UNIT-I: Thermal Power Stations

Selection of site, general layout of a thermal power plant showing paths of coal, steam, water, air, ash and flue gasses, ash handling system, Brief description of components : Boilers, Super heaters, Economizers, electrostatic precipitators, steam Turbines : Impulse and reaction turbines, Condensers, feed water circuit, Cooling towers and Chimney.

Site selection of Thermal Power plant

Following important factors to be considered for the selection of site for thermal power plants are as follows:

1) **Availability of coal**:

The major source of energy which is available in India for thermal power plants is coal. Therefore, it is necessary to concentrate for the best use of coal for power generation. The huge quantity of coal is required for large thermal power stations. A thermal power plant of 400 MW capacity requires 5000 to 6000 tons of coal per day. Therefore, it is necessary to install the power station near the coal mines. In this case, the power generation must be transported to the long distances therefore, it is necessary to find the location which will give the lowest cost considering the coal transport and power transmission charge.

2) **Ash Disposal Facilities:**

The ash removal problem has become more serious particularly in India because the coal used for power generation contains large percentages of ash(20 to 40%). The quantity of ash to be handled is as large as 1500 to 2000 tons per day. The ash handling problem is more serious than coal handling because it comes out in hot condition and it is highly corrosive. Its effect on atmospheric pollution is more serious as the human health is concerned. Therefore there must be sufficient space dispose of large quantity of ash. A 400 MW power station requires nearly 10 hectares area per year if the ash is dumped to a height of 6.5 meters. The ash can be easily disposed off to river ,sea or lake economically if such facilities are available at plant site. Presently the ash from the power plants is used for many industrial processes, therefore, the question of its disposal to sea or river does not arise.

3) **Space Requirement:**

The average land requirement is 3 to 5 acres per MW capacity which includes the space required for coal storage, ash disposal, staff colony, market facilities and the space required for whole machinery. Generally the space occupied in 10% of the buildings, 33% for coal storage,27% for cooling towers,7% for switch yard and 235 for other purposes. The cost of land adds in the final cost of the plant therefore it should be available at cheap rates.

4) **Nature of Land**:

The selected site for the power plant should have good bearing capacity as it has to withstand the dead load of the plant and forces transmitted to the foundation due to machine operations. The minimum bearing capacity of the land should be 10 bar.

5) **Availability of water**:

Large quantities of water are required for condenser, for disposal of ash and as feed water to the boiler and drinking water to the working staff. The quantity of cooling water required in the condenser condensing the steam coming out from the turbines of 60 MW capacity plant is of the order of 20 to 30 thousand tons per hour if it discharged to the lower side of the river. If the cooling towers are used, then the makeup water required is also 500 to 600 tons per hour. It is therefore, necessary to locate the power plant near the water source which will able to supply the required quantity of water throughout the year.

6) **Transport Facilities**:

It is always necessary to have a railway line available near the power station for bringing in heavy machinery for installation and for bringing the coal. It is always thought that the site of thermal power plant near the coal pit-head is more economical than selecting the site near the load centre.

7) **Availability of labour**:

Cheap labour should be available at the proposed site as enough labour is required during construction of the plant.

8) **Public Problems**:

The proposed site should be far away from the towns to avoid the nuisance from smoke, fly ash and heat discharge from the power plant.

9) **Size of the Plant**:

In small capacity plants, the cost of getting fuel into the plant and ease of water supply are relatively insignificant factors and the problem of the plant location reduces almost entirely to an electric transmission problem. Other things being equal, the plant must be located at such a point that the investment in electric cables for transmitting the power together with annual operating costs should be minimum.

Advantages of Thermal Power plant

1) Thermal power plant can be located near the load centre if water source available near the site.
2) They can respond quickly against change of load without difficulty.
3) The power plant does not depend on natural sites available and hydrological cycle in that country as hydro power plant.
4) Thermal power plant is more flexible to use any types of boilers and fuels.The FBC boiler can be used with any types of low grade fuel including municipal wastes and therefore it is a cheaper method of power generation.
5) A portion of steam generated can be used a process steam in different industries.
6) The steam turbine can be work under 25% of overload continuously.
7) Thermal power plant requires less investment cost compared to hydro electric power plants.
8) Less space is required compare to hydro electric power plants.
9) Thermal efficiency of thermal power plant can be increased when it works conjunctions with gas turbine power plant.
10) Thermal power plant requires less time for installation compared to hydro electric power plant.

11) The application of thermal power plant is most economical if sited near coal mines and by the side of river or canal.

1.6.2 Disadvantages of Thermal Power plant

1) Thermal power plant requires large quantity of water for boiler and condenser.

2) The fuel transportation cost is high especially when the power plants are away from coal lines and has no railway siding.

3) It has a very high operating cost compared to hydro and nuclear power plants.

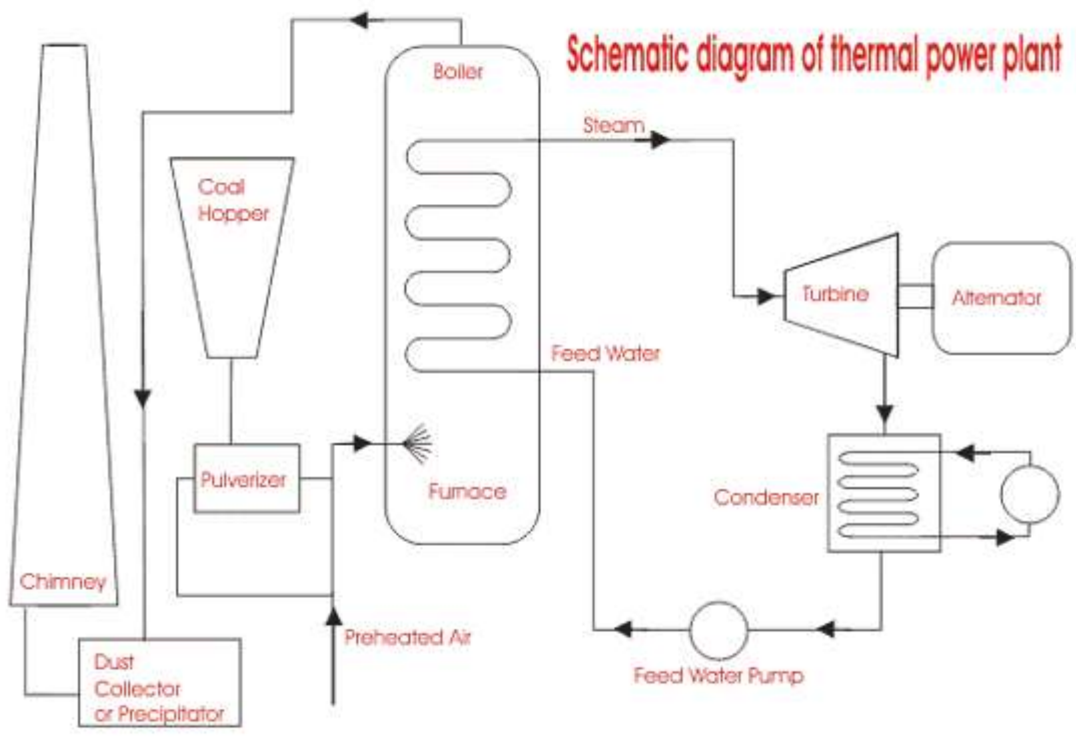
4) The thermal power plant pollutes the atmosphere by fumes, and residues of pulverized fuels.

5) The thermal power plant requires large number of equipments compared to other power plants, hence plant becomes very complex.

6) In thermal power plant, there is great difficulty experienced in coal handling.

7) The thermal power plant is less efficient below 75% of load.

8) The thermal power plant requires long times for erection and putting into action.



Coal: In a coal based thermal power plant, coal is transported from coal mines to the generating station. Generally, bituminous coal or brown coal is used as fuel. The coal is stored in either 'dead storage' or in 'live storage'. Dead storage is generally 40 days backup coal storage which is used when coal supply is unavailable. Live storage is a raw coal bunker in boiler house. The coal is cleaned in a magnetic cleaner to filter out if any iron particles are present which may cause wear and tear in the equipment. The coal from live storage is first crushed in small particles and then taken into pulverizer to make it in powdered form. Fine powdered coal undergoes complete combustion, and thus pulverized coal improves efficiency of the boiler. The ash produced after the combustion of coal is taken out of the boiler furnace and then properly disposed. Periodic removal of ash from the boiler furnace is necessary for the proper combustion.

Boiler: The mixture of pulverized coal and air (usually preheated air) is taken into boiler and then burnt in the combustion zone. On ignition of fuel a large fireball is formed at the center of the boiler and large amount of heat energy is radiated from it. The heat energy is utilized to convert the water into steam at high temperature and pressure. Steel tubes run along the boiler walls in which water is converted in steam. The flue gases from the boiler make their way through superheater, economizer, air preheater and finally get exhausted to the atmosphere from the chimney.

- **Superheater**: The superheater tubes are hanged at the hottest part of the boiler. The saturated steam produced in the boiler tubes is superheated to about 540 °C in the superheater. The superheated high pressure steam is then fed to the steam turbine.
- **Economizer**: An economizer is essentially a feed water heater which heats the water before supplying to the boiler.
- **Air pre-heater**: The primary air fan takes air from the atmosphere and it is then warmed in the air pre-heater. Pre-heated air is injected with coal in the boiler. The advantage of pre-heating the air is that it improves the coal combustion.

Steam turbine: High pressure super heated steam is fed to the steam turbine which causes turbine blades to rotate. Energy in the steam is converted into mechanical energy in the steam turbine which acts as the prime mover. The pressure and temperature of the steam falls to a lower value and it expands in volume as it passes through the turbine. The expanded low pressure steam is exhausted in the condenser.

Condenser: The exhausted steam is condensed in the condenser by means of cold water circulation. Here, the steam loses it's pressure as well as temperature and it is converted back into water. Condensing is essential because, compressing a fluid which is in gaseous state requires a huge amount of energy with respect to the energy required in compressing liquid. Thus, condensing increases efficiency of the cycle.

Alternator: The steam turbine is coupled to an alternator. When the turbine rotates the alternator, electrical energy is generated. This generated electrical voltage is then stepped up with the help of a transformer and then transmitted where it is to be utilized.

Feed water pump: The condensed water is again fed to the boiler by a feed water pump. Some water may be lost during the cycle, which is suitably supplied from an external water source.

This was the **basic working principle of a thermal power station** and its typical components. A practical thermal plant possess more complicated design and multiple stages of turbine such as High Pressure Turbine (HPT), Intermediate Pressure Turbine (IPT) and Low Pressure Turbine (LPT).

<u>Efficiency Of A Thermal Power Station</u>

A huge amount of heat is lost in various stages of the plant. Major part of heat is lost in the condenser. That is why the efficiency of thermal plants is quite low.

1. **Thermal Efficiency**: The ratio of 'heat equivalent of mechanical energy transmitted to the turbine shaft' to the 'heat of coal combustion' is called as thermal efficiency.

$$\text{Thermal Efficiency} = \frac{\text{Heat equivalent of mech. energy transmitted to the turbine shaft}}{\text{Heat produced by coal combustion}}$$

Thermal efficiency of modern thermal power stations is about 30%. It means, if 100 calories of heat are produced by coal combustion, the mechanical energy equivalent of 30 calories will be available at the turbine shaft.

2. **Overall Efficiency**: The ratio of 'heat equivalent of electrical output' to the 'heat of coal combustion' is called as overall efficiency.

$$\text{Overall Efficiency} = \frac{\text{Heat equivalent of electrical output}}{\text{Heat produced by coal combustion}}$$

The overall efficiency of a thermal plant is about 29% (slightly less than the thermal efficiency.

Definition of Boiler

Steam boiler or simply a **boiler** is basically a closed vessel into which water is heated until the water is converted into steam at required pressure.

Working Principle of Boiler

The basic **working principle of boiler** is very very simple and easy to understand. The boiler is essentially a closed vessel inside which water is stored. Fuel (generally coal) is bunt in a furnace and hot gasses are produced. These hot gasses come in contact with water vessel where the heat of these hot gases transfer to the water and consequently steam is produced in the boiler. Then this steam is piped to the turbine of thermal power plant.

Steam Boiler Efficiency

The percentage of total heat exported by outlet steam in the total heat supplied by the fuel (coal) is called **steam boiler efficiency**.

$$Steam\ Boiler\ Efficiency(\%) = \frac{Heat\ exported\ by\ outlet\ steam}{Heat\ supplied\ by\ the\ fuel} \times 100$$

It includes with thermal efficiency, combustion efficiency & fuel to steam efficiency. **Steam boiler efficiency** depends upon the size of boiler used. A typical efficiency of steam boiler is

80% to 88%. Actually there are some losses occur like incomplete combustion, radiating loss occurs from steam boiler surrounding wall, defective combustion gas etc. Hence, efficiency of steam boiler gives this result.

TYPES OF BOILER

There are mainly two **types of boiler** – water tube boiler and fire tube boiler. In fire tube boiler, there are numbers of tubes through which hot gases are passed and water surrounds these tubes. Water tube boiler is reverse of the fire tube boiler. In water tube boiler the water is heated inside tubes and hot gasses surround these tubes. These are the main two **types of boiler** but each of the types can be sub divided into many which we will discuss later.

WORKING PRINCIPLE OF FIRE TUBE BOILER

Operation of fire tube boiler is as simple as its construction. In **fire tube boiler**, the fuel is burnt inside a furnace. The hot gases produced in the furnace then passes through the fire tubes. The fire tubes are immersed in water inside the main vessel of the boiler. As the hot gases are passed through these tubes, the heat energy of the gasses is transferred to the water surrounds them. As a result steam is generated in the water and naturally comes up and is stored upon the water in the same vessel of **fire tube boiler**. This steam is then taken out from the steam outlet for utilizing for required purpose. The water is fed into the boiler through the feed water inlet.

As the steam and water is stored is the same vessel, it is quite difficult to produce very high pressure steam from. General maximum capacity of this type of boiler is 17.5 kg/cm^2 and with a capacity of 9 Metric Ton of steam per hour. In a fire tube boiler, the main boiler vessel is under pressure, so if this vessel is burst there will be a possibility of major accident due to this explosion.

Types of Fire Tube Boiler

According to the location of furnace there are two **types of fire tube boiler** and these are external furnace and internal furnace type. There are mainly three types of external furnace fire tube boiler.

1. Horizontal return tubular fire tube boiler.

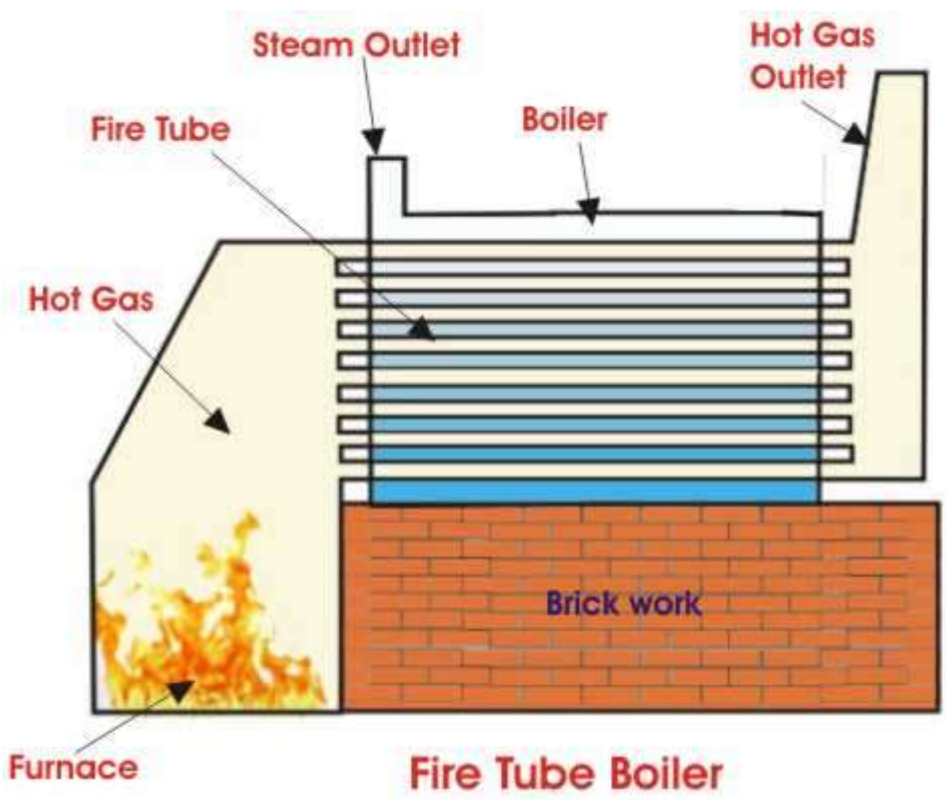
2. Short fire box fire tube boiler.
3. Compact fire tube boiler.

There are also two types of internal furnace fire tube boiler

1. Horizontal tubular.
2. Vertical tubular fire tube boiler.

Working Principle of Horizontal Return Fire Tube Boiler

Horizontal return fire tube boiler is most suitable for low capacity thermal power plant. The main constructional features of this boiler are one big size steam drum which lies horizontally upon supporting structures. There are numbers of fire tubes come from furnace and also aligned horizontally inside the drum. When the drum is filled with water these tubes are submerged in water.



The fuels (normally coal) burnt in the furnace and combustible gasses move into the fire tubes, travel through these tubes from rear to front of the boiler drum and finally the gases come into the smoke box. The hot gasses in the tubes under water transfer heat to the water via the tube walls. Due to this heat energy steam bubbles are created and come upon the water surface. As the amount of steam is increased in that closed drum, steam pressure inside the drum increases which increase significantly the boiling temperature of the water and hence rate of production of steam is reduced. In this way a fire tube boiler controls its own pressure. In other words this is a self pressure controlled boiler.

Advantages of Fire Tube Boiler

1. Compact in construction.
2. Fluctuation of steam demand can be met easily.
3. Cheaper than water tube boiler.

Disadvantages of Fire Tube Boiler

1. Due to large water the required steam pressure rising time quite high.
2. Output steam pressure cannot be very high since the water and steam are kept in same vessel.
3. The steam received from fire tube boiler is not very dry.
4. In a **fire tube boiler**, the steam drum is always under pressure, so there may be a chance of huge explosion which resulting to severe accident.

WATER TUBE BOILER

Types of Water Tube Boiler

There are many types of water tube boilers, such as

1. Horizontal Straight Tube Boiler.
2. Bent Tube Boiler.
3. Cyclone Fired Boiler.

Horizontal Straight Tube Boiler again can be sub - divided into two different types,

1. Longitudinal Drum Water Tube Boiler.
2. Cross Drum Water Tube Boiler.

Bent Tube Boiler also can be sub divided into four different types,

1. Two Drum Bent Tube Boiler.

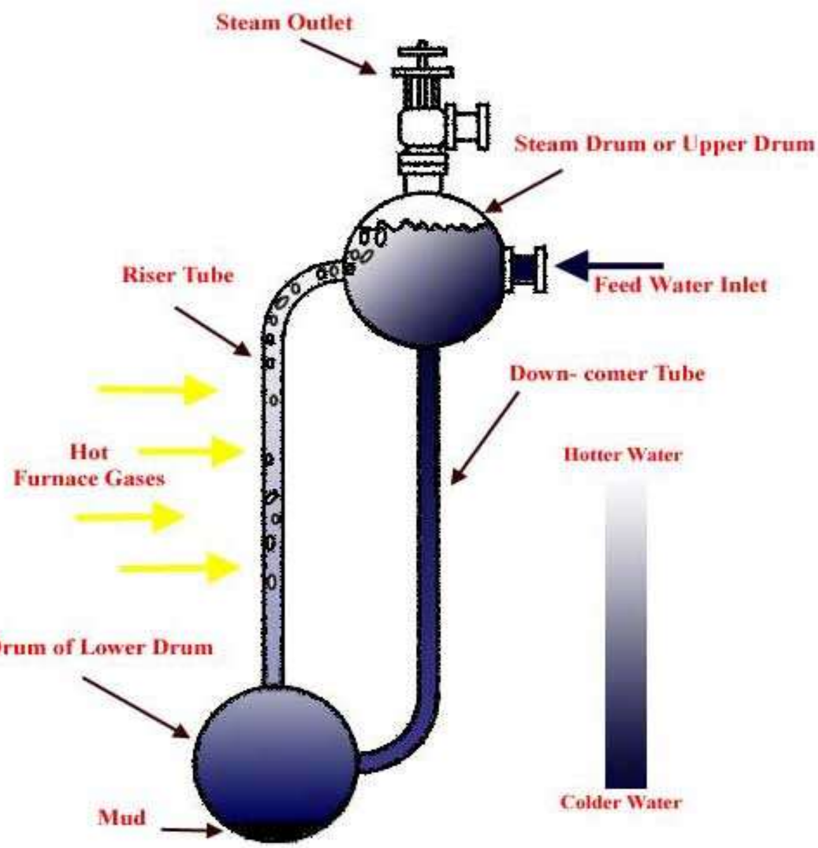
2. Three Drum Bent Tube Boiler.
3. Low Head Three Drum Bent Tube Boiler.
4. Four Drum Bent Tube Boiler.

Working Principle of Water Tube Boiler

The working principle of water tube boiler is very interesting and simple. Let us draw a very basic diagram of **water tube boiler**. It consists of mainly two drums, one is upper drum called steam drum other is lower drum called mud drum. These upper drum and lower drum are connected with two tubes namely down-comer and riser tubes as shown in the picture.

Water in the lower drum and in the riser connected to it, is heated and steam is produced in them which comes to the upper drums naturally. In the upper drum the steam is separated from water naturally and stored above the water surface. The colder water is fed from feed water inlet at upper drum and as this water is heavier than the hotter water of lower drum and that in the riser, the colder water push the hotter water upwards through the riser. So there is one convectional flow of water in the boiler system.

More and more steam is produced the pressure of the closed system increases which obstructs this convectional flow of water and hence rate production of steam becomes slower proportionately. Again if the steam is taken trough steam outlet, the pressure inside the system falls and consequently the convectional flow of water becomes faster which result in faster steam production rate. In this way the **water tube boiler** can control its own pressure. Hence this type of boiler is referred as self controlled machine.



Water Tube Boiler - Conceptual Diagram

Advantages of Water Tube Boiler

There are many advantages of water tube boiler due to which these types of boiler are essentially used in large thermal power plant.

1. Larger heating surface can be achieved by using more numbers of water tubes.
2. Due to convectional flow, movement of water is much faster than that of fire tube boiler, hence rate of heat transfer is high which results into higher efficiency.
3. Very high pressure in order of 140 kg/cm^2 can be obtained smoothly.

Disadvantages of Water Tube Boiler

1. The main disadvantage of water tube boiler is that it is not compact in construction.
2. Its cost is not cheap.
3. Size is a difficulty for transportation and construction.

PULVARIZATION PROCESS

1. First the coal is crushed by preliminary crasher. The coal is crushed to 2.5 cm. or less.
2. Then this crushed coal is passed through magnetic separator to separate any iron content in the coal. Iron must be removed, otherwise during pulverizing iron particles will cause spark which results unwanted fire hazard.
3. After that, crushed coal is dried properly before pulverization. The moisture content must be less than 2% after drying operation.
4. Then the coal is crushed again in fine particles in ball mill. This process is referred as pulverization.
5. This pulverized coal is then puffed with air and put into furnace as fluid.

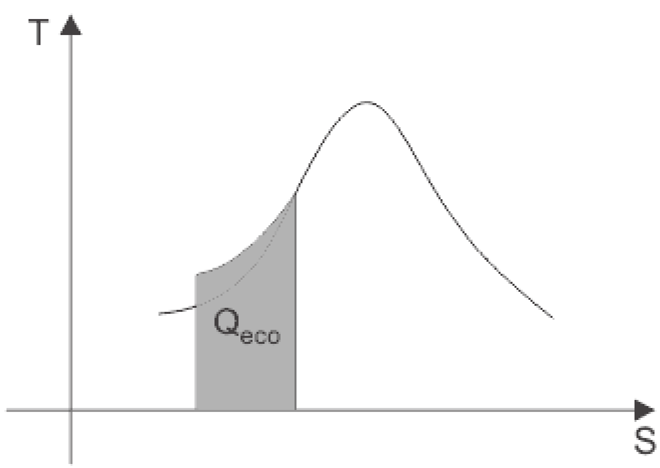
PULVARIZED FUEL FIRING

For getting most calorific value of coal, the coal is pulvarized in fine powder and then mixed with sufficient air. The mixture of coal powder and air is fired in the steam boiler furnace to achieve most efficient combustion process. This is most modern and efficient method of boiler firing. Due to pulverization, the surface area of coal becomes much larger, and in this method air required for combustion is much less. As the quantity of required air and fuel both are less, loss of heat in this method of boiler firing is much less, hence temperature can easily be reached to the designated level. As the combustion is most efficient pulverized coal firing increases the overall efficiency of steam boiler. As handling of lighter coal dust is much easier than handling of heavier coal chips, it is quite easy to control the output of the boiler by controlling supply of fuel to the furnace. Hence fluctuation of system load can smoothly be met. In addition these advantages, pulverized coal firing system has may disadvantages. Such as

1. The initial cost of installing this plant is very high.
2. Not only initial cost, running cost of this plant is quite high as separate pulverization plant to installed and run additionally.
3. High temperature causes high thermal loss through flue gas.
4. This type of method of boiler firing has always a risk of explosion.
5. This is also difficult and expensive to filter fine ash particles from fine gas. Moreover, the quantity of ash particles in the flue gas is more in pulverized system.

Economizer

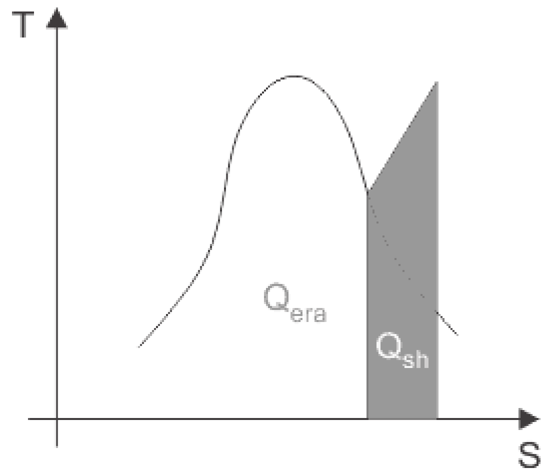
- **Economizer** is a heat exchanger which takes heat from the flue gas, and increases the temperature of feed water coming from **feed water** common header to about the saturation temperature corresponding to the boiler pressure.
- Throwing away the flue gases of high temperature into the atmosphere involves a great deal of energy losses. By utilizing these gases in heating feed water, higher efficiency and better economy can be achieved, and hence the heat exchanger is called “Economizer”.
- Structurally economizer is a collection of bent hollow tubular elements through which feed water passes. Outside of the tubes are heated by Exhaust flue gases. More no. of **water tubes** more will be the heat exchange surface. No. of tubes and tube cross section are pre-designed as per required boiler parameters.
- In the T-S curve above, the shadow portion illustrates the zone of economizer. The heat absorbed by feed water is denoted by ‘Q_{eco}’.



Super-Heaters

Super heater is an important part of Feed Water and Steam Circuit of Boiler

- Super-Heater is an important element of the feed water-steam circuit. It is basically a heat exchanger in which heat is transferred to the saturated steam to increase its temperature. In high pressure boilers more than 40% of the total heat is absorbed by the super heaters. The T-S diagram beside illustrates the heat absorbed by the super Heater and is denoted by Q_{sh}.

- 

- In super-heater the rate of heat absorption is more. Hence, in the modern water tube boilers there are more. Hence, in the modern water tube boilers there are more super heating surfaces.
- Super-heater tubes are exposed to the highest steam pressure and temperature on the inside and the maximum gas temperature on the outside. They are made of costliest alloys.

Functions of Super-Heater

- An increase in inlet steam temperature gives a steady improvement in cycle efficiency. Hence, the function of super-heater is to raise the overall efficiency. In addition, it reduces the moisture content in the later stages of the turbine and thus increases the turbine internal efficiency.
- However, the increase in temperature is limited by the properties of the construction materials of boilers and turbines. Usually the optimum temperature of steam is maintained 450^{o}C at the turbine inlet.

Definition of Steam Turbine

Steam turbine is one of the most important prime mover for generating electricity. This falls under the category of power producing turbo machines. In the turbine, the energy level of the working fluid goes on decreasing along the flow stream.

Principle of Operation of Steam Turbine

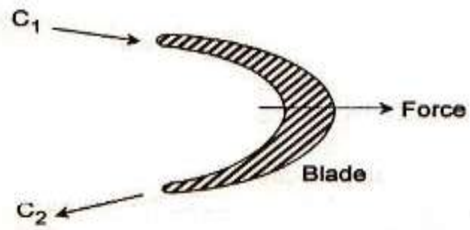


Fig.. 2.1(a). Principle of Working of Turbine.

- The principle of the operation of steam turbine is entirely different from the steam engine. In reciprocating steam engine, the pressure energy of steam is used to overcome external resistance and the dynamic action of steam is negligibly small. But the steam turbine depends completely upon the dynamic action of the steam. According to Newton's Second law of Motion, the force is proportional to the rate of change of momentum (mass X velocity). If the rate of change of momentum is caused in the steam by allowing a high velocity jet of steam to pass over curved blade, the steam will impart a force to the blade. If the blade is free, it will move off (rotate) in the direction of force [Fig.2.1 (a)].

CLASSIFICATION OF STEAM TURBINE

(A)On the basis of the principle Operation:-

(i) Impulse turbine

(a)Simple, (b) Velocity stage, (c)Pressure stage, (d) combination of (b) and (c)

(ii)Impulse-reaction turbine

(a)50% (Parson's) reaction, (b)Combination of impulse and reaction.

(i) Impulse Turbine : If the flow of steam through the nozzles and moving blade of a turbine takes place in such a manner that the steam is expanded only in nozzles and pressure at the outlet sides of the blades is equal to that at inlet side"

(ii) Impulse-Reaction Turbine: In the turbine, the drop in pressure of steam takes place in fixed (nozzles) as well as moving blades

Difference between Impulse and Reaction Turbines

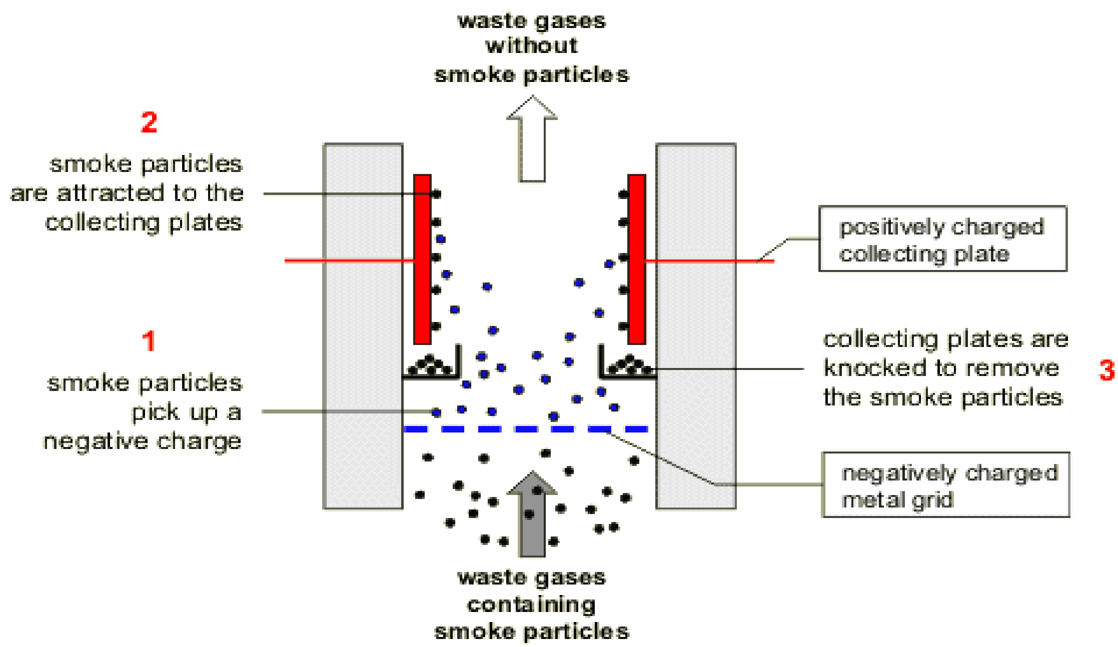
Impulse Turbine	Reaction Turbine
Pressure drops only in nozzles and not in moving blade channels.	Pressure drops in fixed blades (nozzles) as well as moving blade channels.
Constant blade channels area.	Varying blade channels area(converging types)
Profile type blades.	Aerofoil type blades.
Not all round or complete admission of steam.	All round or complete admission.
Diaphragm contains the nozzles.	Fixed blades similar to moving blades attached to casing serve nozzles and guide the steam.
Not much power can be developed.	Much power can be developed.
Occupies less space for same power.	Occupies more space for same power
Lesser blading efficiency.	Higher blading efficiency.
Suitable for small power requirements.	Suitable for medium and higher power requirements.
Blade manufacturing is not difficult an thus not costly.	Blade manufacturing process is difficult compared to impulse and hence costly.
Velocity of steam is slightly higher.	Reduced velocity of steam.

ELECTROSTATIC PRECIPITATOR

It is one of dust collection method by using electrostatic forces. The ESP has two sets of electrodes basically. One is the emitting electrode (-ve charge) and the collecting electrode (grounded). A high voltage is applied to the electrode to form an electrical field between the electrode and the collecting plates. When flue gas passes through the ESP, due to corona effect the dust particles are charged (-ve) and they are attracted towards the collecting electroded (+ve). The charged particles to be collected on the collecting plates, and the gas is purified. This is the principle of electrostatic precipitation. The particles collected on the collecting plates are removed by using different methods such as (1) dislodging by rapping the collecting plates, (2) scraping off with a brush, or (3) washing off with water, and removing from a hopper.

In the example fig:

1. Smoke particles pick up a negative charge
2. Smoke particles are attracted to the collecting plates, which are earthed or positively charged
3. Collecting plates are knocked to remove the smoke particles, which then fall into a collector.



ASH HANDLING SYSTEMS

- Unlike imported coal (which is of high calorific value at about 5000 Kcal/kg), Indian coal has lower calorific value at 3000 Kcal/kg. This increases the quantity of coal required per unit power generation.

- Secondly, Indian coal has high ash content (40 to 50%) which is also highly abrasive in nature.

- As a result, domestic coal based power plant is likely to produce 3 to 5 times more ash than that based on imported coal.

- The above aspects need special skills to design large capacity ash handling systems for using Indian coal.

- DESEIN has been responsible for the design & engineering of a large number of Ash Handling Systems for thermal power plants having a total aggregate generating capacity of over 35,000 MW.
- DESEIN has mastered the complexity of handling large quantity of highly abrasive ash generated from domestic coal in Indian power plants.

- DESEIN's experience in the design and engineering of Ash Handling Plants backed by its extensive O & M experience is unparalled for any engineering consultancy organization

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.

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 is dry form is used in cement manufacture.

FEED WATER AND STEAM CIRCUIT:

- The steam generated in the boiler is fed to the steam prime mover to develop the power. The steam coming out of prime mover is condensed in the condenser and then fed to the boiler with the help of the pump. The condensate is heated in the feed heaters using the steam tapped from different points of the turbine.
- Some of the steam and water is lost passing through different components of the system, therefore feed water is supplied from external source to compensate this loss.
- The feed water supplied from external source is passed through the purifying plant to reduce the dissolved salts to an acceptable level to avoid the scaling of the boiler tubes.

COOLING WATER CIRCUIT:

- The quantity of cooling water required to condense the steam is considerably large and it is taken either from lake, river or sea. The cooling water is taken from the upper side of the river, it is passed through the condenser and heated water is discharge through the lower side of the river. such system of cooling water is possible if adequate cooling water available throughout the year. This system is known as open system.
- When adequate water is not available, then the water coming out from the condenser is cooled either in cooing tower or cooling pond. The cooling is effected by partly evaporating the water. When the cooling water coming out from the condenser is cooled again supplied to the condenser then the system is known as closed system.

Fly ash and its Disposal

Ash is collected in ESPs and disposed to ash pond by ash handling system.

(1) **Ash Handling Systems**

The ash handling system serves the purpose of extracting the fly ash, as also furnace bottom ash from the unit and disposing off the same to the ash disposal area through slurry pumping facility. The system meant for fly ash removal is designed as "hydro-sluicing system" in which fly ash is sluiced to a sump for further disposal to the a~h dump area through slurry pumps in the ratio of 1: 10 water and ash respectively. The system is designed for complete removal of all ash generated continuously round the clock. Apart from the hydro-sluicing system which is the main and basic system for the plant, additional and parallel pneumatic cleaning facility is also provided for collection of dry ash from the unit as and when required. The bottom ash system is for intermittent removal of bottom ash via. outlet pumps and slurry pumping facility.

(2) **Furnace Bottom Ash System**

Dry ash from furnace bottom is collected in the water impounded bot!om ash as hopper located below and would get quenched. The hoppers have storage capacity of at least ten hours. Once in a shift, the ash collected in the hopper is conveyed to the ash slurry sump through clinker grinder, jet pump and pipe line assembly for further transportation to the ash disposal area through the slurry disposal system.

(3) **Fly Ash System**

Fly ash is separated from the gas and collected in exhaust hoppe~s electrostatic precipator hopper and stalk hopper. The ash thus collected is allowed to fall continuously into the respective "flushing apparatus" provided below each hopper where fly ash is mixed with water. The resultant slurry thus formed is discharged into the sluice trench running below and is conveyed to ash slurry sump by gravity aided by pressuriesed water jet at strategic locations. The slurry thus received into the slurry sump is pumped to the ash pond. In addition to the "hydro-sluicing system" parallel facility for collection of dry ash from the Electrostatic precipitator (ESP) hoppers at a suitable rate (about 40 Te/hr) is provided so that dry fly ash as and when required may be extracted and collected through the above facility. The system envisaged for extraction and collection of dry fly ash from the ESP hoppers is designed as "hydro-pneumatic Vacuum System". In this system fly ash from the hoppers is pneumatically conveyed to the ash storage site via dust collector assembly. The pneumatic conveyance of fly ash is achieved by creation of vacuum into the conveying line by means of either I) Vacuum blowers or ii) Hydraulic exhausters. '

(4) **Ash Slurry Disposal System**

The ash slurry disposal system is common for bottom ash and fly ash units. This system is composed of slurry sump - slurry pump - valves and disposal pipe line assembly and serves to transport the incoming bottom ash and fly ash slurry from the sump up to the disposal pond located at a distance of about 5 KM. The ash slurry disposal system is designed to work continuously round-the-clock. Thus both bottom ash from the furnace hoppers and the fly ash from the dust collecting hoppers are sluiced to the ash disposal pond about 5 Kilometers from the plant. Ash get settled in the pond effluent water is decanted out of the and ash pond which comes through the natural drainage stream present near Zupudi village and finally released into river Krishna about 20 Km. up the stream of Krishna barrage.

Hydro-electric Power Station

A generating station which utilizes the potential energy of water at a high level for the generation of electrical energy is known as a hydro-electric power station.

Hydro-electric power stations are generally located in hilly areas where dams can be built conveniently and large water reservoirs can be obtained. In a hydro-electric power station, water head is created by constructing a dam across a river or lake. From the dam, water is led to a water turbine. The water turbine captures the energy in the falling water and changes the hydraulic energy (i.e., product of head and flow of water) into mechanical energy at the turbine shaft. The turbine drives the alternator which converts mechanical energy into electrical energy. Hydro-electric power stations are becoming very popular because the reserves of fuels (i.e., coal and oil) are depleting day by day. They have the added importance for flood control, storage of water for irrigation and water for drinking purposes.

Advantages

(i) It requires no fuel as water is used for the generation of electrical energy.

(ii) It is quite neat and clean as no smoke or ash is produced.

(iii) It requires very small running charges because water is the source of energy which is available free of cost.

(iv) It is comparatively simple in construction and requires less maintenance.

(v) It does not require a long starting time like a steam power station. In fact, such plants can be put into service instantly.

(vi) It is robust and has a longer life.

(vii) Such plants serve many purposes. In addition to the generation of electrical energy, they also help in irrigation and controlling floods.

(viii) Although such plants require the attention of highly skilled persons at the time of construction, yet for operation, a few experienced persons may do the job well.

Disadvantages

(i) It involves high capital cost due to construction of dam.

(ii) There is uncertainty about the availability of huge amount of water due to dependence on weather conditions.

(iii) Skilled and experienced hands are required to build the plant.

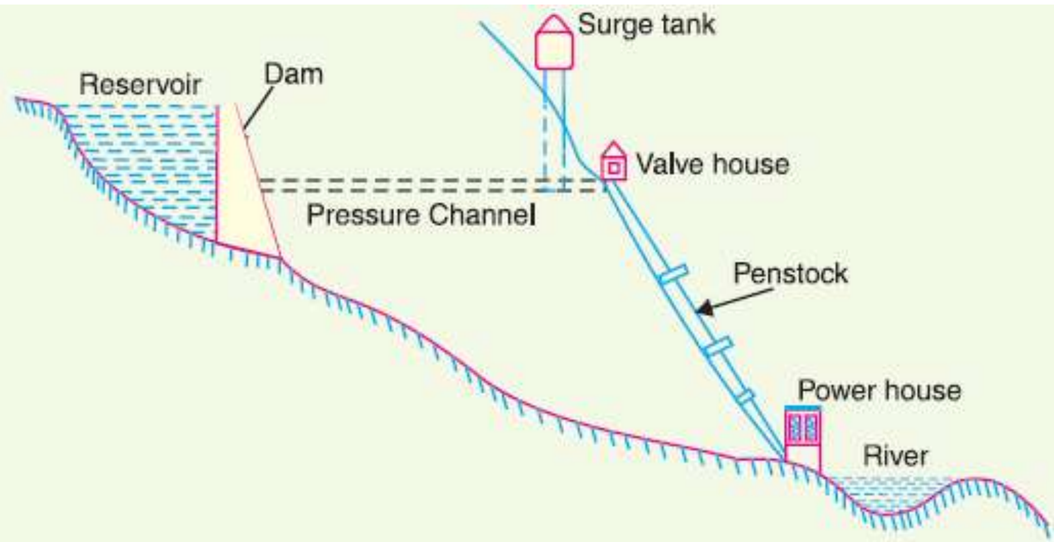
(iv) It requires high cost of transmission lines as the plant is located in hilly areas which are quite away from the consumers.

Schematic Arrangement of Hydro-electric Power Station

Although a hydro-electric power station simply involves the conversion of hydraulic energy into electrical energy, yet it embraces many arrangements for proper working and efficiency. The schematic arrangement of a modern hydro-electric plant is shown in Fig. 2.2.

The dam is constructed across a river or lake and water from the catchment area collects at the back of the dam to form a reservoir. A pressure tunnel is taken off from the reservoir and water brought to the valve house at the start of the penstock. The valve house contains main sluice valves and automatic isolating valves. The former controls the water flow to the power house and the latter cuts off supply of water when the penstock bursts. From the valve house, water is taken to water turbine through a huge steel pipe known as penstock. The water turbine converts hydraulic energy into mechanical energy. The turbine drives the alternator which converts mechanical energy into electrical energy.

A surge tank (open from top) is built just before the valve house and protects the penstock from bursting in case the turbine gates suddenly close due to electrical load being thrown off. When the gates close, there is a sudden stopping of water at the lower end of the penstock and consequently the penstock can burst like a paper log. The surge tank absorbs this pressure swing by increase in its level of water.



Schematic arrangement of a Hydro-electric plant

Fig. 2.2

Nuclear Power Stations

Location of nuclear power plant, Working principle, nuclear fission, nuclear fuels, nuclear chain reaction, nuclear reactor Components: Moderators, Control rods, Reflectors and coolants. Types of Nuclear reactors and brief description of PWR, BWR and FBR. Radiation: Radiation hazards and Shielding, nuclear waste disposal.

Introduction

Steam, diesel and gas turbine power plants are based on conventional sources of energy.

- Availability of this fuels are fast depleting while power demand is ever increasing.
- Thermal power plants also based on coal.
- We have to seek for large alternative source of energy like solar energy, geothermal energy, nuclear energy, tidal energy.
- Nuclear has bright future due availability of uranium and thorium in earth crest.
- Uranium and Thorium in earth crest are estimated to be 1011 tones at a depth 5km.
- 20 x 10^6 tons of Uranium, 1x 10^6tones of Thorium can economically extracted.
- Fission of 1 kg of uranium can produce the energy equivalent to burning about 4x 106 of high grade coal.
- Initial cost is high but operating cost is low as compare to thermal power plant.

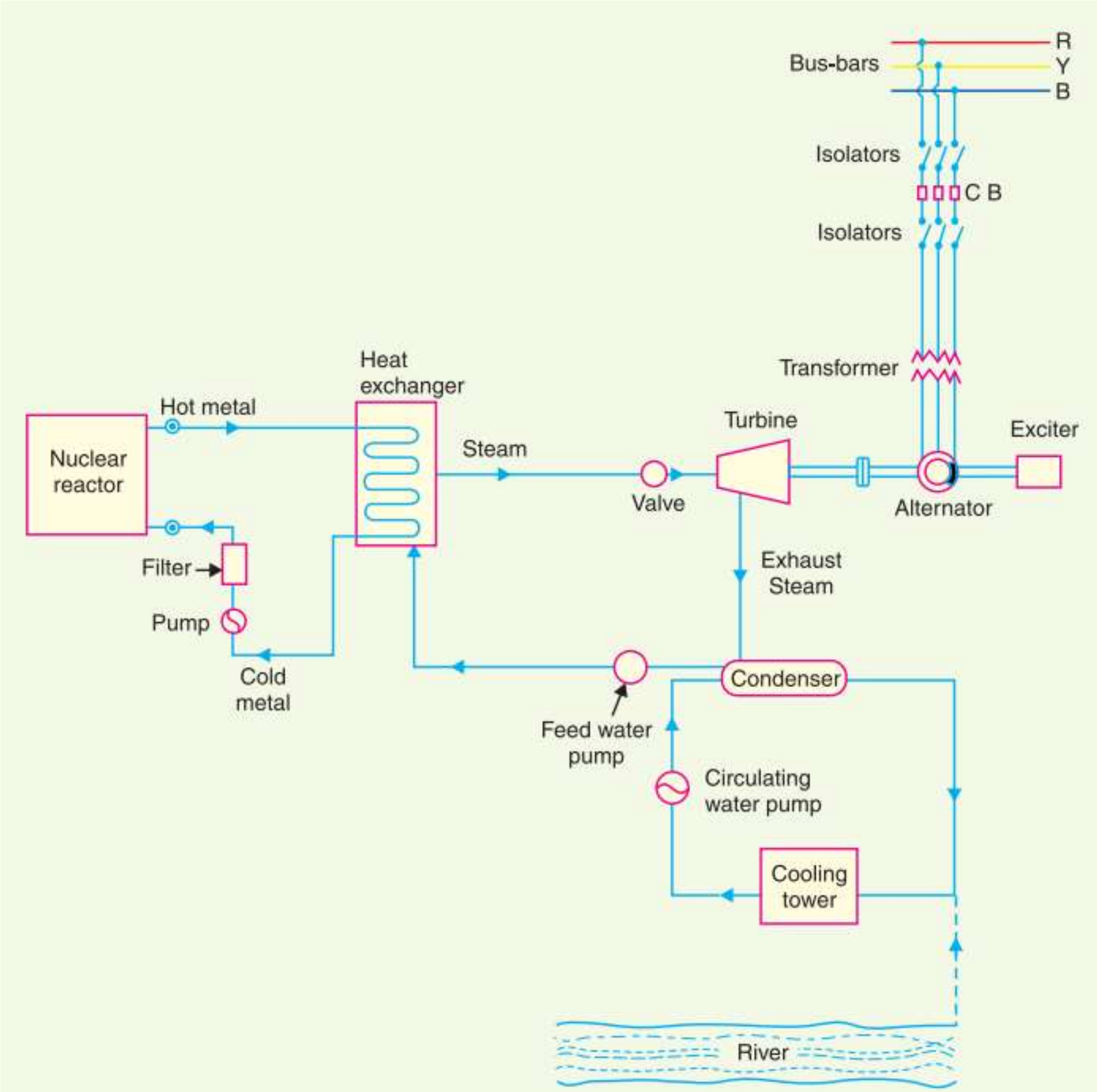
Advantages of Nuclear Power Plant

- Reduce demand of on depleting source of energy and rising cost of fuels like coal, oil and gas.
- Reduce transportation of fuels.
- Load shading and fluctuation in energy production is eliminated.
- Fuel storage facilities are not needed and less space is required.
- Power produce as well as fissile material also produce.
- Less pollution.
- High performance as compare to thermal power plants

Disadvantages

- Capital cost is high.
- Required trained man power.
- Radioactive waste disposal problem.
- High degree of safety needed.

Schematic diagram of nuclear power station



Schematic arrangement of Nuclear Power Station

Nuclear Fission Reaction

- When unstable heavy nuclei are bombarded with high energy neutrons, it splits into several smaller fragments. These fragments, or fission products, are about equal to half the original mass. This process is called Nuclear Fission. Two or three neutrons are also emitted.
- The sum of the masses of these fragments is less than the original mass. This „missing" mass (about 0.1 percent of the original mass) has been converted into energy. Fission can occur when a nucleus of a heavy atom captures a neutron, or it can happen spontaneously.
- This process is possible at room temperature.
- Fission can be caused by bombarding with high energy alpha particles, protons, electrons, deuterons, x-rays as well as neutrons.
- However neutrons are most suitable for fission because of electrically neutral and thus no require high kinetic energy to overcome electrical repulsion for positively charged nuclei.

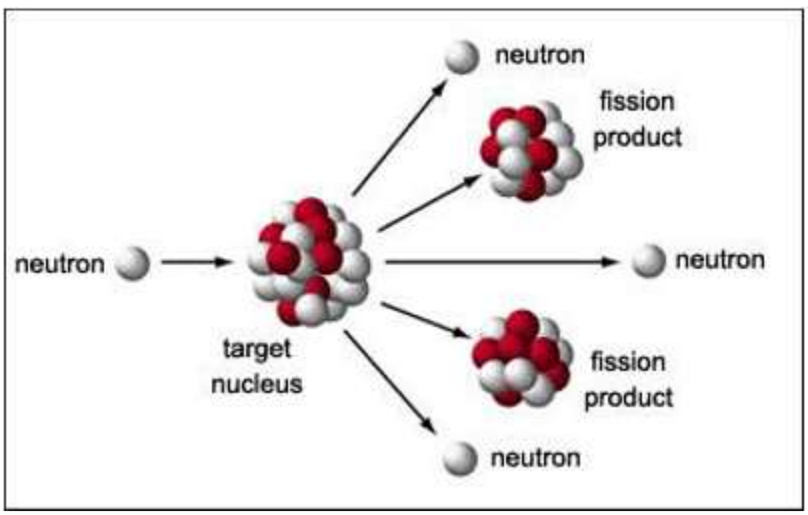


Fig. Nuclear Fission Reaction

Nuclear Fusion Reaction

- It is process in which two light nucleuses makes heavy nucleus called fusion reaction.
- It requires high temperature (1.2 X 10^9 K).
- High particle density.
- High particle confinement.

- It is not possible in earth.
- Sun generates heat and energy is a best example of fusion process.
- There is a 1.6 X 10^7 K temp. Middle of the sun and pressure is more 10^5 times then earth.

  In nuclear physics and nuclear chemistry, nuclear fusion is the process by which multiple like-charged atomic nuclei join together to form a heavier nucleus. It is accompanied by the release or absorption of energy, which allows matter to enter a plasma state.

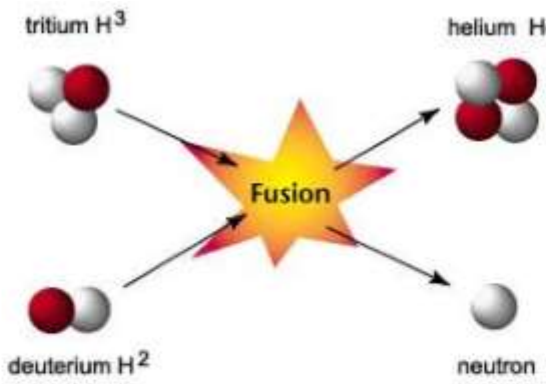


Fig:Nuclear Fusion

The fusion of two nuclei with lower mass than iron (which, along with nickel, has the largest binding energy per nucleon) generally releases energy while the fusion of nuclei heavier than iron absorbs energy; vice-versa for the reverse process, nuclear fission. Nuclear energy can also be released by fusion of two light elements (elements with low atomic numbers). The power that fuels the sun and the stars is nuclear fusion. In a hydrogen bomb, two isotopes of hydrogen, deuterium and tritium are fused to form a nucleus of helium and a neutron. This fusion releases 17.6 MeV of energy. Unlike nuclear fission, there is no limit on the amount of the fusion that can occur.

Comparison of Fusion and Fission Processes

S. No.	Fusion	Fission
1	Light elements fuse together with release of energy	Energy is released by the bombardment of heavy nuclear with neutrons.The nucleus splits into fragments of equal mass.
2	Heavy mass will be converted in to energy.	Light mass will be converted into energy.

3	Amount of radioactive material consumed in a fusion process is very low.	In fission process it is very high
4	Health hazard is very less	Health hazard is high due to higher radio active materials
5	Construction of controlled fusion reactors is very difficult	It is possible to construct self-sustained fission reactors and have positive energy release
6	Very high temperature are required for fusion process (≥ 30 million degrees)	Manageable temperatures are obtained

NUCLEAR CHAIN REACTION

A nuclear chain reaction occurs when one nuclear reaction causes an average of one or more nuclear reactions, thus leading to a self-propagating number of these reactions. The specific nuclear reaction may be the fission of heavy isotopes (e.g. 235U) or the fusion of light isotopes (e.g. 2H and 3H). The nuclear chain reaction is unique since it releases several million times more energy per reaction than any chemical reaction.

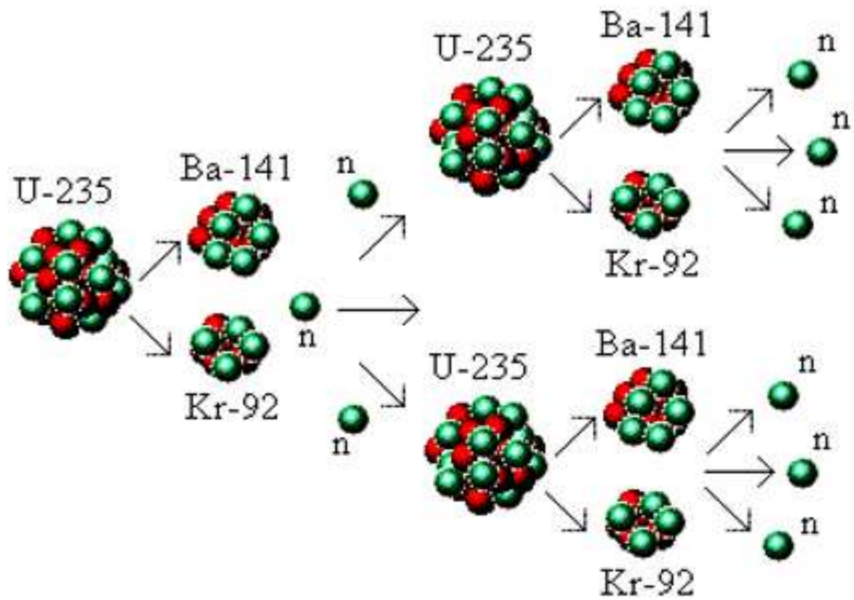


Fig. Nuclear Chain Reaction

- Essential condition for the practical condition of nuclear energy is that self-sustaining chain reaction should be maintained.
- The neutrons released have very high velocity of the order of 1.5 X 10^7 m/s.
- The energy liberated in chain reaction is according to Einstein law $E=MC^2$.
- To maintain continues chain reaction it should be leakage of neutrons is less.

TYPES OF NUCLEAR MATERIALS

Fissile Material

Fissile materials are composed of atoms that can be split by neutrons in a self-sustaining chain-reaction to release enormous amounts of energy. In nuclear reactors, the fission process is controlled and the energy is harnessed to produce electricity. In nuclear weapons, the fission energy is released all at once to produce a violent explosion. The most important fissile materials for nuclear energy and nuclear weapons are an isotope of plutonium, plutonium-239, and an isotope of uranium, uranium-235. Uranium-235 occurs in nature.

Fertile Material

A material, which is not itself fissile (fissionable by thermal neutrons), that can be converted into a fissile material by irradiation in a reactor. There are two basic fertile materials: uranium-238 and thorium-232. When these fertile materials capture neutrons, they are converted into fissile plutonium-239 and uranium-233, respectively.

The chain reaction cannot be maintained In some reactors with natural uranium having only 0.7% fissionable u-235 therefore it is necessary to increase the percentage of u-235 in the fuel if it is used in reactor.

The process used to increase the percentage of u-235 is known as enrichment of fuel. Enrichment also reduces size of the reactor.

Enrichment method

Gaseous diffusion method.

Thermal diffusion method.

Centrifugal method.

Electromagnetic method.

Estimation of all resources of uranium in USA is 33%, South Africa 20%, Canada 20% largest reserve of most economical and low of cost uranium lies in Australia.

COMPONENTS OF NUCLEAR REACTORS

Components of nuclear power plant categorize as under..,

1. FUELS
2. MODERATOR
3. CONTROL RODS.
4. COOLENT
5. REFLECTOR
6. SHIELDING
7. REACTOR VESSEL.

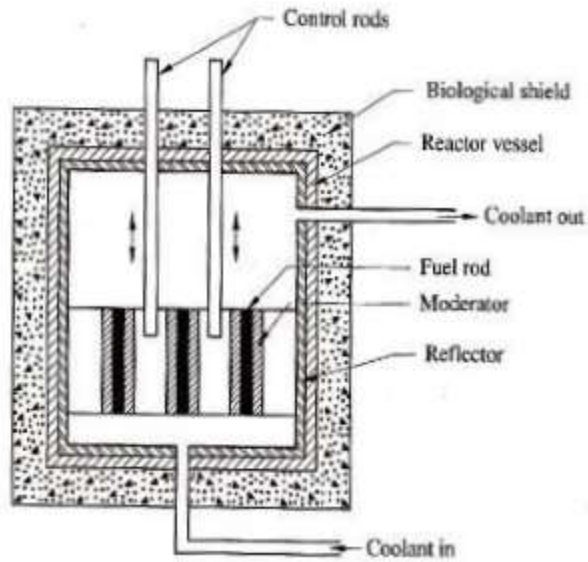


Fig. components of Nuclear Power Plant

1. **FUEL**

- Nuclear reactors use fissionable materials like U233, U235 , Pu239 .
- Natural uranium found in earth crest has 0.714% which unstable and capable of sustainable chain reactions.
- The fuel is shaped in various shapes like roads, plates, pallets, tins etc. and located in the reactor in such a manner that the heat production within the reactor is uniform.
- The fuel elements are designed taking account the heat transfer, corrosion and structural strength.

2. **MODERATOR**

- The function of the moderator is to slow down the neutrons from high kinetic energy to low kinetic energy in a fraction of the second.
- The main function of the moderator is to increase the probability of the reaction.
- The fission chain reaction in the nuclear reactor is maintained due to slow neutrons when ordinary uranium used as a fuel.
- Moderators are lighter then fuel.
- Water, heavy water. Graphite and beryllium.
- Graphite and heavy water is used as a moderator with natural uranium.

- For enriched uranium ordinary water is used.

Characteristic of moderator

- It must be as light as possible.
- It must not absorb the neutrons.
- It must be work under high temperature and pressure with good corrosion resistance.
- It must have high chemical stability.
- It must have high heat conductivity.
- If it is in form of solid then it must have high melting point and good machinability.

3. CONTROL RODS

- The control road controls the rate of energy which is generated.
- Function of control rod is to increase, decrease and stop the reaction.
- The rod may be shaped like fuel rod themselves and are interspersed throughout the reactor core.
- The control is necessary to prevent the melting of fuel rods, disintegration of thecoolant and destruction of reactor as the amount of energy released is enormous.
- Control rod materials like cadmium, boron etc..,

4. COOLANT

- The main purpose of the coolant in the reactor is to transfer the produced heat in to the reactor and keep fuel assembly at a safe temperature to avoid their melting and damage.
- The heat carried away of coolant by using heat exchanger and use to generation of steam or hot gas.
- As a coolant generally water, heavy water carbon dioxide helium gas, liquid metal like sodium (Na) potassium (k) or organic liquid.

Characteristics of Coolant.

- It must have high chemical and nuclear stability.
- It must have high corrosion resistance.
- It must have high boiling point and low melting point.

- It should be non-toxic.
- It must have high sp.heat and high thermal heat transfer co efficient.
- It should have high density and low viscosity.

5. REFLECTOR

- It is important to keep the neutrons as much as possible for reducing consumption of fissile material and keep the size of reactor small.
- This is possible by surrounding the reactor core with a material which reflects escaping neutrons back in to the core
- This material is called reflectors.
- The require properties of good reflectors should have low absorption and high reflection for neutrons.
- It should have high resistance to corrosion and high radiation stability.
- Materials are used for moderators are also used for reflectors.

6. SHIELDING

- Shielding is the radioactive zones in the reactor from possible radiation hazard are essential to protect the human life from harmful effects.
- To prevent effects those radiation on the human life it is necessary to absorb them before emitting to atmosphere.
- Shielding consists of inner lining of 50 to 60cm thick steel plate on the reactor core called thermal shield.
- With a few meters of thick concrete wall surrounding the inner shield called biological shield.
- Thermal shield cooled by circulation of water.

7. REACTOR VESSEL

- It is enclose the reactor core, reflector and shield.
- It also provides coolant inlet and outlet passages.
- It has to with stand the pressure at 200 bar or above.
- The reactor core, fuel and assembly are generally placed at the bottom of the vessel.

CLASSIFICATION OF REACTORS

1. On the basis of neutron energy

   Fast reactors: In these reactors, the fission is affected by fast neutrons without any use of moderator.

   Thermal reactors: In these reactors the fast moving neutrons are slowed down with help of moderator.

   Intermediate reactors: In this reactor velocity of the neutrons is kept between fast reactors and thermal reactors.

2. On the basis of fuel used
3. Natural uranium fuel reactors.
4. Enriched uranium fuel reactor.
5. On the basis of coolant used
   Water /heavy water cooled reactors.
   Gas cooled reactors Liquid metal /organic liquid cooled reactors.
6. On the basis of moderator:
   Water moderated.
   Heavy water moderated.
   Graphite moderated.
   Beryllium moderated.
7. On the basis of reactor core used
   Homogeneous reactor.
   Heterogeneous reactor.

PRESSURIZED WATER REACTOR (PWR)

- In a PWR the primary coolant (water) is pumped under high pressure to the reactor core where it is heated by the energy generated by the fission of atoms. The heated water then flows to a steam generator where it transfers its thermal energy to a secondary system where steam is generated and flows to turbines to rotate an electric generator.

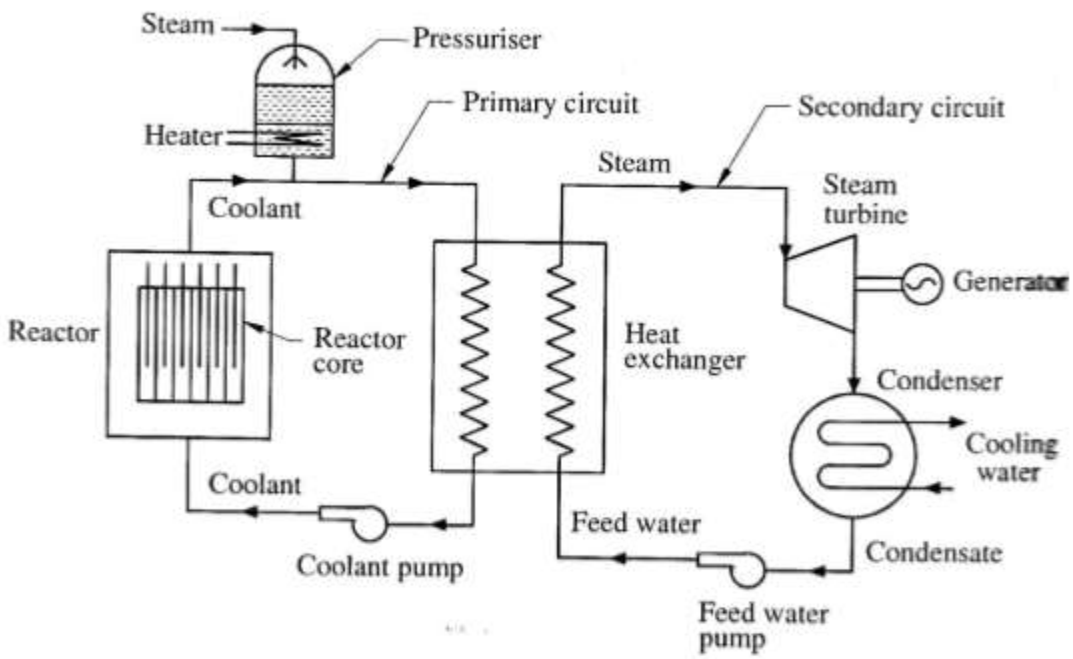


Fig. Pressurized Water Reactor.

- Nuclear fuel in the reactor vessel is engaged in a fission chain reaction, which produces heat, heating the water in the primary coolant loop by thermal conduction through the fuel casing.
- The hot primary coolant is pumped into a heat exchanger called the steam generator, where it flows through hundreds or thousands of tubes (usually 3/4 inch in diameter).
- Heat is transferred through the walls of these tubes to the lower pressure secondary coolant located on the sheet side of the exchanger where it evaporates to pressurized steam. The transfer of heat is accomplished without mixing the two fluids, which is desirable since the primary coolant might become radioactive. Some common steam generator arrangements are u-tubes or single pass heat exchangers. In a nuclear power station, the pressurized steam is fed through a steam turbine which drives an electrical generator connected to the electric grid for distribution.
- After passing through the turbine the secondary coolant (water-steam mixture) is cooled down and condensed in a condenser. The condenser converts the steam to a liquid so that it can be pumped back into the steam generator, and maintains a vacuum at the turbine outlet so that the pressure drop across the turbine, and hence the energy extracted from the steam, is maximized.

- Before being fed into the steam generator, the condensed steam (referred to as feed water) is sometimes preheated in order to minimize thermal shock.

Advantages

- PWR reactors are very stable due to their tendency to produce less power as temperatures increase; this makes the reactor easier to operate from a stability standpoint.
- It uses ordinary water as a coolant, moderator and reflector since water is available near the plant location this is great savings in cost.
- Reactor is compact and high power density.
- As steam is not effected by radiation so the inspection and maintenance of the turbine condenser and feed pump is possible.
- Small numbers of control road are required.
- PWR turbine cycle loop is separate from the primary loop, so the water in the secondary loop is not contaminated by radioactive materials.

Disadvantages

- Its capital cost is high due to heavy and strong pressure vessel is required in the primary circuit.
- Thermodynamic efficiency is less 20% due to low pressure in secondary circuit.
- Its required enriched uranium fuel cost of enriched uranium is high.
- It is necessary to shut down the reactor for fuel charging.
- Because water acts as a neutron moderator, it is not possible to build a fast neutron reactor with a PWR design.

BOILING WATER REACTOR (BWR)

- The BWR uses dematerialized water as a coolant and neutron moderator.
- Heat is produced by nuclear fission in the reactor core, and this causes the cooling water to boil, producing steam.
- The steam is directly used to drive a turbine, after which it is cooled in a condenser and converted back to liquid water.
- This water is then returned to the reactor core, completing the loop.

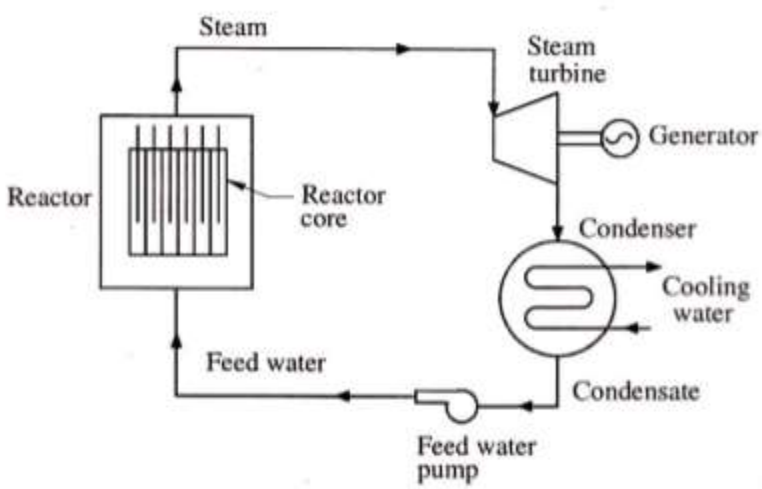


Fig. Boiling Water Reactor

Advantages

- The pressure inside the reactor is less than PWR as water is allowed to boil inside the reactor. Therefore the reactor vessel can be much lighter then PWR and reduce the cost of pressure vessel considerably.
- It eliminates the use of heat exchanger, pressure equalizer, circulating pump and piping therefore the cost of further reduced.
- The thermal efficiency of this reactor is 30% is considerably higher than PWR plant.
- The metal temperature remains low for given output conditions.

Disadvantages

- The steam leaving the reactor is slightly radioactive. Therefore light shielding of turbine and piping is necessary.
- It cannot meet the sudden changes in load the plant.
- The size of vessel is comparatively large as compare to PWR.
- It required enriched uranium as a fuel.

FAST BREEDER REACTOR (FBR)

- The Process of Converting More Fertile Material in to Fissile Material in a Reactor is Called Breeding.

- In fast breeder reactor the core containing U235 is surrounded by a blanket of fertile material U238.
- In this reactor no moderator is used the fast moving neutrons liberated due to fission of U235 are absorbed by U238 which gets converted in to Pu239 a fissile material.
- This reactor also uses two liquid metal coolants in which sodium is used as primary coolant and sodium potassium as secondary coolant.(sodium boils at 850^{O}C under atmospheric pressure and freeze at 95^{O} C).

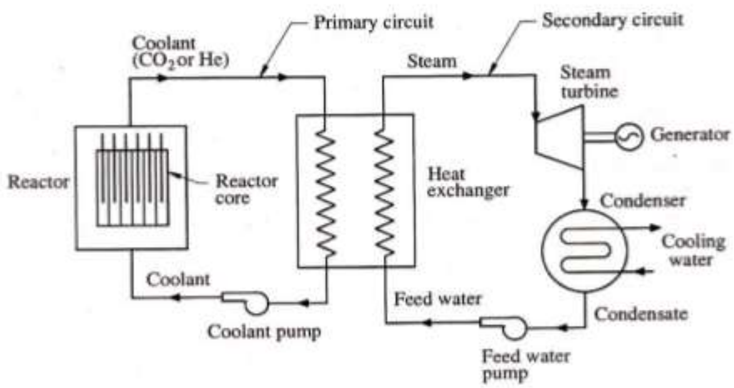


Fig. Fast Breeder Reactor

- Liquid sodium is circulated through the reactor to carry the heat produced.
- The heat produced by the sodium is transferred to secondary coolant sodium potassium.
- In the primary heat exchanger which in turn transfer the heat in secondary heat exchanger called steam generator.

Advantages

- It gives high power density than any other reactor therefore small core is sufficient.
- Moderator is not required.
- Secondary fusible materials by breeding are obtained.
- Absorption of neutrons is slow.

Disadvantages

- It require highly enriched uranium fuel.
- Safety must be provided against melt down.

- Neutron flux is high at the center of the core.
- Thick shielding is necessary.

ATOMIC STRUCTURE

All atoms are composed of a central nucleus surrounded by a number of orbiting electrons – like planets orbiting the sun.

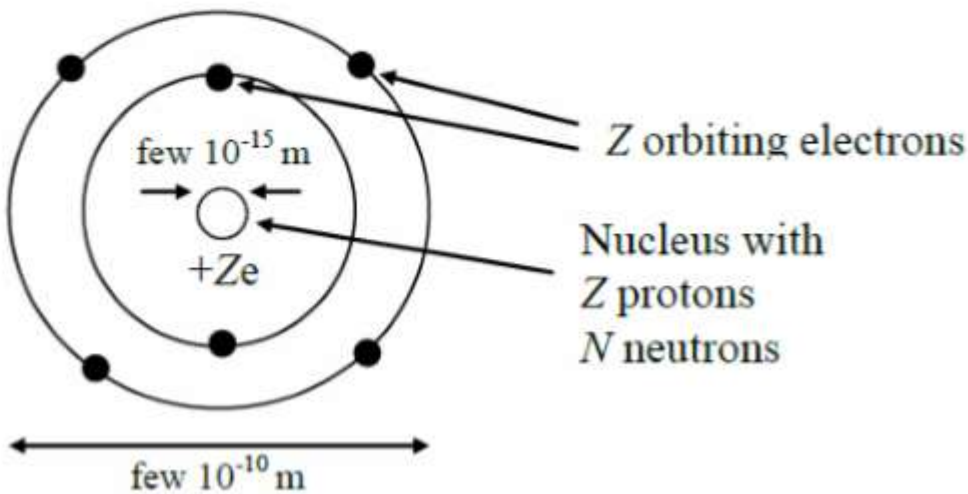


Fig: Atomic Structure

A problem is that orbiting electrons would be accelerating and should radiate energy causing them to spiral into the nucleus.

Atomic Nomenclature:

An atomic nucleus is the small heavy central part of an atom consisting of a nucleons: Z protons and N neutrons. A is referred to as the mass number and Z the atomic number. Nuclear size is measured in fermis (also called femtometres), where 1 fm = 10^{-15} m.

The basic properties of atomic constituents are as follows:

	Charge	Mass (u)	Spin ($h/2\pi$)*	Magnetic Moment ($J\,T^{-1}$)**
Proton	e	1.007276	1/2	1.411×10^{-26}
Neutron	e	1.008665	1/2	-9.66×10^{-27}
Electron	e	0.000549	1/2	9.28×10^{-24}

* h = 6.626 × 10^{-34}Js, is Planck‟s constant

** The unit T is the tesla – the SI unit of magnetic field.

CHARGE

Protons have a positive charge equal and opposite to that of the electron. Neutrons are uncharged.

MASS

Nuclear and atomic masses are expressed in atomic mass units (u) based on the definition that the mass of a neutral atom of ^{12} C is exactly 12.000 u. (1 u = 1.6605 ×10^{-27} kg).

NUCLEAR WASTE AND ITS DISPOSAL

- The radioactive emission during the operation of the plant is negligible but the emission intensity is very high which comes out from the waste. Therefore, safe nuclear waste disposal is major problem before the nuclear industry.
- It is estimated that the radioactive products of 400MW power plants is exposed to atmosphere would kill all the living organism with in the area about 160 square kilometers.
- The waste produced in a nuclear power plant may be in the form of liquid, gas and solid each is treated in different water.

SOLID WASTE

- It will arise used filters, sludge from the cooling ponds, pieces from discarded fuel element cans, splitters control rods etc..,
- The combustible solid waste is burnt and flue gases formed are filtered and then exposed to the high level of atmosphere.

- Active solid wastes are stored in water for about 100 or more days to allow radioactivity to decay then these are disposed off to deep salt mines or an ocean floor or in deep wells drilled in stable geological strata.

LIQUID WASTE

- Radioactive effluents will arise from the laundry, personal decontamination etc.., together with activity accumulating from the corrosion of the irradiated fuel elements in the storage ponds.
- The disposal of liquid waste has done in two ways.

1. Dilution

- The liquid waste are diluted with large quantity of water and then released in to the ground.
- The major drawback of this method there is a chance of contamination of underground water if dilution factor is not adequate.

2. Concentration to small volumes and storage

- If the dilution of water in not possible then liquid will store in leakage proof and high strength material storage can or tank and then stored in deep drilled salt mines.

GASEOUS WASTE

- Gaseous waste are generally diluted with air passed through filters and then released to the atmosphere through large chimneys.
- Krypton is removed by cryogenic treatment of dissolved off gas stream and packed in gas cylinder under pressure.
- Generally gaseous waste filtered in filter and then allows escaping to the atmosphere or stored in pressure tanks and then stored in deep drilled salt mines.

HEALTH HAZARDS

About 80 percent of the public believes it is more dangerous to generate electricity from nuclear power than from coal. The enormous public misunderstanding about nuclear power may be largely attributed to:

(a) A widespread and exaggerated fear of radiation,

(b) A highly distorted picture of reactor accidents,

(c) Grossly unjustified fears about disposal of radioactive waste, and

(d) Failure to understand and quantify risk.

Radiation

How Dangerous Is Radiation?

Is being struck by a particle of radiation a terrible tragedy? No. Every person is struck by about a million particles of radiation every minute from natural sources. (The rate varies with geography and other factors.) This rate is hundreds of times greater than our exposure to radiation from the nuclear power industry. So is our average exposure to radiation from medical X-rays. Although a single particle of radiation can cause cancer, the chance it will do so is only about one in 30 quadrillion. Hence, the million particles that strike us each minute have only one chance in 30 billion of causing a cancer. A human lifespan is about 40 million minutes; thus, all of the natural radiation to which we are exposed has about one chance in 700 of causing a cancer. Since our overall chance of dying from cancer is one in five, only one in 140 of all cancers may be due to natural radiation. The average exposure from a nuclear power plan to those who live closest to it is about 1 percent of the exposure to natural radiation; hence, if they live there for a lifetime, there is perhaps once chance in 70,000 (1/100th the chance from natural radiation and 1/14,000 the chance from all causes) that they will die of cancer as a result of exposure to its radiation. Routine Emissions from the Nuclear Industry In operation, nuclear power plants routinely release small quantities of radioactive gases and contaminants in water into the environment. More importantly, when reactor fuel is chemically reprocessed, more radioactive gases are released at the reprocessing plant. Extensive studies predict that, with current technology, routine releases of radiation due to operation of one large power plant for one year, including reprocessing, will cause 0.25 cancer deaths over the next 500 years. Since we are not reprocessing fuel now, effects of current operations are only about 20 percent of this. Available technologies can drastically reduce releases from reprocessing plants.

Reactor Accidents

Power plants include many levels of protection against radioactivity releases, based on a defense in depth design philosophy. For example, an accident could be initiated by a sudden rupture in the system, allowing the cooling water to escape. Levels of protection against this are :

(a) The highest quality standards on materials and equipment in which such a rupture might occur;

(b) Elaborate inspection programs to detect flaws in the system using X-ray, ultrasonic, and visual techniques;

(c) Leak-detection systems (Normally a rupture starts out as a small crack, allowing water to leak out slowly. Such leaks would be detected by these systems and repaired before a rupture could occur);

(d) An emergency cooling system, which would rapidly replace the water lost in such a rupture accident, restoring cooling to the reactor fuel. (In this type of accident there are several different pumping systems, any one of which would provide sufficient water to avert a meltdown if all the other somehow failed.);

(e) The containment, a strong building in which the reactor is housed, which would normally hold the released radioactivity inside even if there were a meltdown.

SAFETY PRECAUTIONS

Treatment and Conditioning of Nuclear Wastes Treatment and conditioning processes are used to convert radioactive waste materials into a form that is suitable for its subsequent management, such as transportation, storage and final disposal. The principal aims are to:

(a) Minimize the volume of waste requiring management via treatment processes.

(b) Reduce the potential hazard of the waste by conditioning it into a stable solid form that immobilizes it and provides containment to ensure that the waste can be safely handled during transportation, storage and final disposal.

It is important to note that, while treatment processes such as compaction and incineration reduce the volume of waste, the amount of radioactivity remains the same. As such, the radioactivity of the waste will become more concentrated as the volume is reduced.

Conditioning processes such as cementation and vitrification are used to convert waste into a stable solid form that is insoluble and will prevent dispersion to the surrounding environment. A systematic approach incorporates :

(a) Identifying a suitable matrix material – such as cement, bitumen, polymers or borosilicate glass - that will ensure stability of the radioactive materials for the period necessary. The type of waste being conditioned determines the choice of matrix material and packaging.

(b) Immobilizing the waste through mixing with the matrix material.

(c) Packaging the immobilized waste in, for example, metallic drums, metallic or concrete boxes or containers, copper canisters.

The choice of process used is dependent on the level of activity and the type (classification) of waste. Each country's nuclear waste management policy and its national regulations also influence the approach taken.