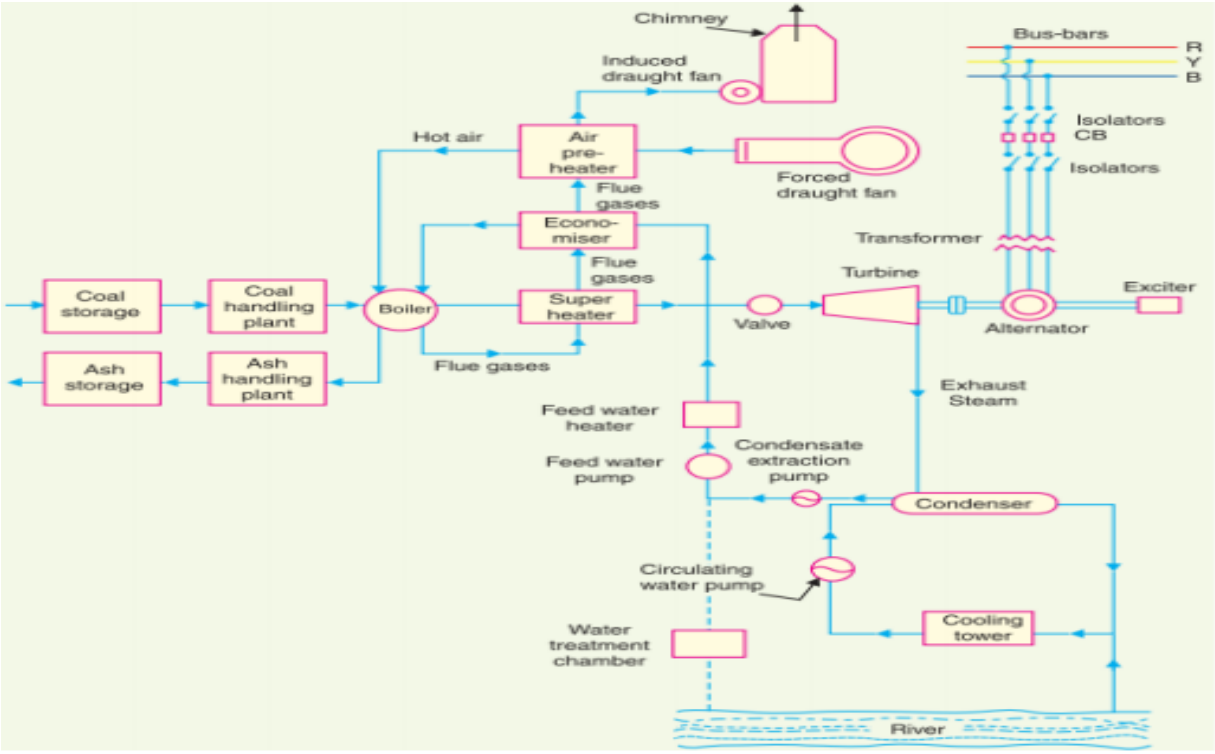
HE↔ KE↔ ME↔ EE
Or
CE ↔HE↔ KE ↔ME ↔EE

The heat produced for burning of coal & with the help of water steam is produced. This produced steam flow towards turbine i.e. kinetic energy is converted into mechanical energy. The input steam drives the prime mover or turbine, simultaneously the generator also start to rotate. At that time mechanical energy is converted into electrical energy.

UNIT 2: CONVENTIONAL ENERGY SOURCES

SELECTION OF SITE, WORKING OF THERMAL POWER PLANT, SCHEMATIC DIAGRAMS & COMPARATIVE ADVANTAGES/ DISADVANTAGES.

Schematic arrangement of Thermal Power Plant



The plant can be divided into following main parts namely:

1. Coal and ash handling arrangement.
2. Steam generating plant.
3. Steam turbine.
4. Alternator.
5. Feed water.
6. Cooling arrangement

Functions of each part used in Thermal Power Station

1. Coal Storage & Coal Handling Plant

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 strikes, 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 (i.e., crushed into small pieces) in order to increase its surface exposure, thus promoting rapid combustion without using large quantity of excess air. The pulverised 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.

UNIT 2: CONVENTIONAL ENERGY SOURCES

SELECTION OF SITE, WORKING OF THERMAL POWER PLANT, SCHEMATIC DIAGRAMS & COMPARATIVE ADVANTAGES/ DISADVANTAGES.

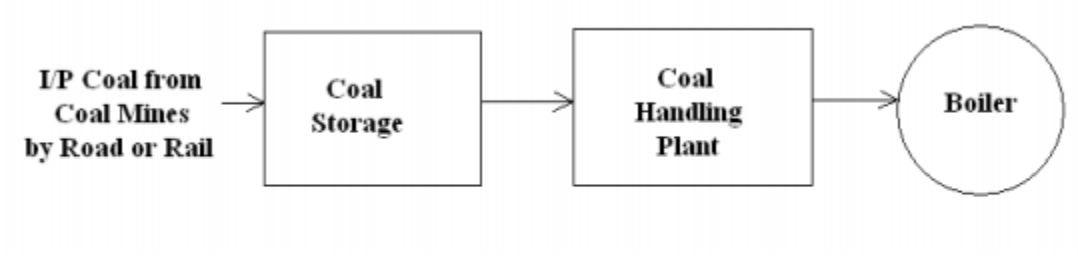


Fig: Coal Handling Plant

A large quantity of coal is required as a fuel in furnace of boiler for combustion to produce heat energy for production of steam for this purpose coal handling unit is used.

Steps/Activities for coal handling:

1. coal delivery 2. coal unloading

3. coal storage:- a) outdoor storage (dead storage) b) Indoor storage (live storage)

4. In the plant coal is crushed into small pieces with the help of crusher and breaker. The coal is crushed to 2.5 cm. or less.

5. Then it is cleaned by passing forced air to remove the dust contain.

6. Then it is dewatered (remove of moisture) with the help of dryer. The moisture content must be less than 2% after drying operation.

7. Then it is passed through magnetic separator to separate the iron particles mixed in it.

8. Then coal is passed to pulverizing mill.

9. Pulverized Coal weighing

10. Pulverized coal is than transfer into the boiler furnace.

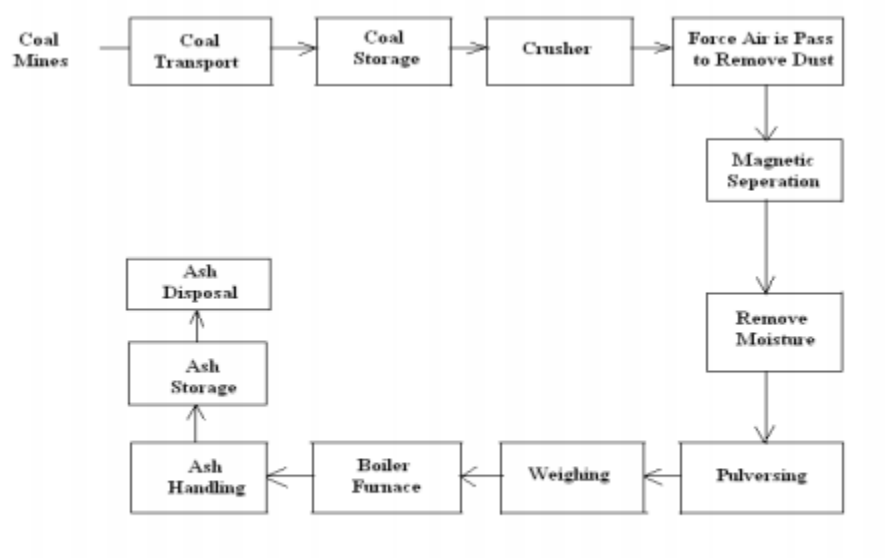


Fig: Coal & Ash Handling Unit

2. Ash handling Plant & Ash Storage

The removal of the ash from the boiler furnace is necessary for proper burning of coal. It is worthwhile to give a passing reference to the amount of coal burnt and ash produced in a modern thermal power station. A 100 MW station operating at 50% load factor may burn about 20,000 tons of coal per month and ash produced may be to the tune of 10% to 15% of coal fired i.e.., 2,000 to 3,000 tons. In fact, in a thermal station, about 50% to 60% of the total operating cost consists of fuel purchasing and its handling.

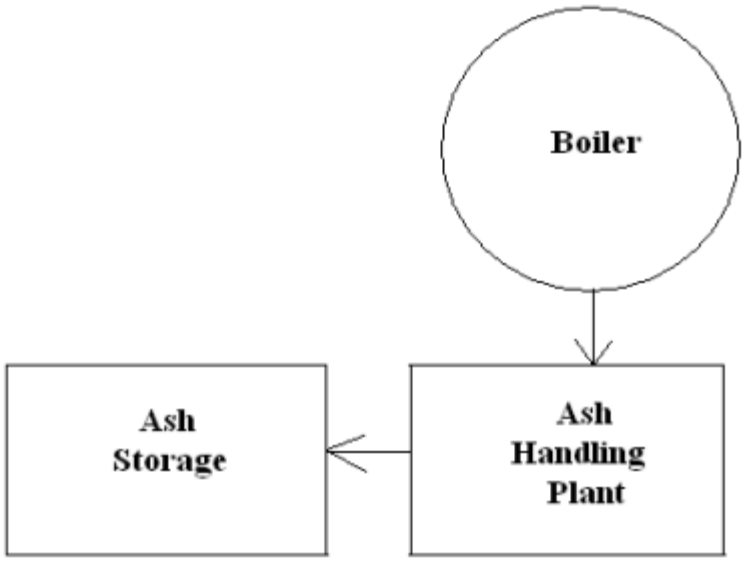


Fig: Ash Handling Unit

3. Ash is disposed in a thermal power plant

A large quantity of ash about 10 % produces in furnace, the removal of ash from boiler furnace is necessary for efficient combustion for this purpose ash handling unit is used.

Steps for Ash handling

Before handling the Ash it is desirable to quench the ash.

Handling of Ash includes:

1. Removal of ash from furnace.

2. Loading of ash on conveyer's belt.

3. And delivered to the space where it can be disposed off.

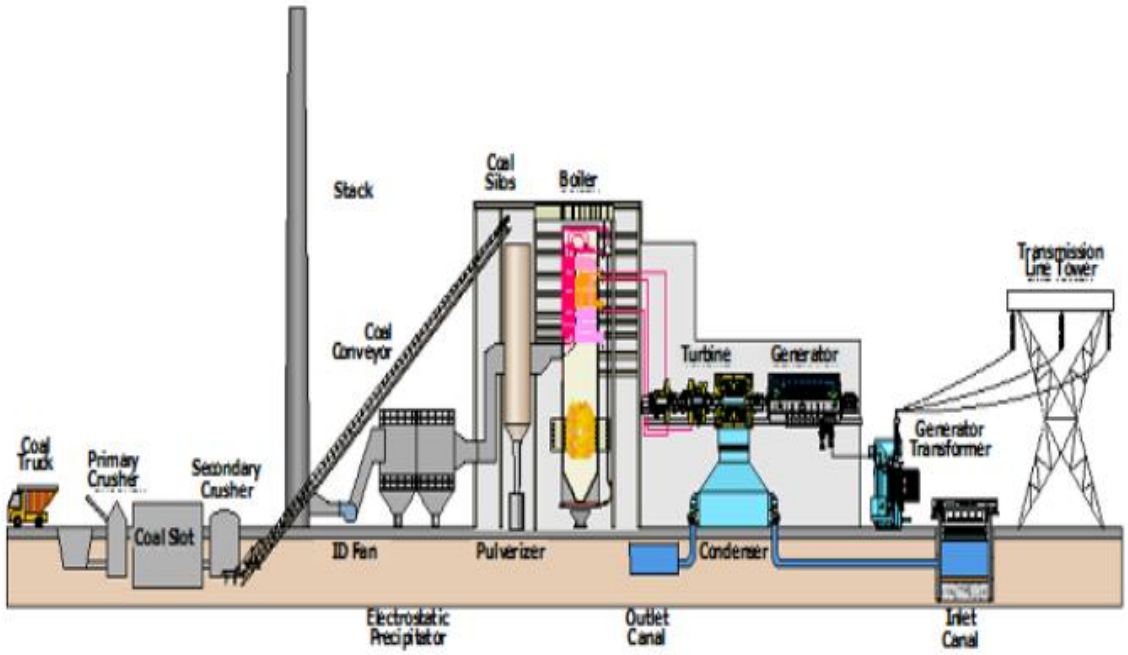
The various methods for the disposal of ash are as follows:

a. Hydraulic system.

b. Water Jetting.

c. Pneumatic system.

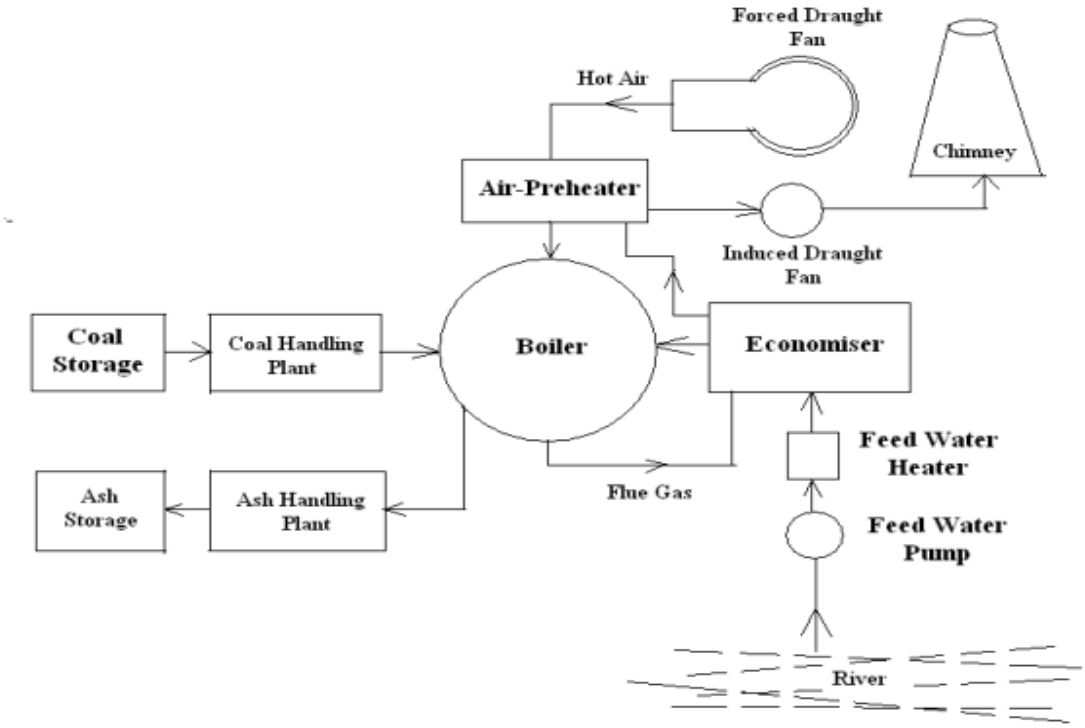
d. Mechanical ash handling system.



4. Boiler: (Steam Generating Plant)

A boiler is a closed vessel in which water is converted into steam by utilizing the heat of coal combustion. The heat of combustion of coal in the boiler is utilised to convert water into steam at high temperature and pressure. The flue gases from the boiler make their journey

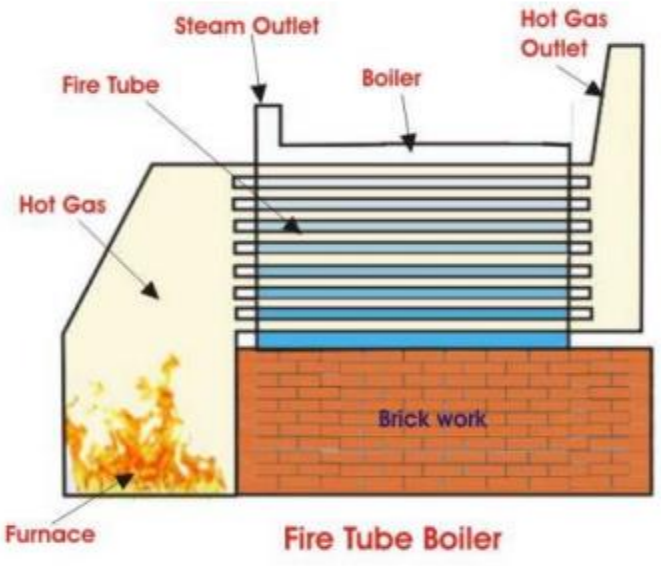
through super heater economiser, air pre-heater and are finally exhausted to atmosphere through the chimney.



Major types of boilers are: (i) fire tube boiler and (ii) water tube boiler

i) Fire tube boiler: In fire tube boilers hot gases are passed through the tubes and water surrounds these tubes. Depending on whether the tube is vertical or horizontal the fire tube boiler is divided into two types

1. Vertical tube boiler
2. Horizontal tube boiler



Maximum pressure: High pressures of steam are not possible, maximum pressure that can be attained is about17.5kg/sq-cm.

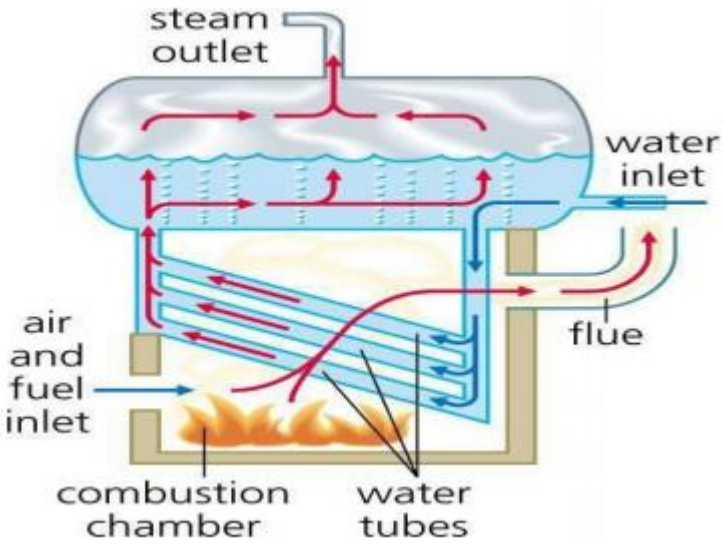
Capacity: A capacity of about 9,000 kg -15000 kg (9 ton-15 ton) of steam per hours.

Example: Where low pressure, low temperature, low capacity steam is required.

ii) Water tube boiler: In these boilers water is inside the tubes and hot gases are outside the tubes. They consist of drums and tubes.

Water tube boiler are classified as

1. Vertical tube boiler 2. Horizontal tube boiler 3. Inclined tube boiler



Maximum pressure: We can attain pressure as high as 125 kg/sqcm.

Capacity: A capacity of about 10, 00,000kg (1000 ton) per hour of steam per hours.

Example: Where high pressure, high temperature, high capacity steam is required (e.g. thermal power station).

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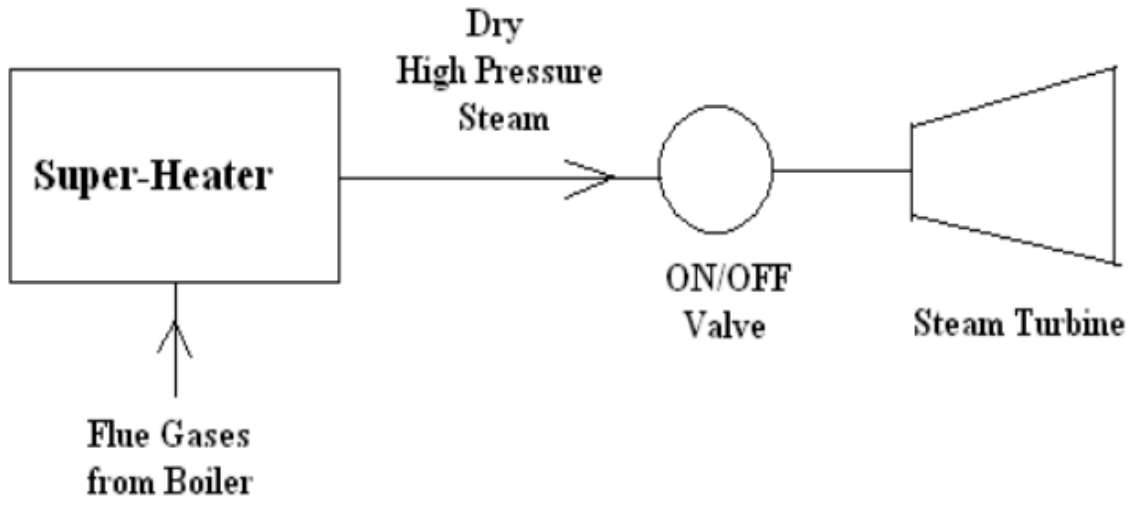
Comparison between Fire tube boiler and Water tube boiler

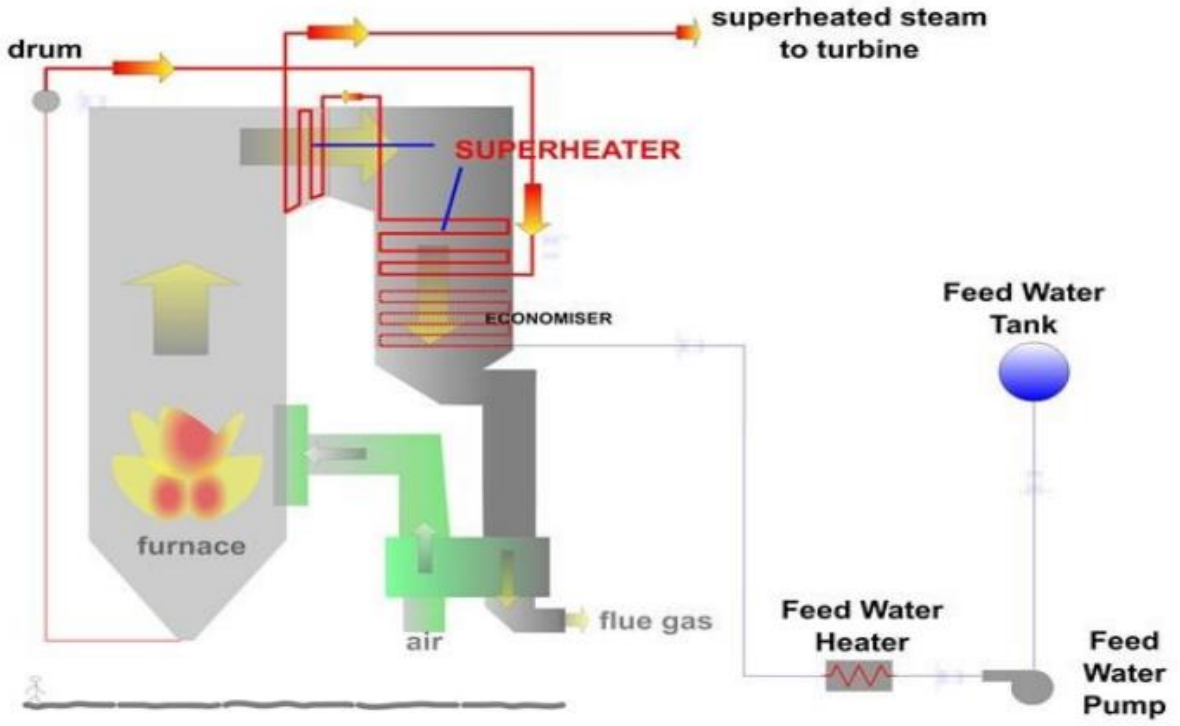
FIRE TUBE BOILER	WATER TUBE BOILER
1) Hot gases are inside the tube and water is outside.	1) Water is inside the tube and hot gases outside.
2) Operating Pressure limited to 25 bar.	2) Can work under as high pressure as more than 25 bar.
3) Rate of steam generation is lower.	3) Rate of steam generation is higher.
4) Not suitable for large power plant.	4) Suitable for large power plant.
5) Chance of explosion is less due to low pressure.	5) Chance of explosion is higher due to high pressure.
6) Floor space requirement is more.	6) Floor space requirement is less.
7) Cost is less.	7) Cost is more.
8) Required less skill for efficient and economic working.	8) Required more skill and careful attention for efficient and economic working.
9) For producing process steam.	9) For producing steam for power generation as well as process heating.
10) There is no problem of scale deposition and less problem of overheating and bursting.	10) Small deposition of scale will cause overheating and bursting of the tubes.

5. 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 temperature increased above that of boiling point of water) by the flue gases on their way to chimney. A Super heater consists of a group of tubes made of special alloy steels such as chromium-molybdenum. These tubes are heated by the heat of flue gases during their journey from the boiler furnace to the chimney. The steam produced in the boiler is led through the superheater where it is superheated by the heat of flue gases from

boiler. Super heating provides two principal benefits. Firstly, the overall efficiency is increased. Secondly, too much condensation in the last stages of turbine (which would cause blade corrosion) is avoided. The superheated steam from the super heater is fed to steam turbine through the main valve.



The superheater mainly classified into two types:

a. Radiant superheater: The Radiant superheater is placed in the boiler furnace between the water walls & receives heat from the fuel burning through radiation process.

b. Convection superheater: The convection superheater is placed in the boiler tube bank & receives heat from flue gases entirely through convection process.

6. Economiser

Boilers are provided with economizer and air pre-heaters to recover heat from the flue gases. An increase of about 20% in boiler efficiency is achieved by providing both economizer and air pre-heaters.

• Economizer alone gives only 10-12% efficiency increase, causes saving in fuel consumption 5-15 %. The feed water from the high pressure heaters enters the economizer and picks up heat from the flue gases after the low temperature super heater.

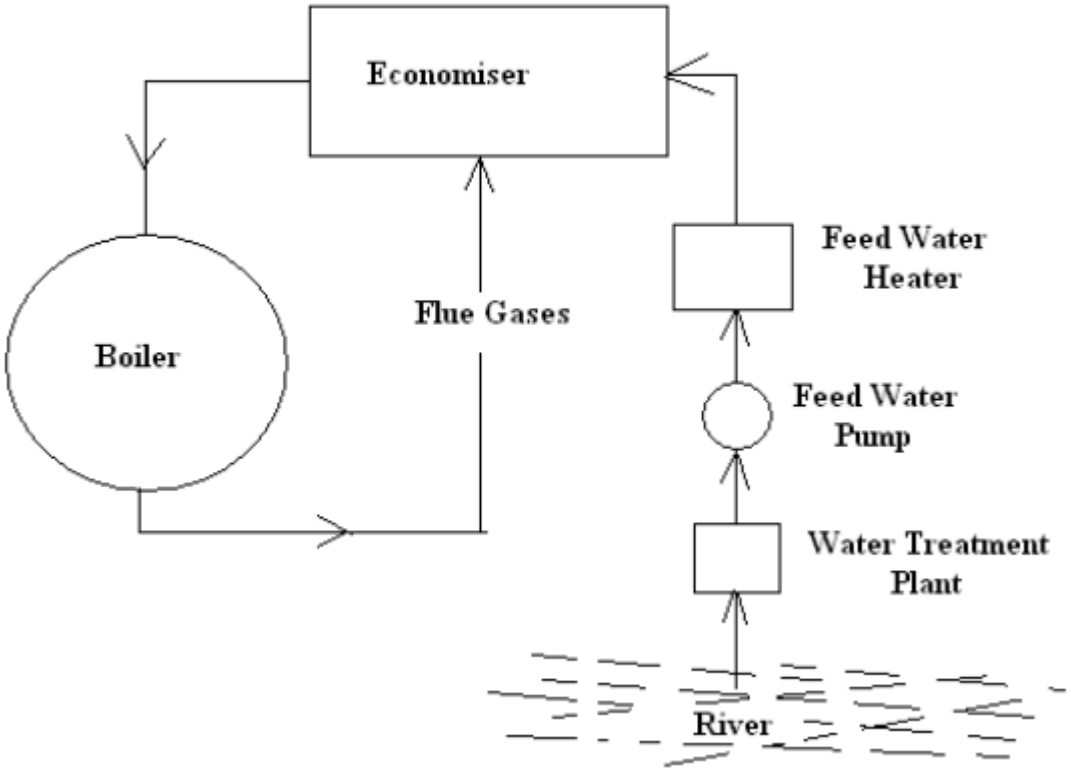
• Economizer can be classified as an inline or staggered arrangement based on the type of tube arrangement.

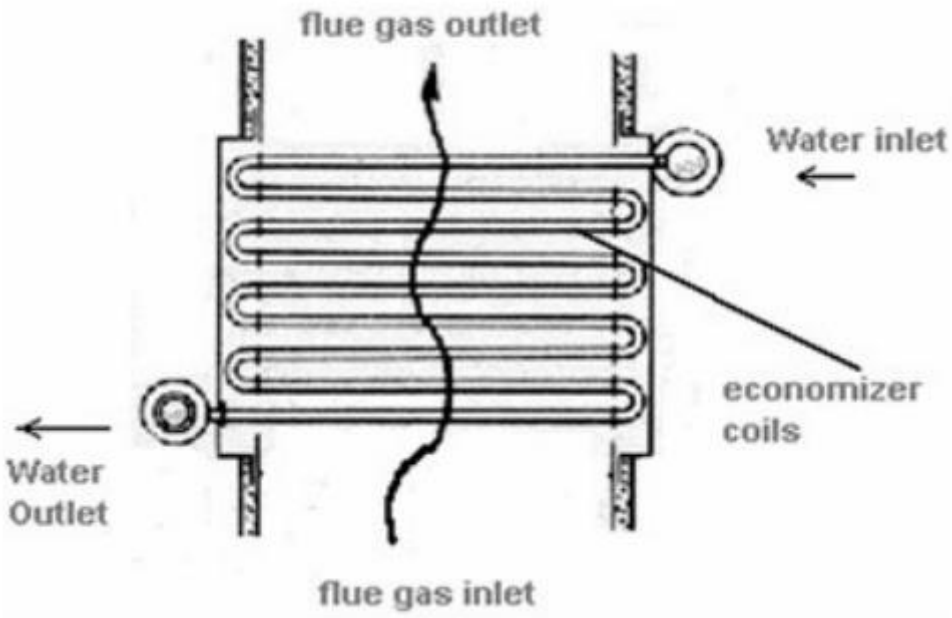
• For pressure of 70 Kg/cm2 or more economizer becomes a necessity.

• The tubes are arranged in parallel continuous loops.

• Feed water flows through the tubes and the flue gases outside the tubes across them. The feed water should be sufficiently pure not to cause forming of scales and cause internal corrosion and under boiler pressure.

• The temperature of the feed water entering the economizer should be high enough so that moister from the flue gases does not condense on the economizer tubes.





7. Feed water Arrangement

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.

Necessity of heating feed waterbefore feeding it back to the boiler arises due to the following reasons.

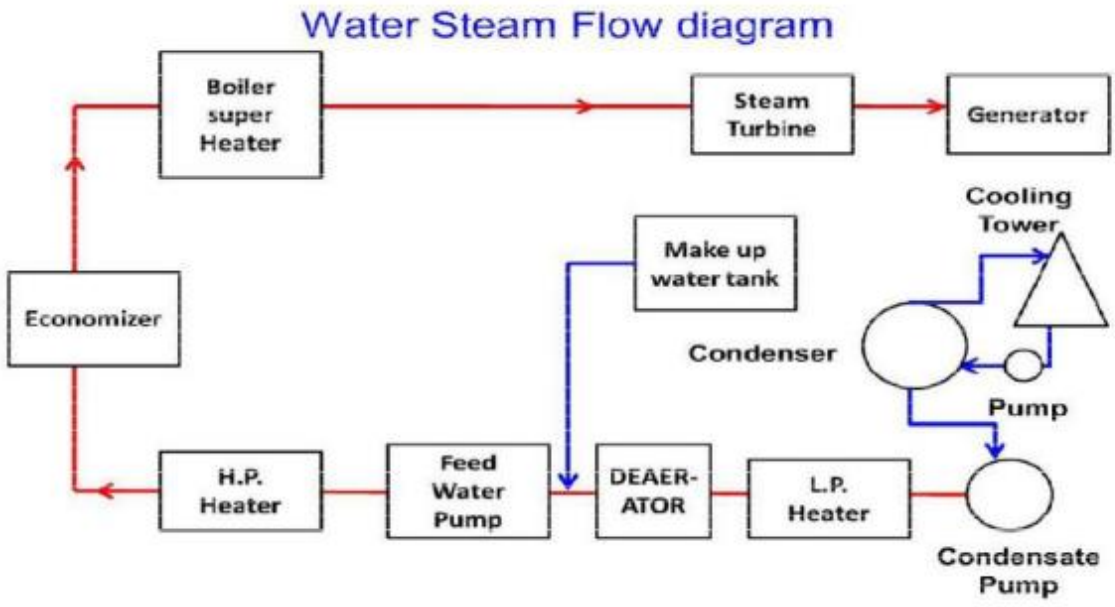
• Feed Water heating improve overall efficiency.

• The dissolved oxygen which would otherwise cause boiler corrosion are removed in the feed water heater.

• Thermal stresses due to cold water entering the boiler drum are avoided.

• Quantity of steam produced by the boiler is increased.

• Some other impurities carried by steam and condensate, due to corrosion in boiler and condenser, are precipitated outside the boiler.



8. Air Pre-heater

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 draught fan and is passed through air pre-heater before supplying to the boiler furnace. The air pre-heater extracts heat from flue gases and increases the temperature of air used for coal combustion.

The principal benefits of preheating the air are:

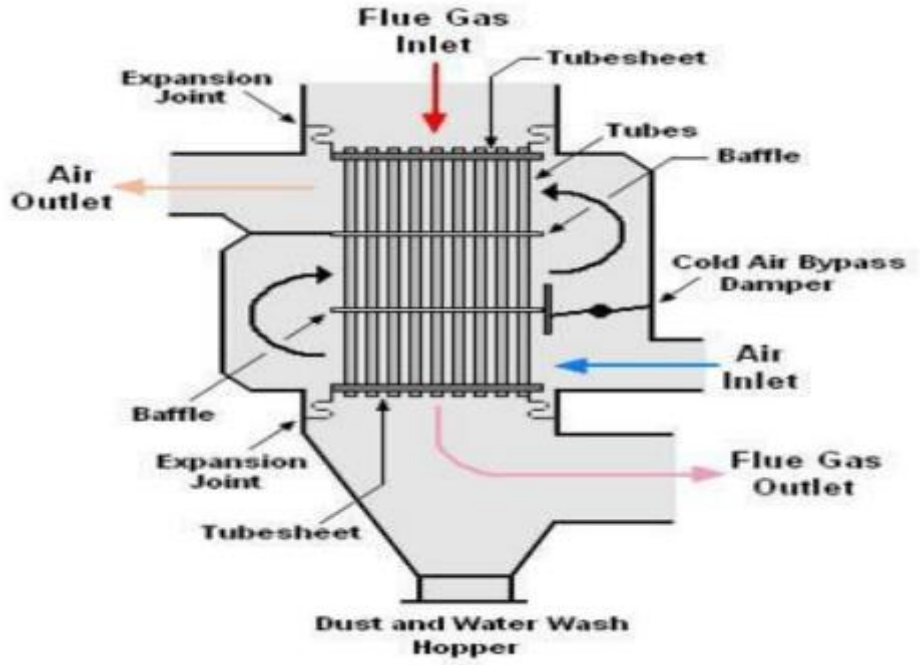
- increased thermal efficiency and

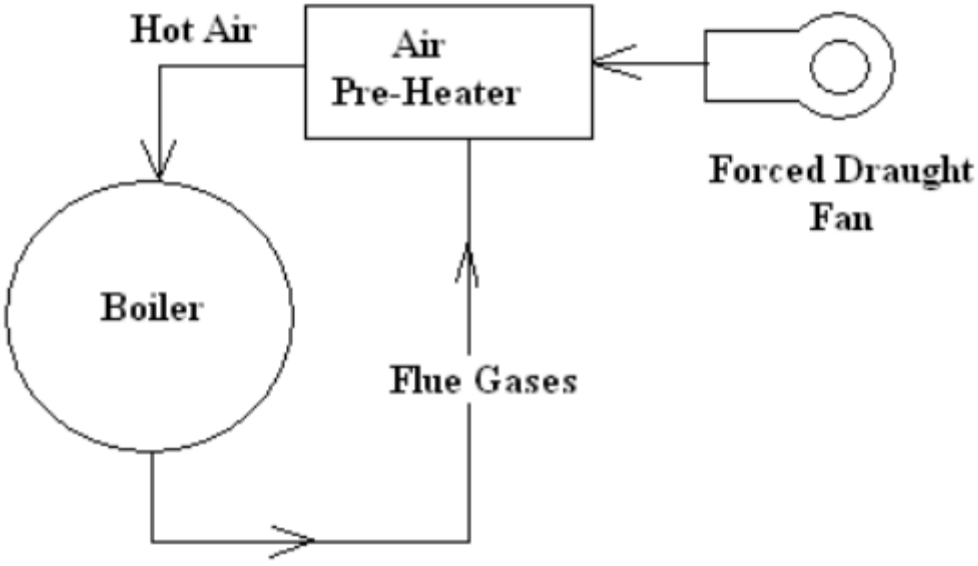
- increased steam capacity per square meter of boiler surface.

Depending upon the method of heat transfer from flue gases in boiler to the air, the **air-preheater can be divided into two main types**:

a. Recuperative Type: The recuperative type air-preheater 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 transferred to air.

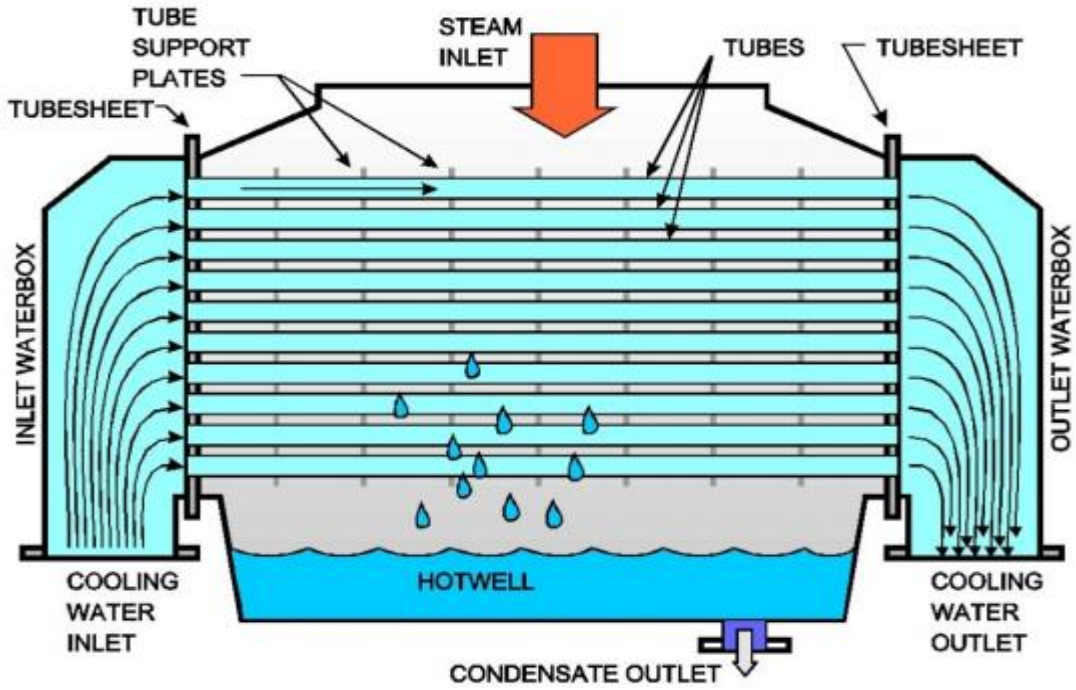
b. Regenerative Type: The regenerative type air pre-heater consists of slowly moving drum made up of corrugated metal plates. The flue gases flow continuously on one side of the drum & air on the other side. This action permits the transference heat of flue gases to the air being supplied to the boiler furnace for coal combustion.





9. Condenser

A condenser is a device which condenses the steam at the exhaust of the turbine. It serves two important functions. Firstly, it creates a very low pressure at the exhaust of the steam turbine, thus permitting expansion of the 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.



Condensers are classified into two types:

a. Jet Condenser: In a jet condenser, cooling water & exhausted steam are mixed together. Therefore, the temperature of cooling water & condensate is the same when leaving the condenser.

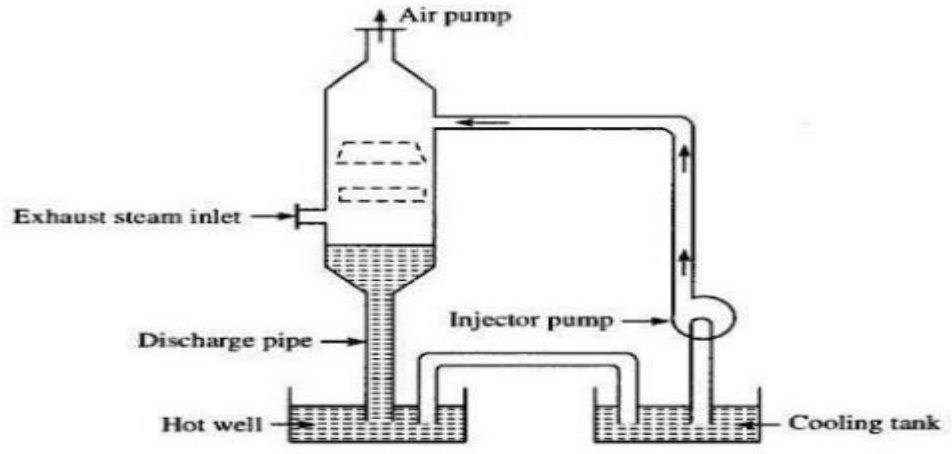
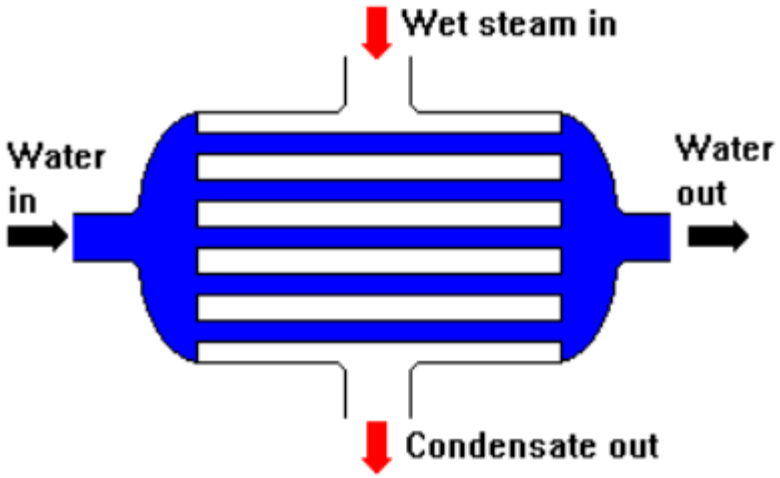


Figure : Jet Condenser

b. Surface Condenser: In surface condenser, there is no direct contact between cooling water & exhausted seam. It consists of bank of horizontal tubes; the cooling water flows through the tubes & exhausted steam over the surface of the tubes. The steam gives up its heat to water & is condensed itself.



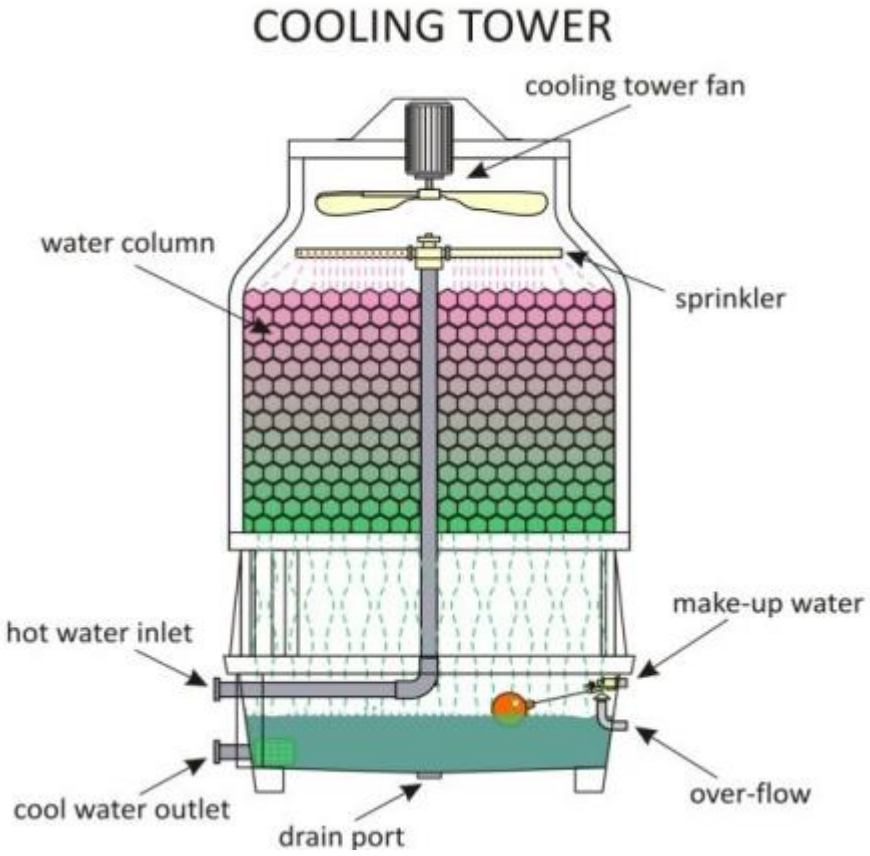
Water cooled surface type condenser

Table : Jet and Surface Condensers

Jet condenser (contact type)	Surface condenser (non-contact type)
Exhaust steam mixes with cooling water.	Steam and water do not mix.
Temperature of the condensate and cooling water is same while leaving the condenser.	Condensate temperature higher than the cooling water temperature at outlet.
Condensate cannot be recovered.	Condensate recovered is fed back to the boiler.
Heat exchanged by direct conduction	Heat transfer through convection.
Low initial cost	High initial cost.
High power required for pumping water.	Condensate is not wasted so pumping power is less.

10. 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 source of supply such as a river, canal or lake and is circulated through the condenser. The circulating water takes up the heat of the exhausted steam and it becomes hot. This hot water coming out from the condenser 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 towers are used. During the scarcity of water in the river, 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.



11. Prime Mover (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.

There are two types of steam turbines:

1) Impluse turbine 2) Reaction Turbine

Impulse Turbine:

➢ In this turbine there are alternate rows of moving and fixed blades. The moving blades are mounted on the shaft and fixed blades are fixed to the casing of the turbine.

➢ A set of fixed nozzle is provided and steam is passed through these nozzles. The P.E in steam due to pressure and internal energy is converted to K.E. The steam comes out of the nozzles with very high velocity and impinges on the rotor blades.

➢ The direction of steam flow changes without changing its pressure.

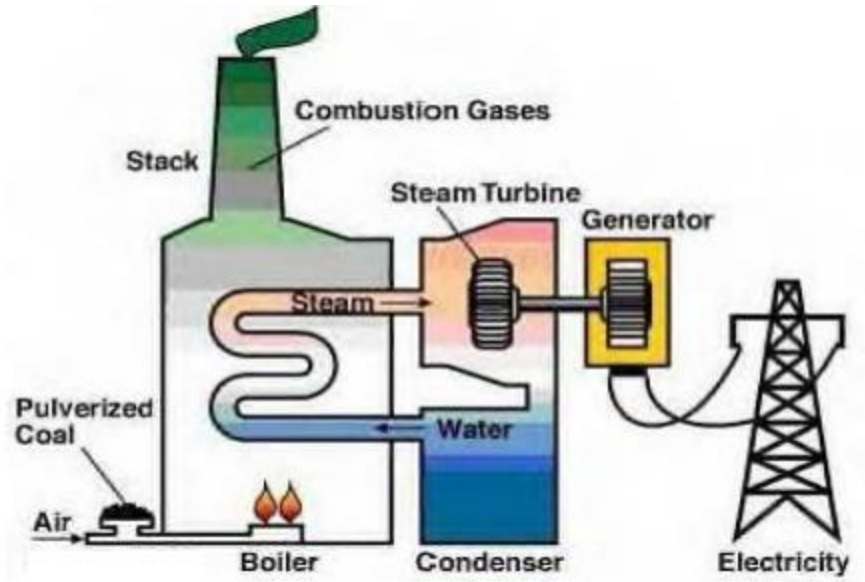
➢ Thus due to the change in momentum the turbine rotor starts rotating.

Reaction Turbine:

➢ Reaction turbine have no nozzles. These two have alternate rows of moving and fixed blades. The moving blades are mounted on shaft, while fixed blades are fixed in casing of turbine.

➢ When high pressure steam passes through fixed blades, then steam pressure drops down and velocity of steam increases.

➢ As steam passes over moving blades, the steam expands and imparts energy,resulting in reduction in pressure and velocity of steam.



12. Water Treatment Plant

The boiler of the thermal plant required clean & soft water for longer life & better efficiency. However, the source of boiler feed water is generally a river or lake which may contain

suspended & dissolved impurities, gases etc. therefore, it is very important that water is purified & softened by chemical treatment & then delivered to boiler.

13. Draught System used in Thermal Power Plant

Induced Draught fan (IDF): It consists of Exhaust fan.

Its (IDF) function is to remove rapidly flue gases (smoke) from the furnace chamber produced during combustion.

OR

The fans suck the flue gases from combustion chamber and discharge it rapidly to the air through chimney.

Forced Draught fan (FDF): It consists of fan.

Its (FDF) function is to provide forced air (oxygen) for combustion process in furnace.

OR

Its (FDF) function is to supply required amount of air (oxygen) to the furnace chamber for efficient and fast combustion.

Function of

1. Natural draught systems- Is to reduce temperature of water in cooling tower by the use of natural (atmosphere) air.

2. Mechanical draught systems- Is to reduce temperature of water in cooling tower by the use of fan.

3. Forced draught systems- Is to reduce temperature of water in cooling tower by the use of forced draught fan.

4. Induced draught systems- Is to reduce temperature of water in cooling tower by the use of induced (exhaust) draught fan.

14. Function of Chimney

Flue gases (smoke) are produced during combustion process. These flue gases produce air pollution, SO_2 to reduce air pollution it should be passed in air as high as possible with the help of Chimney.

15. List major electrical equipment in thermal power station

i) Alternator The steam turbine is coupled to an alternator. The alternator converts mechanical energy of turbine into electrical energy. The electrical output from the alternator is delivered to the bus bars through transformer, circuit breakers and isolators.

ii) Exciter

iii) Transformer: A generating station has different types of transformers viz,

Main step-up transformer which step-up the generation voltage for transmission of power.

Station Transformer which is used for general services (e.g. lighting) in the power station.

Auxiliary transformer which supply to individual unit-auxiliaries.

iv) Switchgear: It is used to locate the fault & isolate the faulty part from healthy section. It contains circuit breaker, relays, switches and other control devices.

MERITS AND DEMERITS OF A THERMAL POWER PLANT

Advantages:

Cost of fuel: Fuel used in thermal power station (TPS) is cheaper than cost of fuel used in diesel & nuclear power station.

Capital cost: Capital cost of TPS is less than hydro & nuclear power station.

Near load center: TPS can be located near load center. The coal can be transport from coal mines to power plant. As it is located load centre it reduces transmission cost and losses in it.

Space required: Less space required as compared to hydro power station.

Generating cost: TPS can be built/construct of high generating capacity.

Generating capacity: TPP can be build/construct of high generating capacity, so used as a base load power plant.

Overload capacity: Steam engines and turbine can work under 25% overloads continuously.

Time required for completion of project: Time required for completion of TPP project is very less as compare to hydro power station.

Disadvantages:

Air pollution: It produces air pollution due to smoke and ash produced during combustion of fuel.

Starting Time: TPP cannot be put into service immediately like HPP. As thermal power plant required few hours (6-7 hour) to generate steam at high pressure and high temperature.

Handling of fuel: Handling of coal and disposal of ash is quite difficult.

Fuel transportation cost: When power plant are located away from coal mines i.e. near load centre at that time fuel transportation cost is more.

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SELECTION OF SITE, WORKING OF THERMAL POWER PLANT, SCHEMATIC DIAGRAMS & COMPARATIVE ADVANTAGES/ DISADVANTAGES.

Preparation for fuel: There is more expenditure for preparation of coal (raw coal to pulverized coal).

Space required: Large amount of space is required for storage of fuel and ash as compare to NPP.

Efficiency: It is less efficient power plant overall efficiency is maximum 30 %.

Stand by losses: Stand by losses is more as furnace is required to keep in operation even when there is no load.

Maintenance cost: High maintenance and operating cost because number of axillaries plant are required such as coal and ash handling plant, pulverizing plant, condensing plant and water purification plant etc.

Availability of fuel: Less availability of high grade coal.

Simplicity and cleanness: Layout of thermal power plant is complicated than HPP due to coal and ash.

Life: Life of TPP is less than HPP.

Cost per unit (cost of generation) - High