

MODULE-3



POWER SYSTEMS-1

ELECTRICAL POWER GENERATION

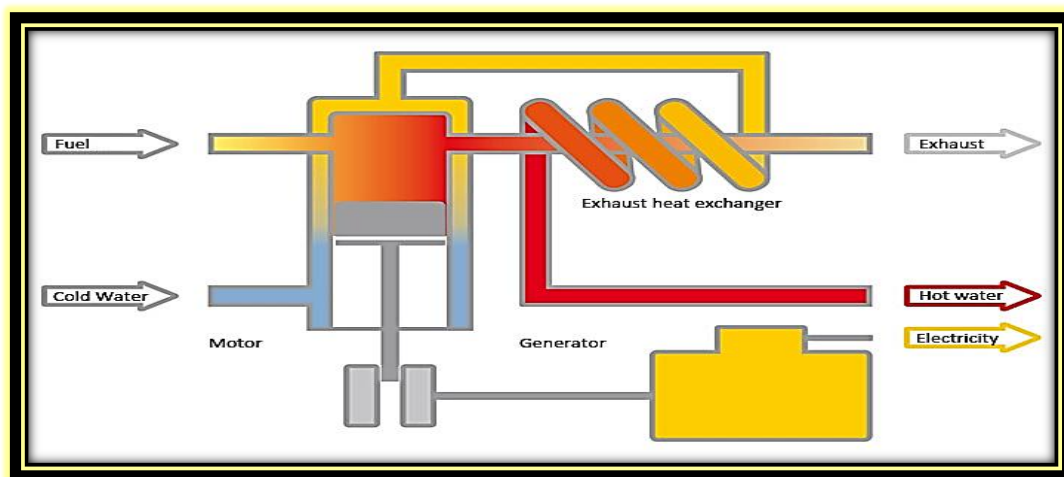
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BASIC PRINCIPLE OF THERMAL POWER PLANT

- ❖ A **Thermal Power Station** is a power plant in which the prime mover is steam driven. Water is heated, turns into steam and spins a steam turbine which drives an electrical generator. After it passes through the turbine, the steam is condensed in a condenser and recycled to where it was heated, this is known as a Rankine Cycle.
- ❖ **Thermal Power Plants** are modular systems which are used for decentralized generation of electricity and heat through the use of power-heat coupling. A special industrial combustion engine, designed for long-duration operation, drives the generator (electrical power) of the TPP. For the motor, a number of different fuels, both solid and liquid, can be used.
- ❖ The greatest variation in the design of thermal power stations is due to the different fuel sources. Some prefer to use the term *energy center* because such facilities convert forms of heat energy into electricity. Some thermal power plants also deliver heat energy for industrial purposes, for district heating, or for desalination of water as well as delivering electrical power. A large part of human CO₂ emissions comes from fossil fueled thermal power plants, efforts to reduce these outputs are various and widespread.
- ❖ Thermal Power Station, designed only for electricity production, is called condensation electric stations (IES). Power stations, intended for the combined production electrical energy and release steam and hot water heat consumers have a steam turbine with intermediate steam or pressure. In such installations the heat of spent steam partially or even completely used for heating, resulting in loss of heat with the cooling water is reduced.



SITE SELECTION OF THERMAL POWER PLANT

❖ In general, both the construction and operation of a power plant requires the existence of some conditions such as water resources and stable soil type. Still there are other criteria that although not required for the power plant, yet should be considered because they will be affected by either the construction or operation of the plants such as population centers and protected areas. The following list covers most of the factors that should be studied and considered in selection of proper sites for power plant construction:

✚ **Transportation Network:** Easy and enough access to transportation network is required in both power plant construction and operation periods.

✚ **Gas pipe Network:** Vicinity to the gas pipes reduces the required expenses.



BIRD VIEW OF NEVEDA THERMAL POWER PLANT, USA

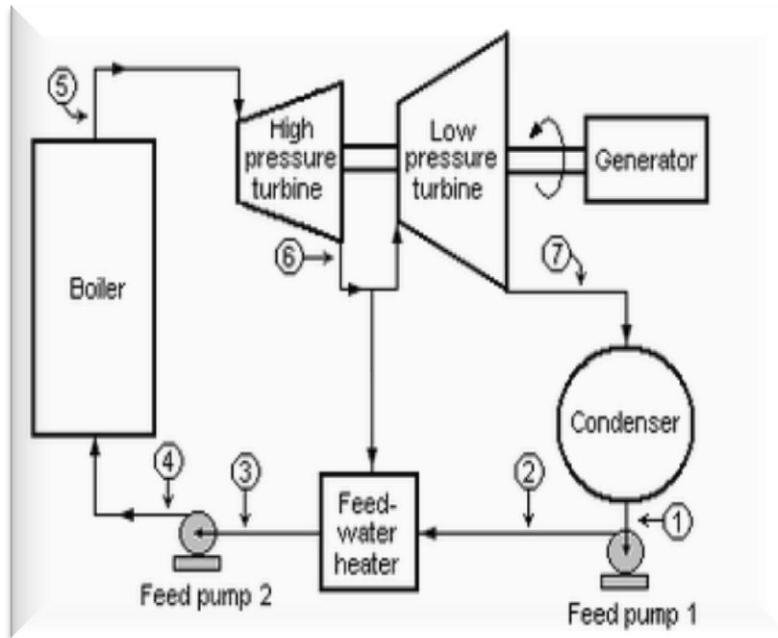
- ✚ **Power Transmission Network:** To transfer the generated electricity to the consumers, the plant should be connected to electrical transmission system. Therefore the nearness to the electric network can play a roll.
- ✚ **Geology and Soil Type:** The power plant should be built in an area with soil and rock layers that could stand the weight and vibrations of the power plant.
- ✚ **Earthquake and Geological Faults:** Even weak and small earthquakes can damage many parts of a power plant intensively. Therefore the site should be away enough from the faults and previous earthquake areas.
- ✚ **Topography:** It is proved that high elevation has a negative effect on production efficiency of gas turbines. In addition, changing of a sloping area into a flat site for the construction of the power plant needs extra budget. Therefore, the parameters of elevation and slope should be considered.
- ✚ **Rivers and Floodways:** obviously, the power plant should have a reasonable distance from permanent and seasonal rivers and floodways.
- ✚ **Water Resources:** For the construction and operating of power plant different volumes of water are required. 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.
- ✚ **Environmental Resources:** Operation of a power plant has important impacts on environment. Therefore, priority will be given to the locations that are far enough from national parks, wildlife, protected areas, etc.
- ✚ **Population Centers:** For the same reasons as above, the site should have an enough distance from population centers.
- ✚ **Need for Power:** In general, the site should be near the areas that there is more need for generation capacity, to decrease the amount of power loss and transmission expenses.

- ✚ **Climate:** Parameters such as temperature, humidity, wind direction and speed affect the productivity of a power plant and always should be taken into account.
- ✚ **Land Cover:** Some land cover types such as forests, orchard, agricultural land, pasture are sensitive to the pollutions caused by a power plant. The effect of the power plant on such land cover types surrounding it should be counted for.
- ✚ **Area Size:** Before any other consideration, the minimum area size required for the construction of power plant should be defined.
- ✚ **Distance from Airports:** Usually, a power plant has high towers and chimneys and large volumes of gas. Consequently for security reasons, they should be away from airports.
- ✚ **Archeological and Historical sites:** Usually historical building are fragile and at same time very valuable. Therefore the vibration caused by power plant can damage them, and a defined distance should be considered.



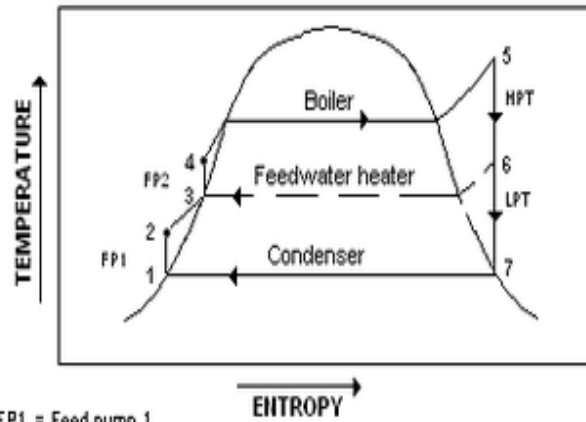
BIRD VIEW OF KOTA THERMAL POWER PLANT, RAJASTHAN, INDIA

WORKING PRINCIPLE OF THERMAL POWER PLANT



BLOCK DIAGRAM OF THERMAL POWER PLANT

- ❖ Above the critical point for water of 705 °F (374 °C) and 3212 psi (22.06 MPa), there is no phase transition from water to steam, but only a gradual decrease in density. Boiling does not occur and it is not possible to remove impurities via steam separation. In this case a super critical steam plant is required to utilize the increased thermodynamic efficiency by operating at higher temperatures. These plants, also called *once-through* plants because boiler water does not circulate multiple times, require additional water purification steps to ensure that any impurities picked up during the cycle will be removed.
- ❖ This purification takes the form of high pressure ion exchange units called condensate polishers between the steam condenser and the feed water heaters. Sub-critical fossil fuel power plants can achieve 36–40% efficiency. Super critical designs have efficiencies in the low to mid 40% range, with new "Ultra Critical" designs using pressures of 4400 psi (30.3 MPa) and dual stage reheat reaching about 48% efficiency.
- ❖ To demonstrate working principle of Thermal Power Plant we must need Rankine Cycle. The Rankine cycle most closely describes the process by which steam-operated heat engines most commonly found in power generation plants generate power. The two most common heating processes used in these power plants are nuclear fission and the combustion of fossil fuels such as coal, natural gas, and oil.

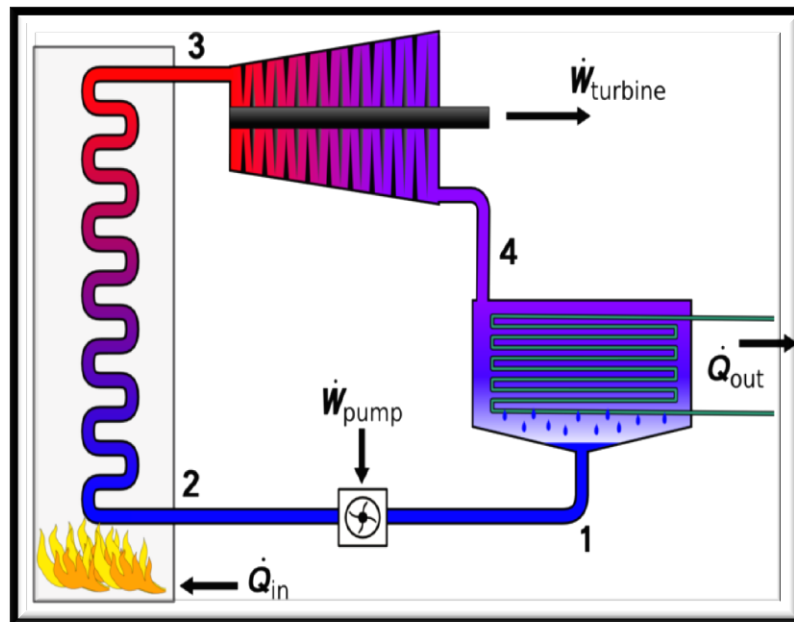


FP1 = Feed pump 1
 FP2 = Feed pump 2
 HPT = High pressure turbine
 LPT = Low pressure turbine

Rankine cycle with a two-stage steam turbine and a single feed water heater.

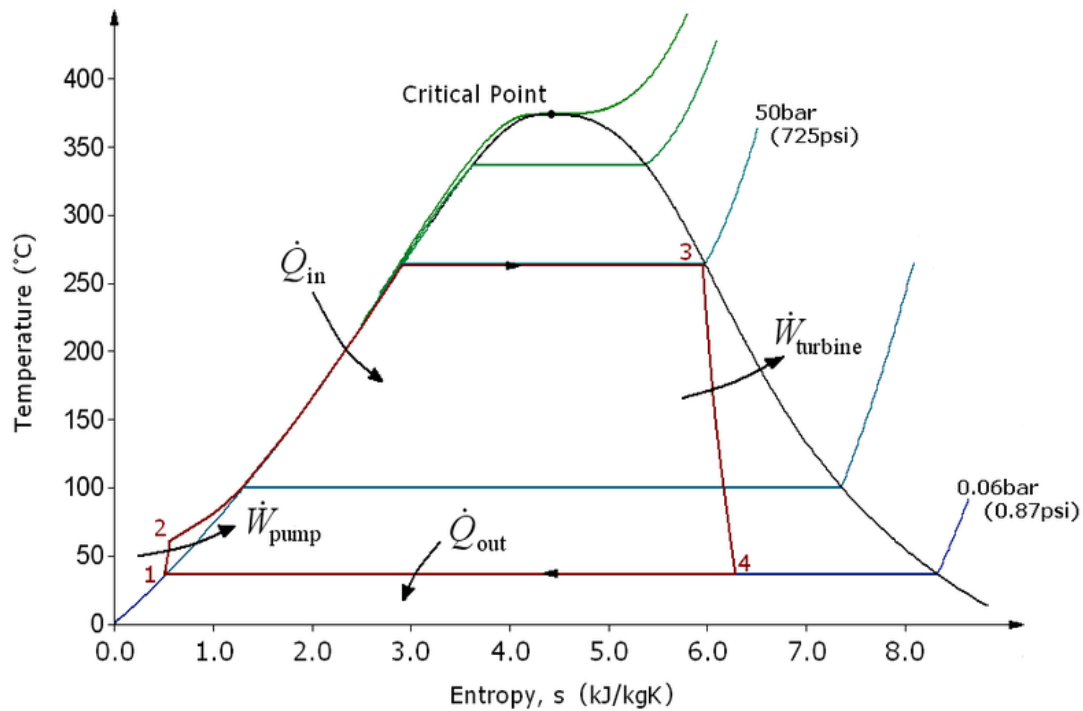
RANKINE CYCLE

- ❖ The Rankine cycle is sometimes referred to as a practical Carnot cycle because, when an efficient turbine is used, the TS diagram begins to resemble the Carnot cycle. The main difference is that heat addition (in the boiler) and rejection (in the condenser) are isobaric in the Rankine cycle and isothermal in the theoretical Carnot cycle.



Physical layout of the four main devices used in the Rankine cycle

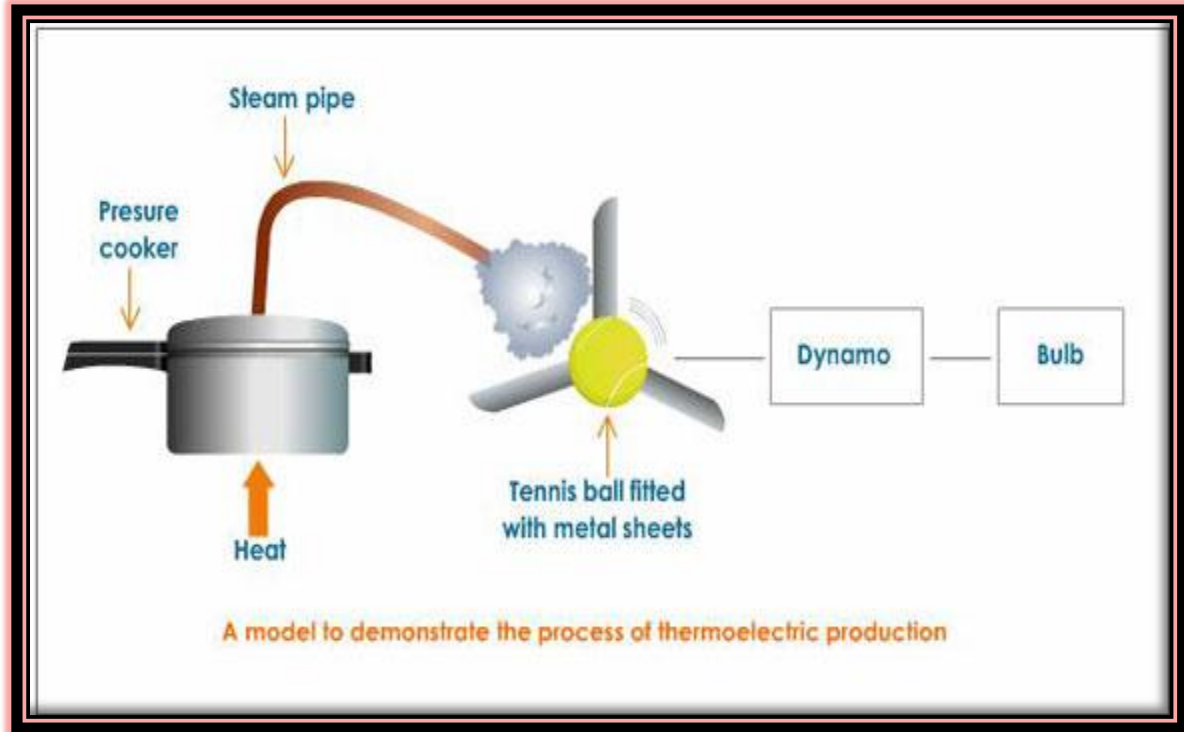
- ❖ There are four processes in the Rankine cycle. These states are identified by numbers (in brown) in the diagram to the left.



RANKINE CYCLE (Temperature vs. Entropy)

- **Process 1-2:** The working fluid is pumped from low to high pressure. As the fluid is a liquid at this stage the pump requires little input energy.
 - **Process 2-3:** The high pressure liquid enters a boiler where it is heated at constant pressure by an external heat source to become a dry saturated vapor. The input energy required can be easily calculated using mollier diagram or h-s chart or enthalpy-entropy chart also known as steam tables.
 - **Process 3-4:** The dry saturated vapor expands through a turbine, generating power. This decreases the temperature and pressure of the vapor, and some condensation may occur. The output in this process can be easily calculated using the Enthalpy-entropy chart or the steam tables.
 - **Process 4-1:** The wet vapor then enters a condenser where it is condensed at a constant temperature to become a saturated liquid.
- ❖ In an ideal Rankine cycle the pump and turbine would be isentropic, i.e., the pump and turbine would generate no entropy and hence maximize the network output. Processes 1-2 and 3-4 would be represented by vertical lines on the T-S diagram and more closely resemble that of the Carnot cycle. The Rankine cycle shown here prevents the vapor ending up in the superheat region after the expansion in the turbine, which reduces the energy removed by the condensers.

SIMPLE EXPERIMENT TO DEMONSTRATE THE WORKING OF A THERMAL POWER PLANT



❖ PROCEDURE:-

- Take a table tennis ball and make 3 slits into it. Fix semicircular fins of a metal sheet into these slits as shown in the figure. A straight metal wire is passed through the center of the tennis ball which is fixed to a rigid support. Now pivot the tennis ball with the wire on an axle such that it is able to rotate freely. Connect a cycle dynamo to this fan. Connect a bulb in series with the dynamo. Direct a jet of water or steam produced in a pressure cooker at the fins.

❖ OBSERVATION:-

- The force of the steam rotates the blades, and it acts like a simple turbine. This rotational energy produces a small current in the dynamo and lights the bulb.

❖ INFERENCE:-

- Mechanical energy is converted into electrical energy. This is the principle used in the Thermal Power Plant.

WORKING OF THERMAL POWER PLANT

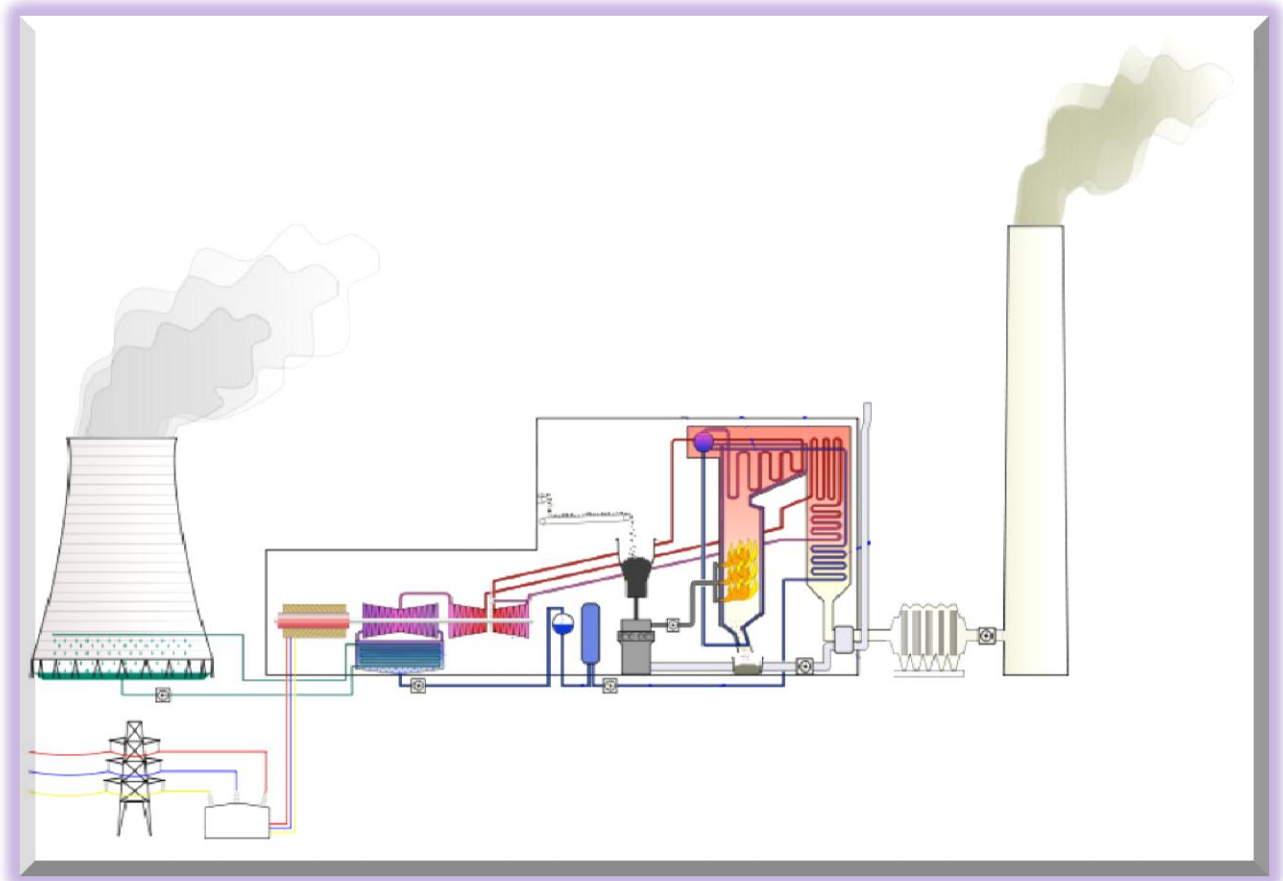


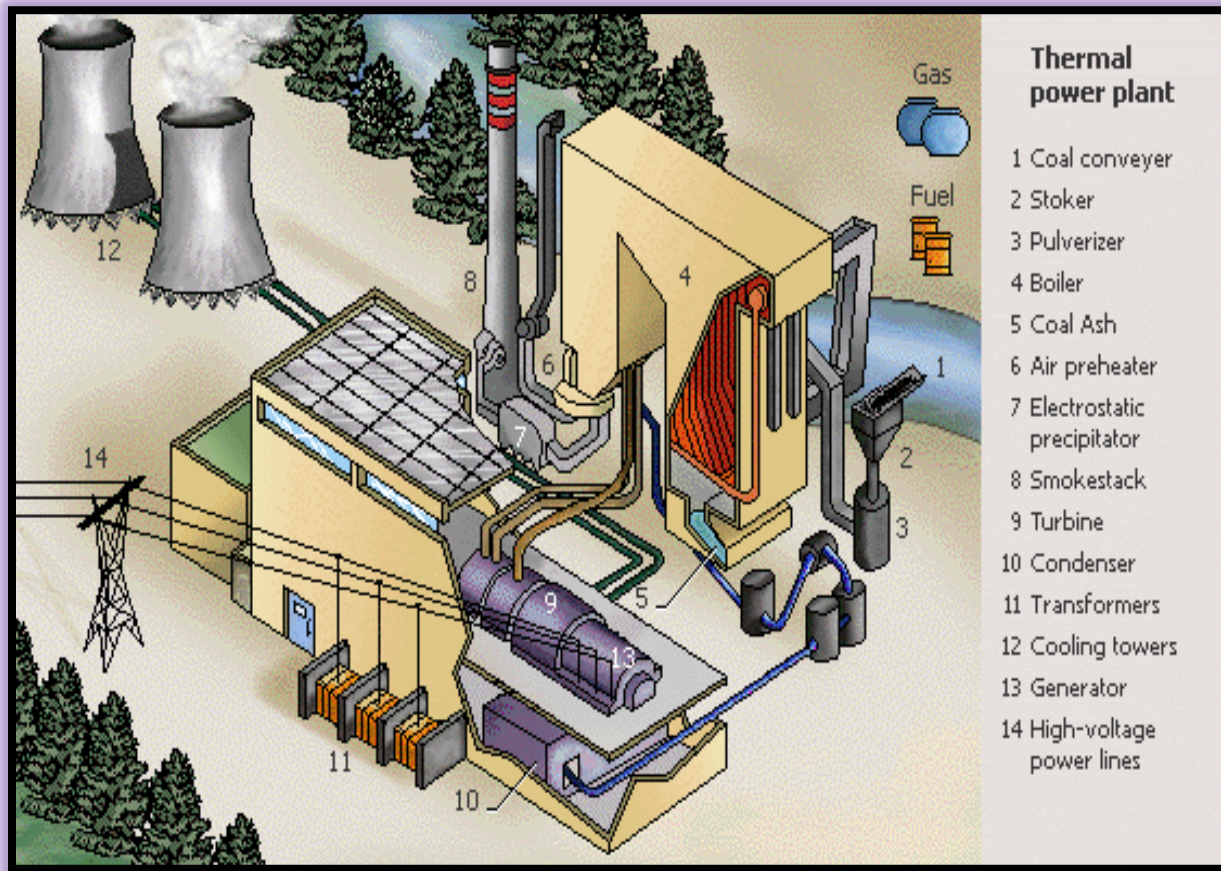
DIAGRAM OF THERMAL POWER PLANT

❖ Working process for Thermal Power Plant is as given below.

- 1)** Coal is conveyed with the help of Coal Conveyer from an external stack and ground to a very fine powder by large metal spheres in the pulverized fuel mill.
- 2)** There it is mixed with preheated air driven by the Forced draught fan.
- 3)** The hot air-fuel mixture is forced at High pressure into the Boiler where it rapidly ignites.
- 4)** Water of a high purity flows vertically up the tube-lined walls of the boiler, where it turns into steam, and is passed to the boiler drum, where steam is separated from any remaining water.

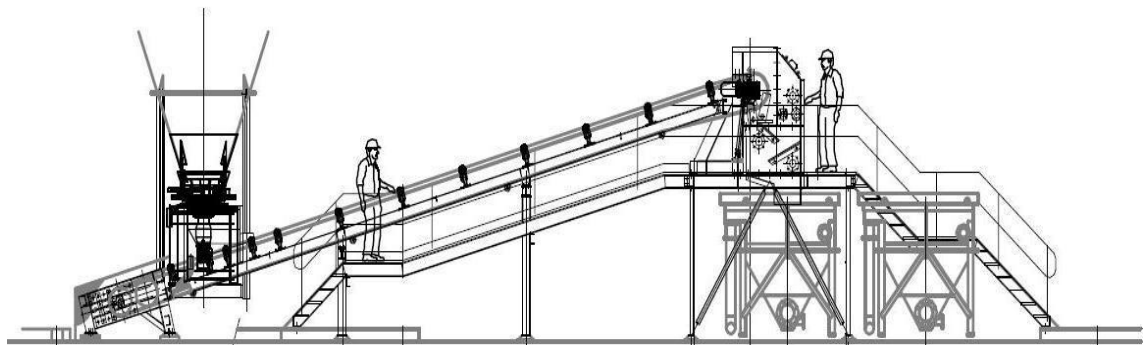
- 5)** The steam passes through a manifold in the roof of the drum into the pendant Super heater where its temperature and pressure increase rapidly to around 200 bar and 570°C, sufficient to make the tube walls glow a dull red.
- 6)** The steam is piped to the High-pressure turbine, the first of a three-stage turbine process.
- 7)** A Steam governor valve allows for both manual control of the turbine and automatic set point following.
- 8)** The steam is exhausted from the high-pressure turbine, and reduced in both pressure and temperature, is returned to the boiler Reheater.
- 9)** The reheated steam is then passed to the Intermediate pressure turbine, and from there passed directly to the low pressure turbine set.
- 10)** The exiting steam, now a little above its boiling point, is brought into thermal contact with cold water (pumped in from the cooling tower) in the Condenser, where it condenses rapidly back into water, creating near vacuum-like conditions inside the condenser chest.
- 11)** The condensed water is then passed by a feed pump through a Deaerator, and prewarmed, first in a feed heater powered by steam drawn from the high pressure set, and then in the Economizer, before being returned to the boiler drum.
- 12)** The cooling water from the condenser is sprayed inside a Cooling tower, creating a highly visible plume of water vapor, before being pumped back to the Condenser in cooling water cycle.
- 13)** The three turbine sets are coupled on the same shaft as the three-phase electrical Generator which generates an intermediate level voltage (typically 20-25 kV).
- 14)** This is stepped up by the unit Transformer to a voltage more suitable for transmission (typically 250-500 kV) and is sent out onto the Three-phase Transmission System.
- 15)** Exhaust gas from the boiler is drawn by the Induced draft fan through an Electrostatic Precipitator and is then vented through the Chimney stack.

MAIN PARTS OF THERMAL POWER PLANT



✿ **Coal Conveyer:**

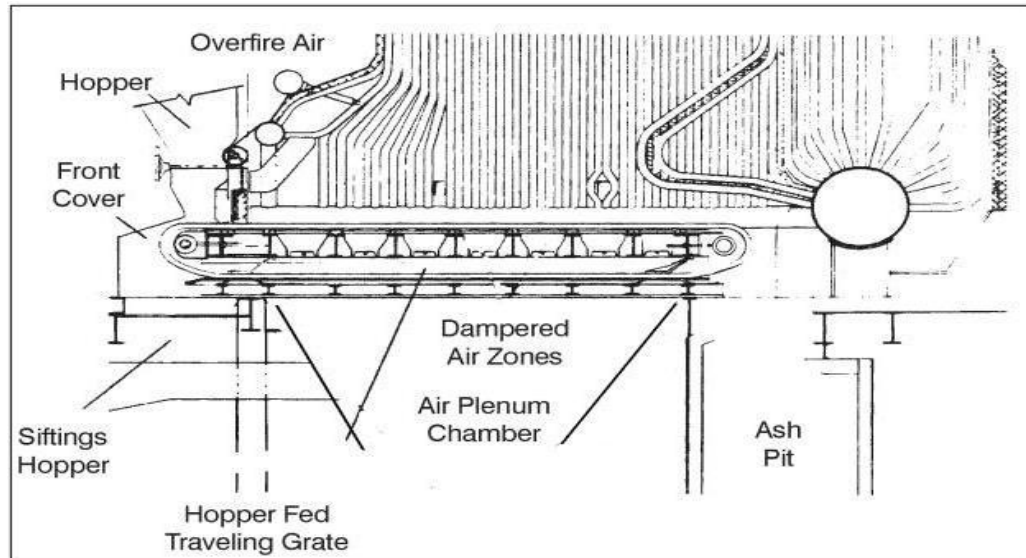
- This is a belt type of arrangement. With this coal is transported from coal storage place in power plant to the place nearby boiler.



COAL CONVEYER

♣ Stoker :

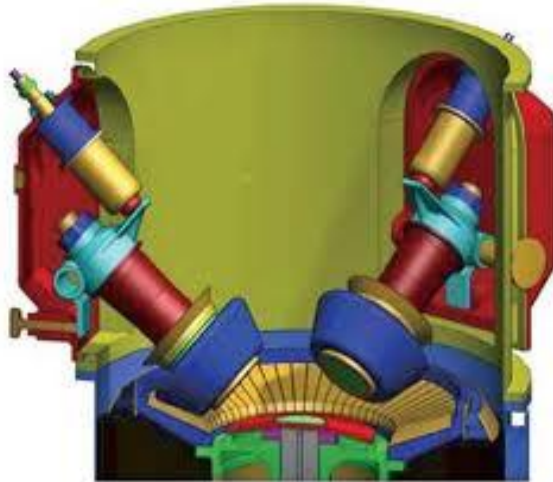
- The coal which is brought nearby boiler has to put in boiler furnace for combustion. This stoker is a mechanical device for feeding coal to a furnace.



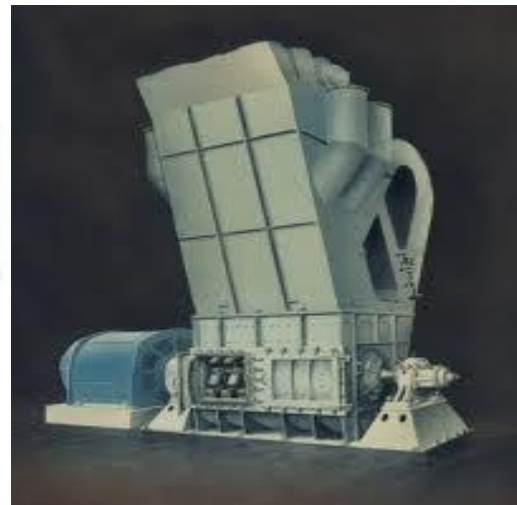
MASS FEED STOKER

♣ Pulverizer:

- The coal is put in the boiler after pulverization. For this pulverizer is used. A pulverizer is a device for grinding coal for combustion in a furnace in a power plant.



INTERNAL VIEW OF PULVERIZER



PULVERIZER

- *Types of Pulverizers :-*

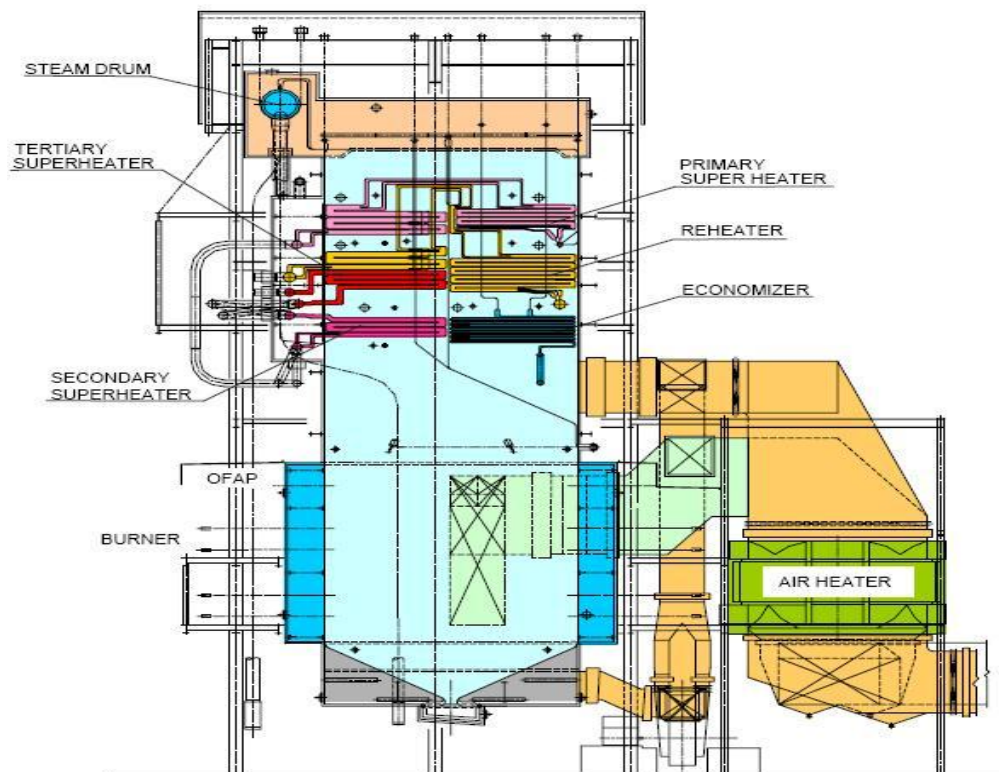
- ♣ **Ball and Tube Mill:-** Ball mill is a pulverizer that consists of a horizontal rotating cylinder, up to three diameters in length, containing a charge of tumbling or cascading steel balls, pebbles, or rods. Tube mill is a revolving cylinder of up to five diameters in length used for fine pulverization of ore,

rock, and other such materials; the material, mixed with water, is fed into the chamber from one end, and passes out the other end as slime.

- ✚ **Ring and Ball:** - This type consists of two rings separated by a series of large balls. The lower ring rotates, while the upper ring presses down on the balls via a set of spring and adjuster assemblies. Coal is introduced into the center or side of the pulverizer and is ground as the lower ring rotates causing the balls to orbit between the upper and lower rings. The coal is carried out of the mill by the flow of air moving through it. The size of the coal particles released from the grinding section of the mill is determined by a classifier separator. These mills are typically produced by Babcock & Wilcox Boiler.

✚ **Boiler :-**

- Now that pulverized coal is put in boiler furnace. Boiler is an enclosed vessel in which water is heated and circulated until the water is turned in to steam at the required pressure.



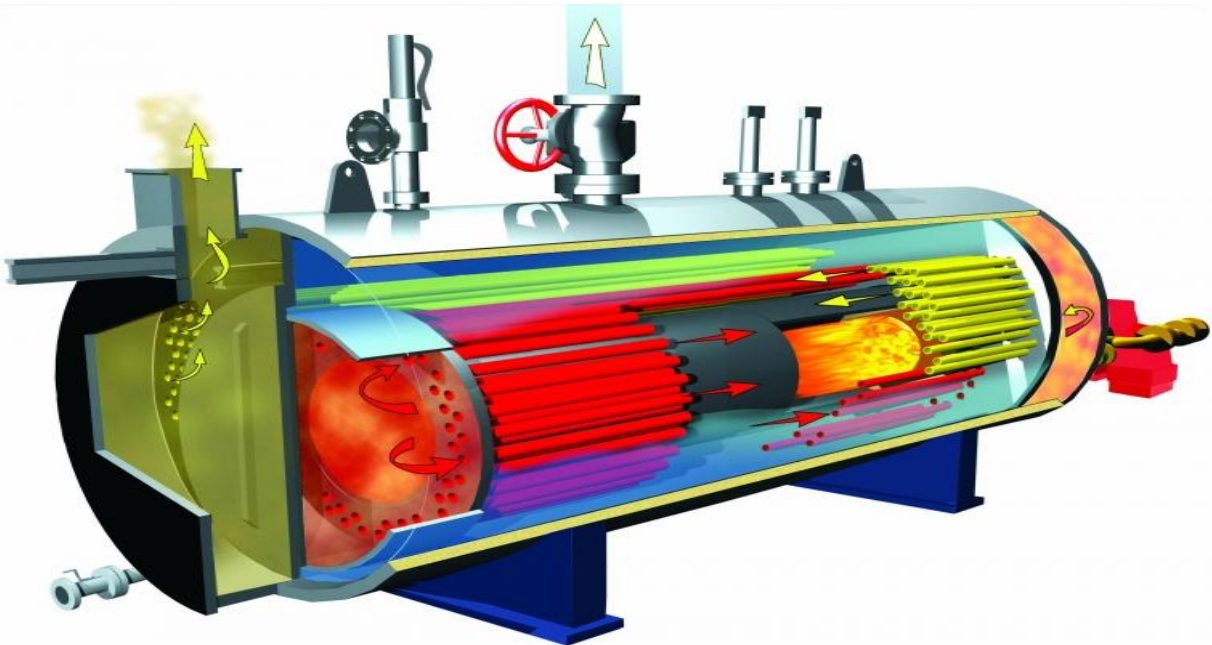
BOILER

- Coal is burned inside the combustion chamber of boiler. The products of combustion are nothing but gases. These gases which are at high temperature vaporize the water inside the boiler to steam. Some times this steam is further heated in a super

heater as higher the steam pressure and temperature the greater efficiency the engine will have in converting the heat in steam in to mechanical work.

- This steam at high pressure and temperature is used directly as a heating medium, or as the working fluid in a prime mover to convert thermal energy to mechanical work, which in turn may be converted to electrical energy. Although other fluids are sometimes used for these purposes, water is by far the most common because of its economy and suitable thermodynamic characteristics.
- *Classification of Boilers:-*

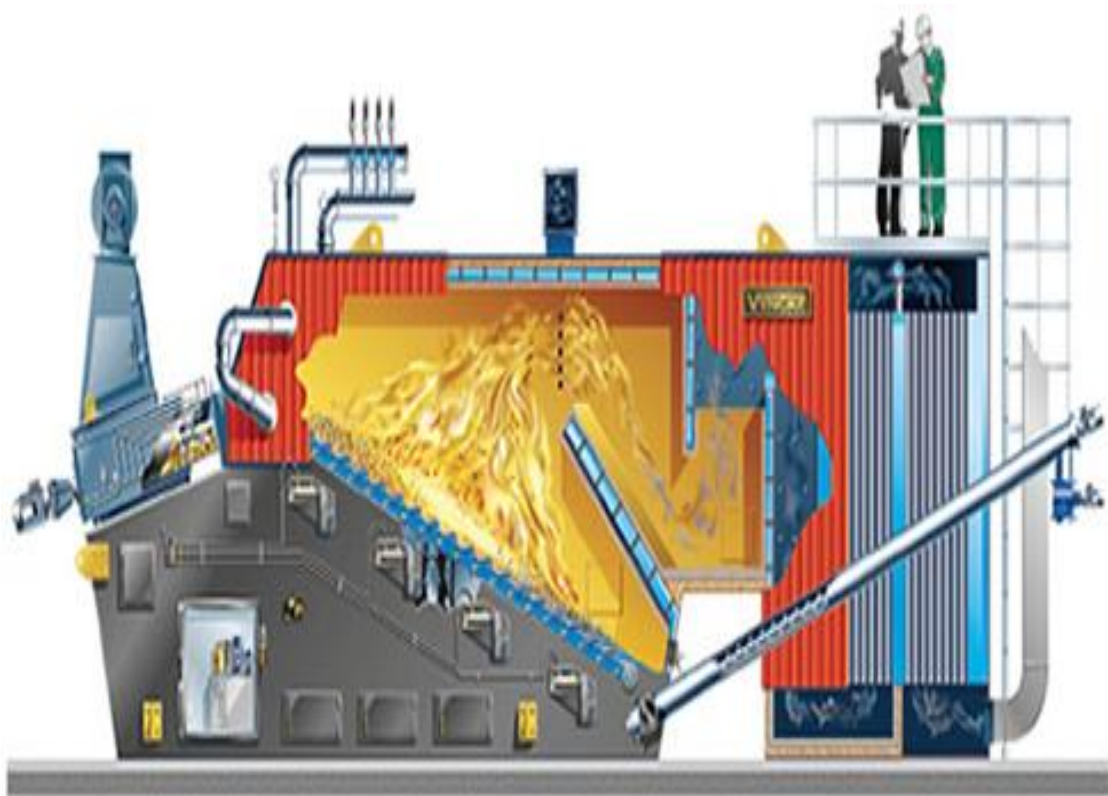
- ✚ **Fire tube Boilers:** In fire tube boilers hot gases are passed through the tubes and water surrounds these tubes. These are simple, compact and rugged in construction. Depending on whether the tubes are vertical or horizontal these are further classified as vertical and horizontal tube boilers. In this since the water volume is more, circulation will be poor. So they can't meet quickly the changes in steam demand. High pressures of steam are not possible, maximum pressure that can be attained is about 17.5kg/sq. cm. Due to large quantity of water in the drain it requires more time for steam raising. The steam attained is generally wet, economical for low pressures.



FIRE TUBE BOILER

- ✚ **Water tube Boilers:** In these boilers water is inside the tubes and hot gases are outside the tubes. They consist of drums and tubes. They may contain any number of drums. Feed water enters the boiler to one drum. This water circulates through the tubes connected external to drums. Hot gases which surround these tubes will convert the water in tubes in to steam. This steam

is passed through tubes and collected at the top of the drum since it is of light weight. So the drums store steam and water. The entire steam is collected in one drum and it is taken out from there. As the movement of water in the water tubes is high, so rate of heat transfer also becomes high resulting in greater efficiency. They produce high pressure, easily accessible and can respond quickly to changes in steam demand. These are also classified as vertical, horizontal and inclined tube depending on the arrangement of the tubes. These are of less weight and less liable to explosion. Large heating surfaces can be obtained by use of large number of tubes.



WATER TUBE BOILER

♣ **Various types of Turbines**

Principle of Operation and Design

An ideal steam turbine is considered to be an isentropic process, or constant entropy process, in which the entropy of the steam entering the turbine is equal to the entropy of the steam leaving the turbine. No steam turbine is truly “isentropic”, however, with typical isentropic efficiencies ranging from 20%-90% based on the application of the turbine. The interior of a turbine comprises several sets of blades, or “buckets” as they

are more commonly referred to. One set of stationary blades is connected to the casing and one set of rotating blades is connected to the shaft. The sets intermesh with certain minimum clearances, with the size and configuration of sets varying to efficiently exploit the expansion of steam at each stage.

Turbine efficiency

To maximize turbine efficiency the steam is expanded, generating work, in a number of stages. These stages are characterized by how the energy is extracted from them and are known as either impulse or reaction turbines. Most steam turbines use a mixture of the reaction and impulse designs: each stage behaves as either one or the other, but the overall turbine uses both. Typically, higher pressure sections are impulse type and lower pressure stages are reaction type.

Impulse turbines

An impulse turbine has fixed nozzles that orient the steam flow into high speed jets. These jets contain significant kinetic energy, which the rotor blades, shaped like buckets, convert into shaft rotation as the steam jet changes direction. A pressure drop occurs across only the stationary blades, with a net increase in steam velocity across the stage.

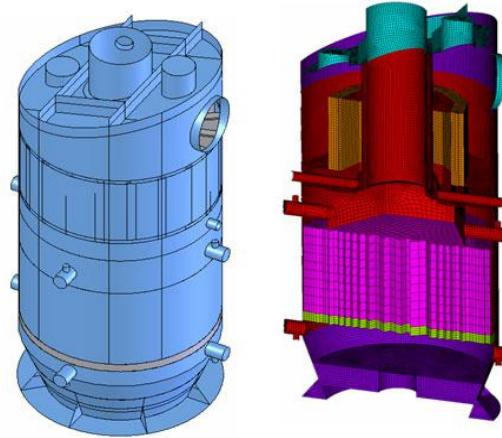
As the steam flows through the nozzle its pressure falls from inlet pressure to the exit pressure (atmospheric pressure, or more usually, the condenser vacuum). Due to this higher ratio of expansion of steam in the nozzle the steam leaves the nozzle with a very high velocity. The steam leaving the moving blades is a large portion of the maximum velocity of the steam when leaving the nozzle. The loss of energy due to this higher exit velocity is commonly called the "carry over velocity" or "leaving loss".

Reaction turbines

In the reaction turbine, the rotor blades themselves are arranged to form convergent nozzles. This type of turbine makes use of the reaction force produced as the steam accelerates through the nozzles formed by the rotor. Steam is directed onto the rotor by the fixed vanes of the stator. It leaves the stator as a jet that fills the entire circumference of the rotor. The steam then changes direction and increases its speed relative to the speed of the blades. A pressure drop occurs across both the stator and the rotor, with steam accelerating through the stator and decelerating through the rotor, with no net change in steam velocity across the stage but with a decrease in both pressure and temperature, reflecting the work performed in the driving of the rotor.

 **Super heater:**

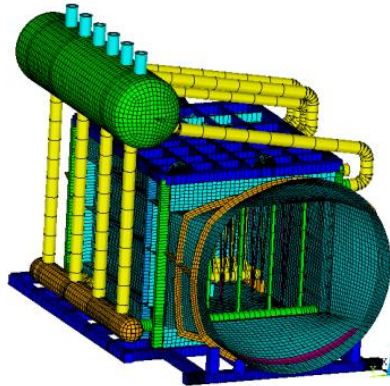
- Most of the modern boilers are having super heater and reheater arrangement. Super heater is a component of a steam-generating unit in which steam, after it has left the boiler drum, is heated above its saturation temperature. The amount of superheat added to the steam is influenced by the location, arrangement, and amount of super heater surface installed, as well as the rating of the boiler. The super heater may consist of one or more stages of tube banks arranged to effectively transfer heat from the products of combustion.



SUPER HEATER

♣ Reheater :

- Some of the heat of superheated steam is used to rotate the turbine where it loses some of its energy. The steam after reheating is used to rotate the second steam turbine where the heat is converted to mechanical energy. This mechanical energy is used to run the alternator, which is coupled to turbine, there by generating electrical energy.

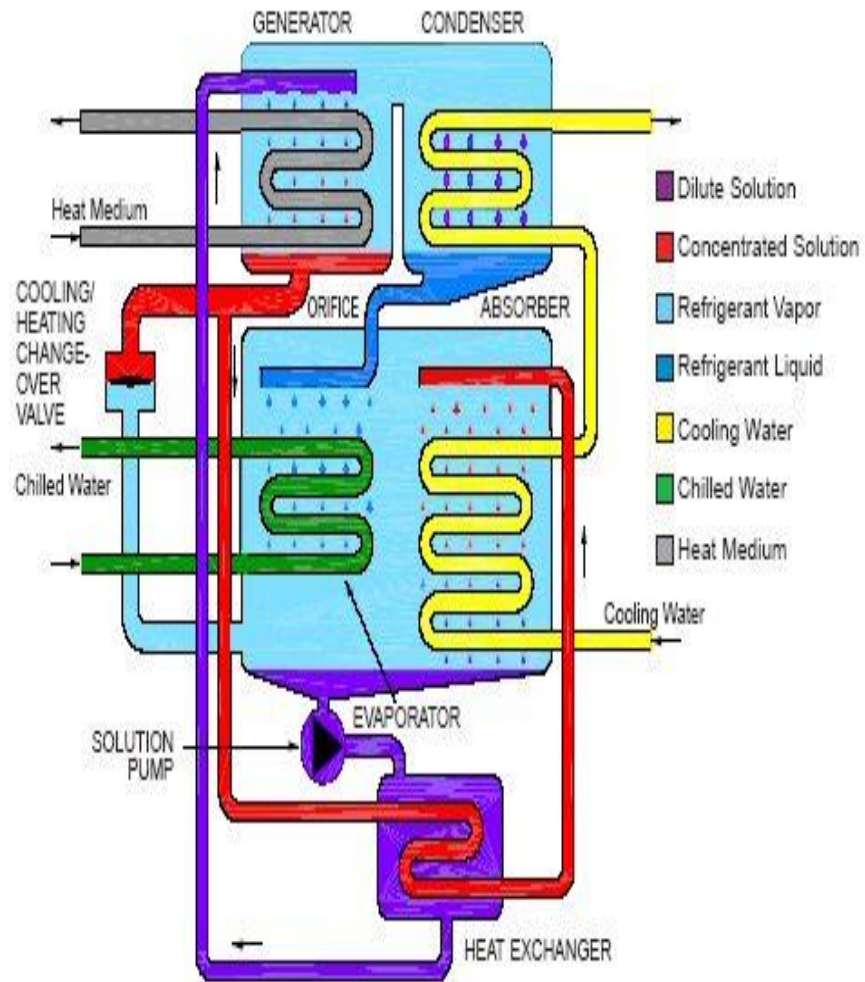


REHEATER

♣ Condenser:

- Steam after rotating steam turbine comes to condenser. Condenser refers here to the shell and tube heat exchanger installed at the outlet of every steam

turbine in Thermal power stations of utility companies generally. These condensers are heat exchangers which convert steam from its gaseous to its liquid state, also known as phase transition. In so doing, the latent heat of steam is given out inside the condenser. Where water is in short supply an air cooled condenser is often used. An air cooled condenser is however significantly more expensive and cannot achieve as low a steam turbine backpressure as a surface condenser.



COOLING CYCLE FOR CONDENSER

❁ Cooling Towers :

- The condensate formed in the condenser after condensation is initially at high temperature. This hot water is passed to cooling towers. It is a tower- or building-like device in which atmospheric air circulates in direct or indirect contact with warmer water and the water is thereby cooled. A cooling tower may serve as the heat sink in a conventional thermodynamic process, such as refrigeration or steam power generation, and when it is convenient or desirable to make final heat rejection to atmospheric air. Water, acting as the heat-

transfer fluid, gives up heat to atmospheric air, and thus cooled, is recirculated through the system, affording economical operation of the process.

- Two basic types of cooling towers are commonly used. One transfers the heat from warmer water to cooler air mainly by an evaporation heat-transfer process and is known as the Evaporative or Wet Cooling Tower. Evaporative cooling towers are classified according to the means employed for producing air circulation through them, atmospheric, natural draft, and mechanical draft. The other transfers the heat from warmer water to cooler air by a sensible heat-transfer process and is known as the No Evaporative or Dry Cooling Tower.

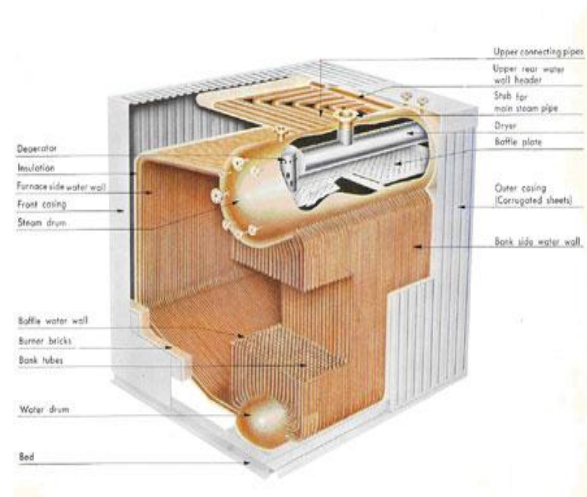


COOLING TOWER

Economizer :

- Flue gases coming out of the boiler carry lot of heat. Function of economizer is to recover some of the heat from the heat carried away in the flue gases up the chimney and utilize for heating the feed water to the boiler. It is placed in the passage of flue gases in between the exit from the boiler and the entry to the chimney. The use of economizer results in saving in coal consumption, increase in steaming rate and high boiler efficiency but needs extra investment and

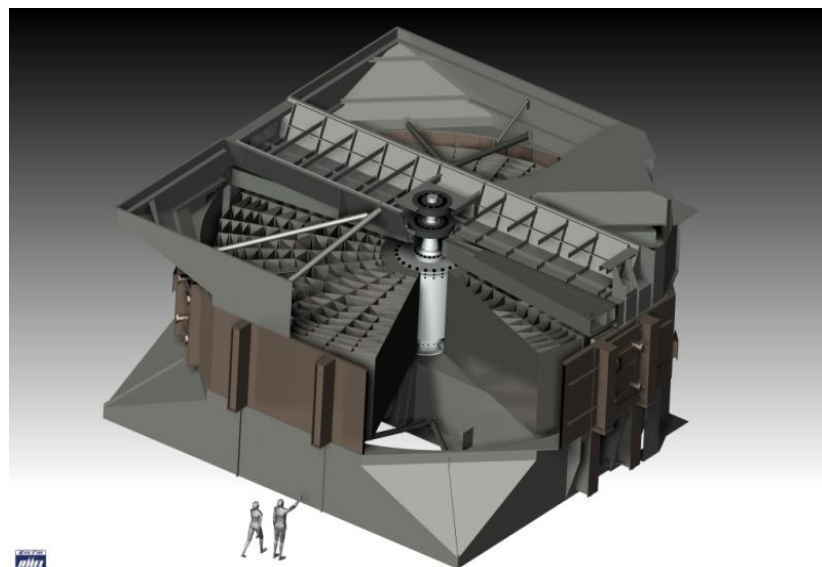
increase in maintenance costs and floor area required for the plant.



ECONOMIZER

Air preheater :

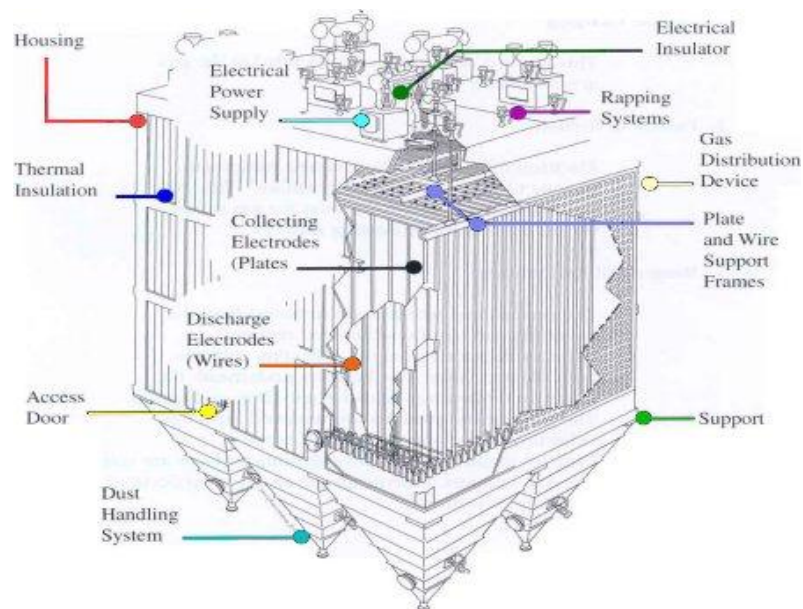
- The remaining heat of flue gases is utilized by air preheater. It is a device used in steam boilers to transfer heat from the flue gases to the combustion air before the air enters the furnace. Also known as air heater; air-heating system. It is not shown in the lay out. But it is kept at a place nearby where the air enters in to the boiler. The purpose of the air preheater is to recover the heat from the flue gas from the boiler to improve boiler efficiency by burning warm air which increases combustion efficiency, and reducing useful heat lost from the flue. After extracting heat flue gases are passed to electrostatic precipitator.



AIR PREHEATER

✿ Electrostatic Precipitator :

- It is a device which removes dust or other finely divided particles from flue gases by charging the particles inductively with an electric field, then attracting them to highly charged collector plates. Also known as precipitator. The process depends on two steps. In the first step the suspension passes through an electric discharge area where ionization of the gas occurs. The charged particles drift toward an electrode of opposite sign and are deposited on the electrode where their electric charge is neutralized. The use of electrostatic precipitators has become common in numerous industrial applications. Among the advantages of the electrostatic precipitator are its ability to handle large volumes of gas, at elevated temperatures if necessary, with a reasonably small pressure drop, and the removal of particles in the micrometer range.



ELECTOSTATIC PRECIPETATOR

✿ Boiler feed pump

Boiler feed pump is a multi stage pump provided for pumping feed water to economiser. BFP is the biggest auxiliary equipment after Boiler and Turbine. It consumes about 4 to 5 % of total electricity generation.

✿ Cooling tower

The cooling tower is a semi-enclosed device for evaporative cooling of water by contact with air. The hot water coming out from the condenser is fed to the tower on the top and allowed to

tickle in form of thin sheets or drops. The air flows from bottom of the tower or perpendicular to the direction of water flow and then exhausts to the atmosphere after effective cooling.

The cooling towers are of 4 types: -

1. Natural Draft cooling tower
2. Forced Draft cooling tower
3. Induced Draft cooling tower
4. Balanced Draft cooling tower

♣ **Fan or draught system**

In a boiler it is essential to supply a controlled amount of air to the furnace for effective combustion of fuel and to evacuate hot gases formed in the furnace through the various heat transfer area of the boiler. This can be done by using a chimney or mechanical device such as fans which acts as pump.

i) Natural draught

When the required flow of air and flue gas through a boiler can be obtained by the stack (chimney) alone, the system is called natural draught. When the gas within the stack is hot, its specific weight will be less than the cool air outside; therefore the unit pressure at the base of stack resulting from weight of the column of hot gas within the stack will be less than the column of extreme cool air. The difference in the pressure will cause a flow of gas through opening in base of stack. Also the chimney is form of nozzle, so the pressure at top is very small and gases flow from high pressure to low pressure at the top.

ii) Mechanized draught

There are 3 types of mechanized draught systems

- 1) Forced draught system
- 2) Induced draught system
- 3) Balanced draught system

Forced draught: – In this system a fan called Forced draught fan is installed at the inlet of the boiler. This fan forces the atmospheric air through the boiler furnace and pushes out the hot gases from the furnace through superheater, reheater, economiser and air heater to stacks.

Induced draught: – Here a fan called ID fan is provided at the outlet of boiler, that is, just before the chimney. This fan sucks hot gases from the furnace through the superheaters, economiser, reheater and discharges gas into the chimney. This results in the furnace pressure lower than atmosphere and affects the flow of air from outside to the furnace.

Balanced draught:-In this system both FD fan and ID fan are provided. The FD fan is utilized to draw control quantity of air from atmosphere and force the same into furnace. The ID fan sucks the product of combustion from furnace and discharges into chimney. The point where draught is zero is called balancing point.

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♣ Ash handling system

The disposal of ash from a large capacity power station is of same importance as ash is produced in large quantities. Ash handling is a major problem.

i) Manual handling: While barrows are used for this. The ash is collected directly through the ash outlet door from the boiler into the container from manually.

ii) Mechanical handling: Mechanical equipment is used for ash disposal, mainly bucket elevator, belt conveyer. Ash generated is 20% in the form of bottom ash and next 80% through flue gases, so called Fly ash and collected in ESP.

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iii) Electrostatic precipitator: From air preheater this flue gases (mixed with ash) goes to ESP. The precipitator has plate banks (A-F) which are insulated from each other between which the flue gases are made to pass. The dust particles are ionized and attracted by charged electrodes. The electrodes are maintained at 60KV. Hammering is done to the plates so that fly ash comes down and collect at the bottom. The fly ash in dry form is used in cement manufacture.

♣ Smoke Stack (Chimney) :

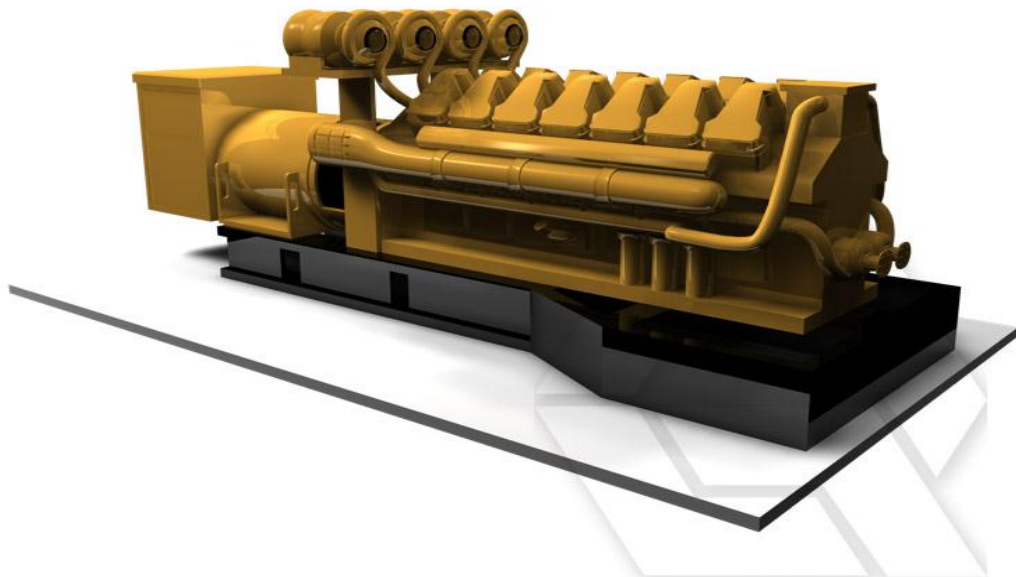
- A chimney is a system for venting hot flue gases or smoke from a boiler, stove, furnace or fireplace to the outside atmosphere. They are typically almost vertical to ensure that the hot gases flow smoothly, drawing air into the combustion through the chimney effect. The space inside a chimney is called flu. In the US, the term smokestack is also used when referring to locomotive chimneys. The term funnel is generally used for ship chimneys and sometimes used to refer to locomotive chimneys.



SMOKE STACK (CHIMNEY)

 Generator:

- An alternator is an electromechanical device that converts mechanical energy to alternating current electrical energy. Most alternators use a rotating magnetic field. In principle, any AC generator can be called an alternator, but usually the word refers to small rotating machines driven by automotive & other internal combustion engines.



GENERATOR

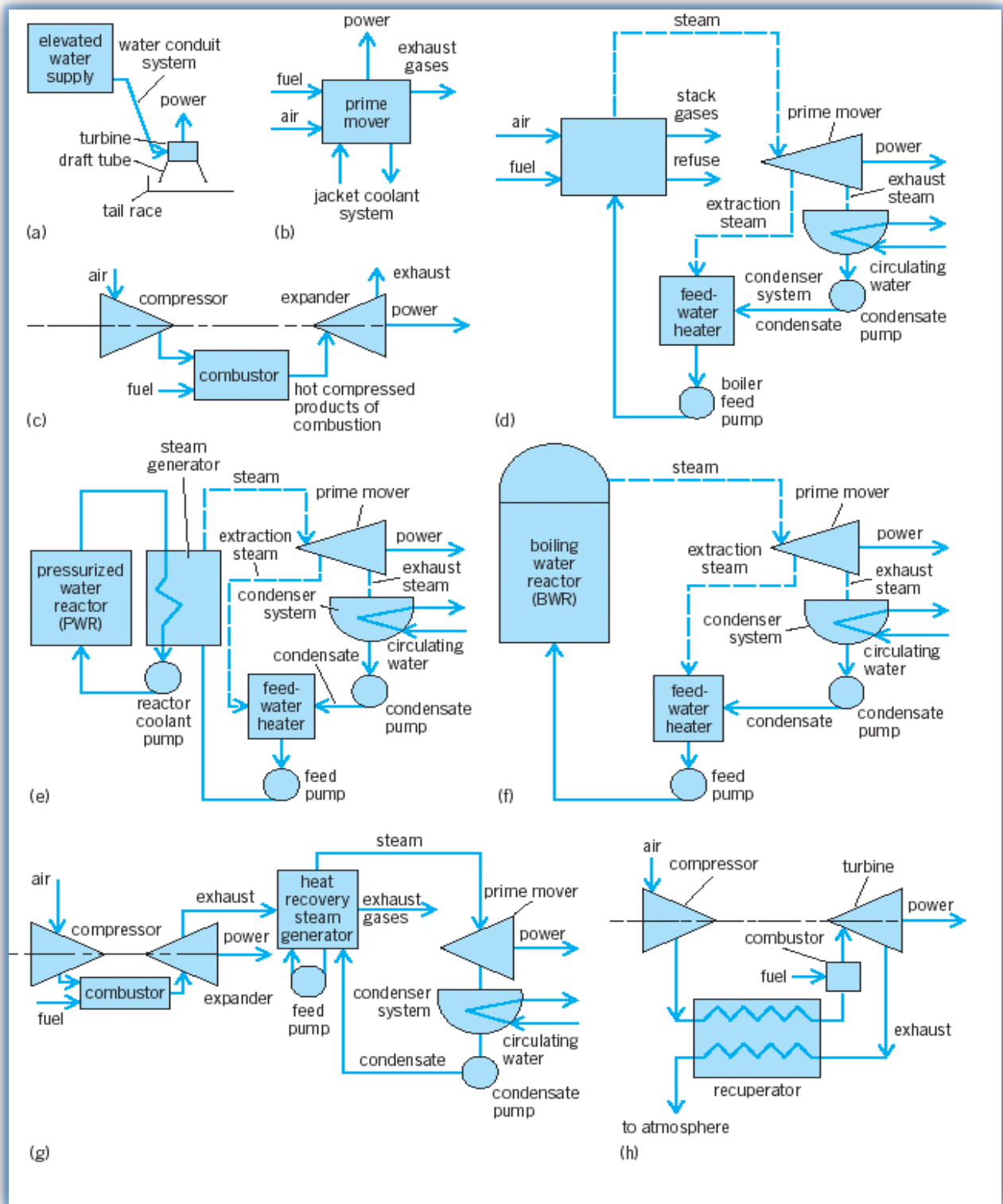
✿ Transformers :

- It is a device that transfers electric energy from one alternating-current circuit to one or more other circuits, either increasing or reducing the voltage. Uses for transformers include reducing the line voltage to operate low-voltage devices and raising the voltage from electric generators so that electric power can be transmitted over long distances. Transformers act through electromagnetic induction, current in the primary coil induces current in the secondary coil.



TRANSFORMER

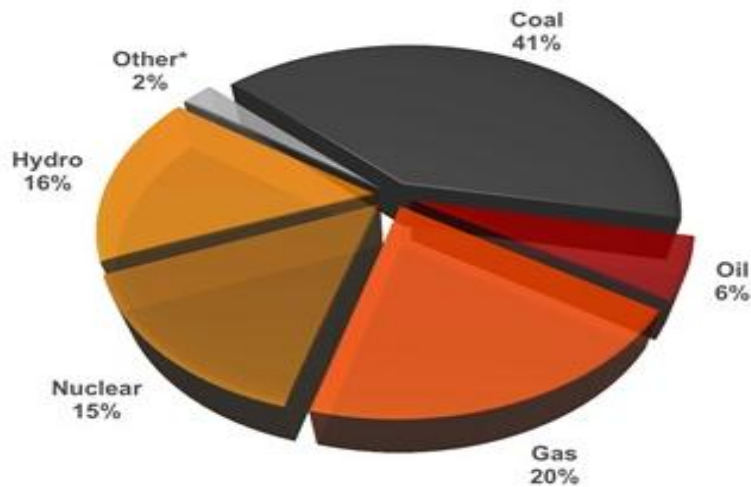
FLOW CHART FOR THERMAL POWER PLANT



TYPES OF COALS ARE USE IN COAL-FIRED THERMAL POWER PLANT

- ❖ Coal is classified into four general categories, or "ranks." They range from lignite through subbituminous and bituminous to anthracite, reflecting the progressive response of individual deposits of coal to increasing heat and pressure. The carbon content of coal supplies most of its heating value, but other factors also influence the amount of energy it contains per unit of weight. (The amount of energy in coal is expressed in British thermal units per pound. A BTU is the amount of heat required to raise the temperature of one pound of water one degree Fahrenheit.)
 - ❖ About 90 percent of the coal in this country falls in the bituminous and subbituminous categories, which rank below anthracite and, for the most part, contain less energy per unit of weight. Bituminous coal predominates in the Eastern and Mid-continent coal fields, while subbituminous coal is generally found in the Western states and Alaska.
 - ❖ Lignite ranks the lowest and is the youngest of the coals. Most lignite is mined in Texas, but large deposits also are found in Montana, North Dakota, and some Gulf Coast states.
1. **Anthracite:**-Anthracite is coal with the highest carbon content, between 86 and 98 percent, and a heat value of nearly 15,000 BTUs-per-pound. Most frequently associated with home heating, anthracite is a very small segment of the U.S. coal market. There are 7.3 billion tons of anthracite reserves in the United States, found mostly in 11 northeastern counties in Pennsylvania.
 2. **Bituminous:**-The most plentiful form of coal in the United States, bituminous coal is used primarily to generate electricity and make coke for the steel industry. The fastest growing market for coal, though still a small one, is supplying heat for industrial processes. Bituminous coal has a carbon content ranging from 45 to 86 percent carbon and a heat value of 10,500 to 15,500 BTUs-per-pound.
 3. **Subbituminous:**-Ranking below bituminous is subbituminous coal with 35-45 percent carbon content and a heat value between 8,300 and 13,000 BTUs-per-pound. Reserves are located mainly in a half-dozen Western states and Alaska. Although its heat value is lower, this coal generally has a lower sulfur content than other types, which makes it attractive for use because it is cleaner burning.
 4. **Lignite:**-Lignite is a geologically young coal which has the lowest carbon content, 25-35 percent, and a heat value ranging between 4,000 and 8,300 BTUs-per-pound. Sometimes called brown coal, it is mainly used for electric power generation.

PRESENT STATUS OF COAL-FIRED THERMAL POWER PLANT



Source: IEA 2008

*other includes solar, wind, combustible renewables, geothermal & waste.

- ❖ Modern life is unimaginable without electricity. It lights houses, buildings, streets, provides domestic and industrial heat, and powers most equipment used in homes, offices and machinery in factories. Improving access to electricity worldwide is critical to alleviating poverty.
- ❖ Coal plays a vital role in electricity generation worldwide. Coal-fired power plants currently fuel 41% of global electricity. In some countries, coal fuels a higher percentage of electricity.

Coal in Electricity Generation		
South Africa 93%	Poland 92%	PR China 79%
Australia 77%	Kazakhstan 70%	India 69%
Israel 63%	Czech Rep 60%	Morocco 55%
Greece 52%	USA 49%	Germany 46%

Source: IEA 2010

- ❖ The importance of coal to electricity generation worldwide is set to continue, with coal fuelling 44% of global electricity in 2030.

THERMAL POWER PLANTS IN INDIA

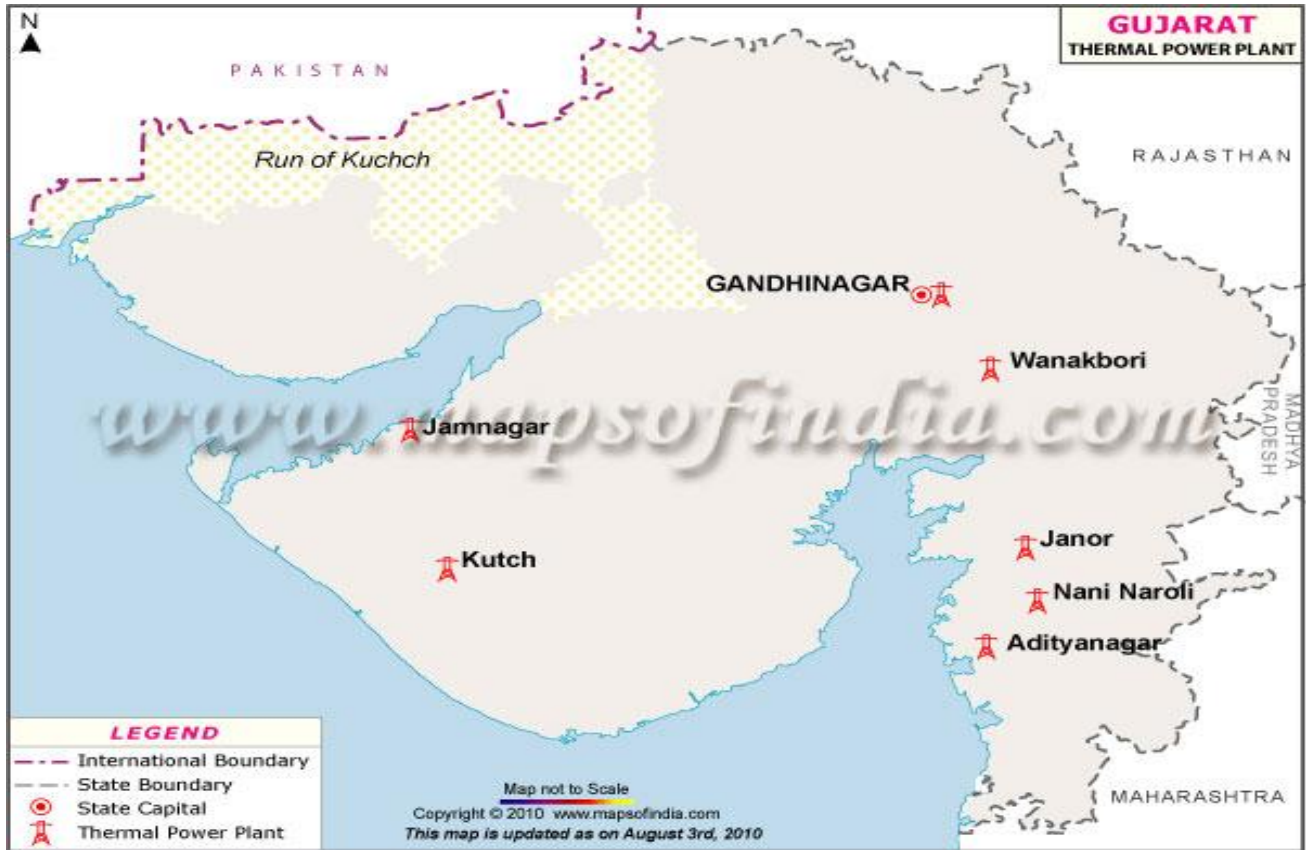


- ❖ More than 50% of India's commercial energy demand is met through the country's vast coal reserves. Public sector undertaking National Thermal Power Corporation (NTPC)

and several other state level power generating companies are engaged in operating coal based Thermal Power Plants.

- ❖ Apart from NTPC and other state level operators, some private companies are also operating the power plants. As on July 31, 2010, and as per the Central Electricity Authority the total installed capacity of Coal or Lignite based power plants in India are 87093.38 MW.
- ❖ Major thermal power plants in India are following:-
 - ✚ **Anpara thermal power station- Uttar Pradesh:**-Located on the banks of rihand reservoir in the district of Sonebhadra in Uttar Pradesh the Anpara thermal power station is a coal fired thermal power plant. This thermal power plant has 5 operational units with a total installed capacity of 500 MW.
 - ✚ **Bakreswar Thermal Power Project - West Bengal:**-It is situated at a distance of just 260 Km away from Kolkata. The project has clear rail track access via Chinpai on the Andal-Sinthia Line of Eastern Railways. The Bakreswar Thermal Power Project is running with five operational units having total installed capacity of 1050 MW.
 - ✚ **Panipat Thermal Power Station II:**-A coal based Thermal Power Plants in India the Panipat Thermal Power Station II is located in Panipat in Haryana. Developed under four stages this thermal power plant has 8 units in total with an installed capacity of 250 MW.
 - ✚ **Deenbandhu Chhotu Ram Thermal Power Station:**-A coal based power plant of HPGCL the Deenbandhu Chhotu Ram Thermal Power Plant is located at Yamunagar in Haryana. Commissioned in April 2008 with its first unit today this power plant has two units with a total installed capacity of 600 MW.
 - ✚ **Rajiv Gandhi Thermal Power Station:**-The Rajiv Gandhi Thermal Power Station is situated in Kedar in the Hisar district of Haryana. One of the lowest costing power projects in India so far this power plant is a coal based power plants of HPGCL. This thermal power plant has 2 units with a total installed capacity of 600 MW.
 - ✚ **Kota Super Thermal Power Plant:**-Situated on the bank of River Chambal near Kota in Rajasthan. Known as one of the most efficient and prestigious thermal power plants in India the Kota Super Thermal Power Plant .This thermal power plant has 28 units with an installed capacity of 1240 MW.

THERMAL POWER PLANTS IN GUJARAT

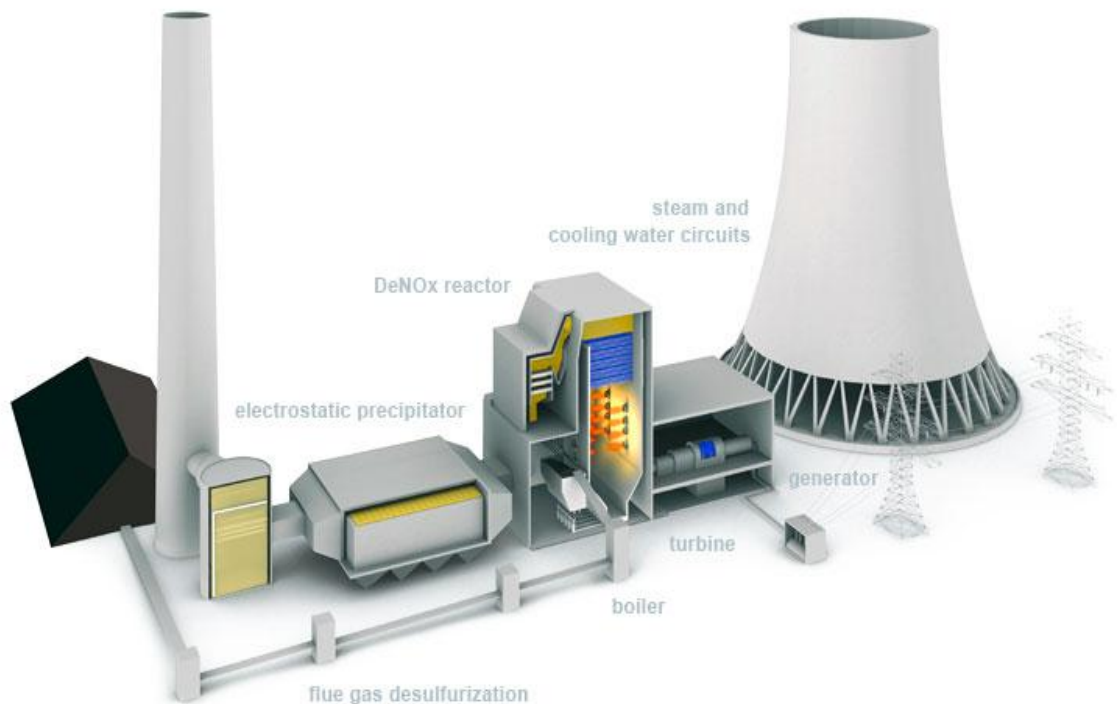


Following are the major Thermal Power Plants in Gujarat:-

SR.NO.	Name of Power Stations	No. of Units	Total MW/ Station
1	Gandhinagar Thermal Power Station	i. 2x120 ii. 3x210	870
2	Ukai Thermal Power Station	i. 2x120 ii. 2x200 iii. 1x210	850
3	Wanakbori Thermal Power Station	7x210	1470
4	Sikka Thermal Power Station	2x120	240
5	Dhuvaran Thermal Power Station	2x110	220

ADVANTAGES OF THERMAL POWER PLANT

- ♠ The fuel used is quite cheap.
- ♠ Less initial cost as compared to other generating plants.
- ♠ Less initial cost as compared to other generating plants.
- ♠ 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 rail or road.
- ♠ It requires less space as compared to Hydro power plants.
- ♠ Cost of generation is less than that of diesel power plants.
- ♠ Steam plants can withstand for overload for certain extent.
- ♠ Thermal plants are able to respond to the load demand more effectively and support the performance of the electrical grid.



VIRTUAL VIEW OF THERMAL POWER PLANT

DISADVANTAGES OF THERMAL POWER PLANT

- ♠ Higher maintenance and operational costs.
- ♠ Pollution of the atmosphere.
- ♠ Huge requirement of water.
- ♠ Handling of coal and disposal of ash is quite difficult and requires large area.
- ♠ Gestation period (period for commissioning of plant) takes long time.
- ♠ Efficiency of thermal plant is quite less (30-35%).
- ♠ Operational cost of thermal plant is more costly compared to hydro and nuclear plant.



POLLUTION FROM THERMAL POWER PLANT

COMPARISON OF THERMAL POWER PLANT WITH OTHER

SR. NO.	ITEM	THERMAL POWER PLANT	HYDRO POWER PLANT	SOLAR POWER PLANT	NUCLEAR POWER PLANT
1.	Simplicity	Complicated.	Simple and easy to construct.	Much easier than Hydro Power.	Much complicated than thermal Power.
2.	Cost	<p>a) Initial little bit less required compare to Hydro Power.</p> <p>b) Running cost is more because importing coal.</p>	<p>a) Initial cost is more required for huge dam construction.</p> <p>b) Running cost is nil.</p>	<p>a) Initial cost is more for setting up solar panels.</p> <p>b) Running cost is nil.</p>	<p>a) Initial cost required more to build safe nuclear reactor.</p> <p>b) Running cost is minimum only required for importing nuclear fuel and small amount of fuel is enough to generate power.</p>
3.	Fuel	Coal.	Water.	Sun Ray.	Nuclear fuel like Uranium, Thorium.
4.	Fuel import	Is required and will be imported. Cost required is more because of huge amount of coal consumption.	Naturally available and cost is nil. Depends on rainfall.	Naturally available during Day time and cost required is nil.	Nuclear fuel is imported and safety maintained because of radioactive rays. Cost required is less because low consumption of fuel.
5.	Pollution and Danger	Pollution is more and dangerous to human health because of released of poisonous gases in air.	Nil	Nil	Radioactive pollution and dangerous to Human health.