The purpose of this digital form of study materials or notes of subject Energy & Environment Engineering is only for circulation among students for study and not for any business /commercial use or for printing books. Most of data is collected from Google, Britannica, G D Rai-Energy Sources , Parulekar B.B conventional, Renewable And Conventional and Govt's Energy lab.

BTES105/205 Energy and Environment Engineering 2 Credits

Teaching Scheme **: 2 Hrs. (Lecture/week)**

Evaluation Scheme **: CA, MSE, ESE**

Marks **: 100**

Course Objectives & Course Outcomes:

1. To Identify conventional, non-conventional energy sources.
2. To understand the power consuming and power developing devices for effective utilization and power consumption
3. To identify various sources of air, water pollution and its effects.
4. To understand noise, soil, thermal pollution and Identify solid, biomedical and hazardous waste.

Reference/Text Books:

Sr.No	Name of Author	Reference / Text book	Publication
1	A Chakrabarti, M. L Soni, P. V. Gupta, U. S. Bhatnagar,	A Text book of Power System Engineering	Dhanpat Rai Publication
2.	Rai. G. D.,	Non Conventional Energy Sources	Khanna Publishers, Delhi, 2006
3	Rao S.,	Energy Technology-Non	Khanna Publishers, Delhi,

	Parulekar B.B.,	conventional, Renewable And Conventional	2005
4.	Glynn Henry J., Gary W. Heinke	Environmental Science and Engineering,	Pearson Education, Inc, 2004
5.	J. M. Fowler	Energy and the Environment	McGraw-Hill, 2 nd Edition, 1984
6	Gilbert M. Masters	Introduction to Environmental Engineering and Science	2nd Edition, Prentice Hall, 2003

Unit 1: Conventional Power Generation: (4 hours)

Steam power station, Nuclear power plant – Gas turbine power plant- Hydro power station: Schematic arrangement, advantages and disadvantages, Thermo electric and thermionic generators, Environmental aspects for selecting the sites and locations of power plants.

Power Generation:

Power is generated from Convention (Non- renewable) & Non-conventional (Renewable) energy source.

Conventional energy sources such as Natural gas, Oil, Coal or Nuclear are finite (exhaustible)

Non-conventional energy sources are Solar, Wind, Ocean and Tidal; which are inexhaustible.

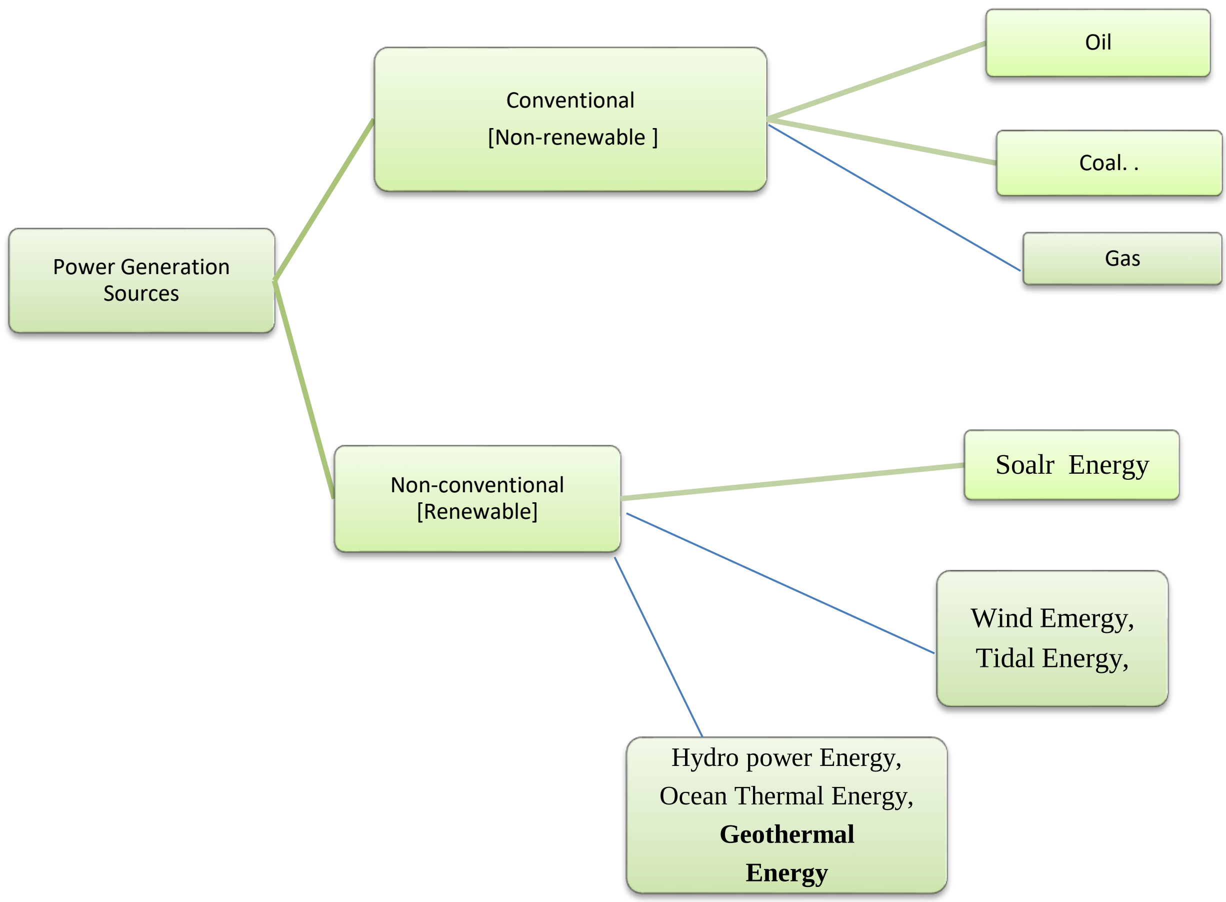


Fig-1.1: General Classification of Energy.

Energy consumption as a measure of Prosperity:

The standard of living of every country is depending on per capita energy consumption. Energy crisis is due to two reasons; firstly the population of the world has increases rapidly and secondly the standard of living of human being has increased.

The per capita income is 50% more than per capita income of the India, and so also is the per capita energy consumption.

The per capita energy consumption in USA is about 8000kWh per year, whereas the per capita energy consumption in India is 150kWh per year.

USA with 7% world's population consume 32% of the total energy consumed in the world, whereas India, a developing country with 20% of the world population consume only 1% of the total energy consumed in the world.

1. Steam Power Station: Or [Thermal Power plant]

Steam produce in the boiler, is expanded in the prime mover (turbine) and its condensed in condenser to be feed in to the boiler again.

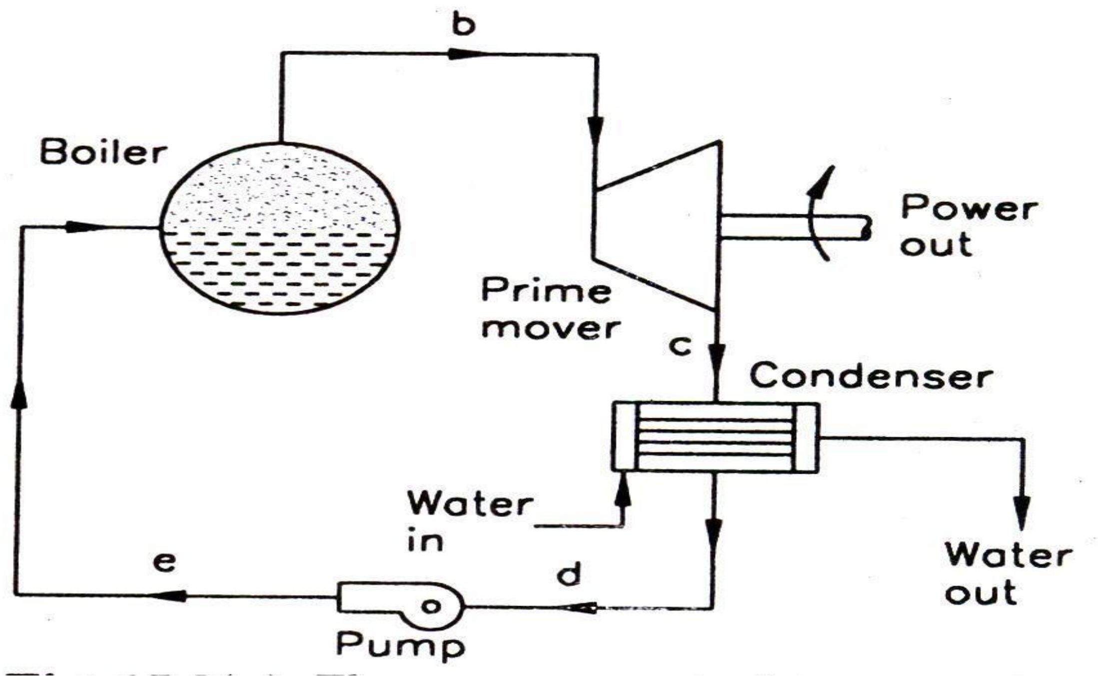


Fig: 1.2 Main Components of Steam Power plant.

1.1: Components of steam power plant [Thermal Power plant]:

a]. Boiler [with mountings Air preheater & Economiser]

b]. Steam turbine & generator

c]. Condenser & Condensate extraction pump.

d]. Cooling Tower

1.1[a] Boiler: It consists of tubes, boiler shell and super heater. Feed water is heated which is converted into wet steam in water tubes. Then the wet steam is superheated in super heater by hot flue gases. Steam is generated at high pressure in the boiler.

1.1[b] Turbine: High pressure super-heated steam rom boiler expands in the turbine to produce the mechanical work. This work is used to run generator which converts the mechanical energy into electric energy.

1.1 [c] Condenser: Expanded steam from the turbine (low pressure) collected in the condenser where the steam is condensate by rejecting heat to circulate water.

1.1[d] Cooling Tower: Cooling water from cooling tower is supplied to condenser to absorb heat from the exhaust steam of the turbine. The resultant heated water feed to cooling tower at the top & gets cooled by the cool air passed from the bottom of cooling tower

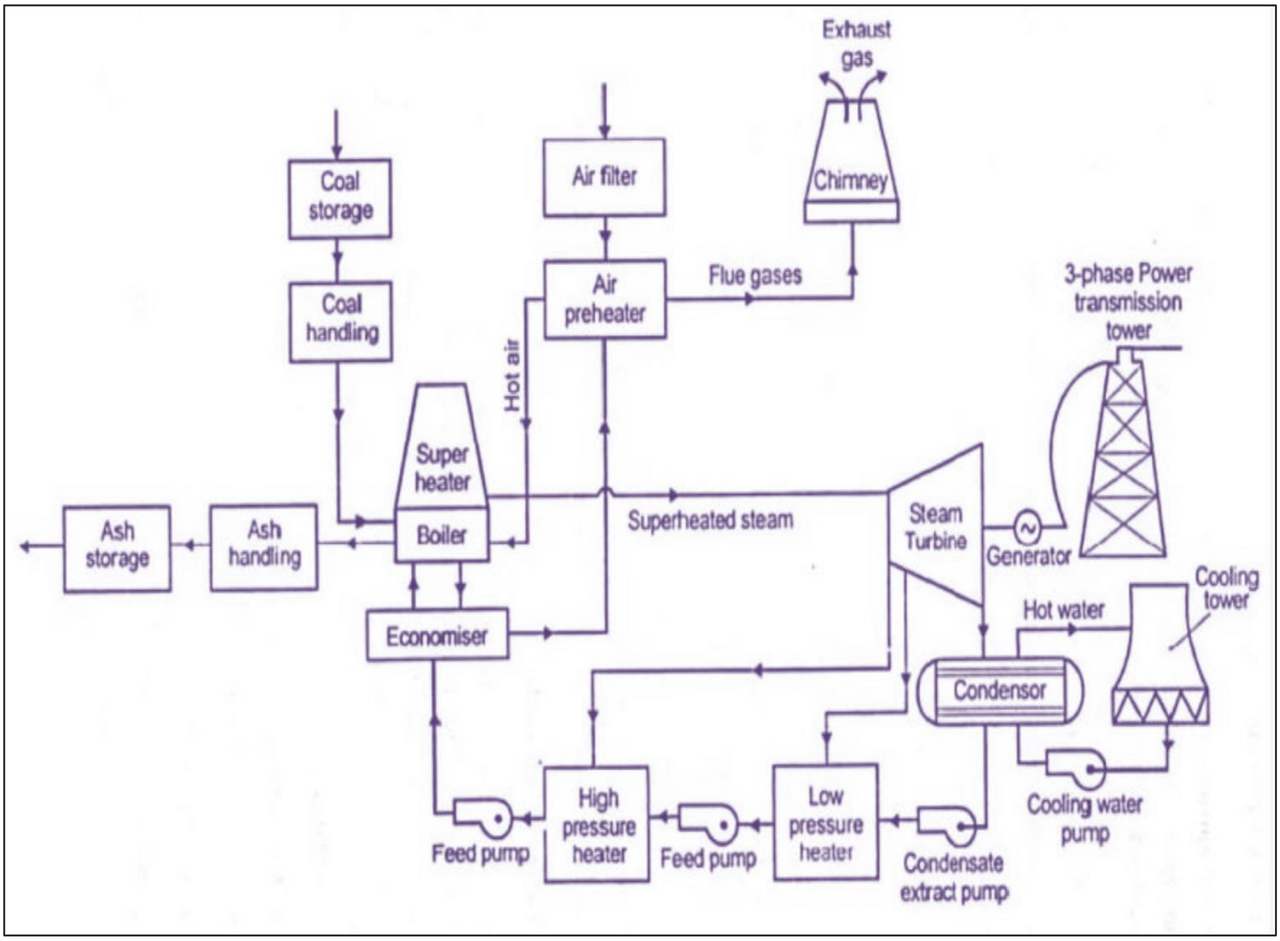


Fig 1.4: Schematic layout of Steam Power plant.

2: The four main circuits one would come across in any thermal power plant layout are:

1. Coal and Ash Circuit
2. Air and Gas Circuit
3. Feed Water and Steam Circuit
4. Cooling Water Circuit

1.2.1. Coal and Ash Circuit: Coal and Ash circuit in a thermal power plant layout mainly takes care of feeding the boiler with coal from the storage for combustion. The ash that is generated during combustion is collected at the back of the boiler and removed to the ash storage by scrap conveyors. The combustion in the Coal and Ash circuit is controlled by regulating the speed and the quality of coal entering the grate and the damper openings.

1.2.2 Air and Gas Circuit: Air from the atmosphere is directed into the furnace through the air preheated by the action of a forced draught fan or induced draught fan. The dust from the air is removed before it enters the combustion chamber of the thermal power plant layout. The exhaust gases from the combustion heat the air, which goes through a heat exchanger and is finally let off into the environment.

1.2.3. Feed Water and Steam Circuit: The steam produced in the boiler is supplied to the turbines to generate power. The steam that is expelled by the prime mover in the thermal power plant layout is then condensed in a condenser for re-use in the boiler. The condensed water is forced through a pump into the feed water heaters where it is heated using the steam from different points in the turbine. To make up for the lost steam and water while passing through the various components of the thermal power plant layout, feed water is supplied through external sources. Feed water is purified in a purifying plant to reduce the dissolve salts that could scale the boiler tubes.

1.2.4. Cooling Water Circuit: The quantity of cooling water required to cool the steam in a thermal power plant layout is significantly high and hence it is supplied from a natural water source like a lake or a river. After passing through screens that remove particles that can plug the condenser tubes in a thermal power plant layout, it is passed through the condenser where the steam is condensed. The water is finally discharged back into the water source after cooling. Cooling water circuit can also be a closed system where the cooled water is sent through cooling towers for re-use in the power plant. The cooling water circulation in the condenser of a thermal power plant layout helps in maintaining allow pressure in the condenser all throughout. All these circuits are integrated to form a thermal power plant layout that generates electricity to meet our needs.

2. Boiler's: Boiler is Steam producing device.

2.1. Cochran Boiler:

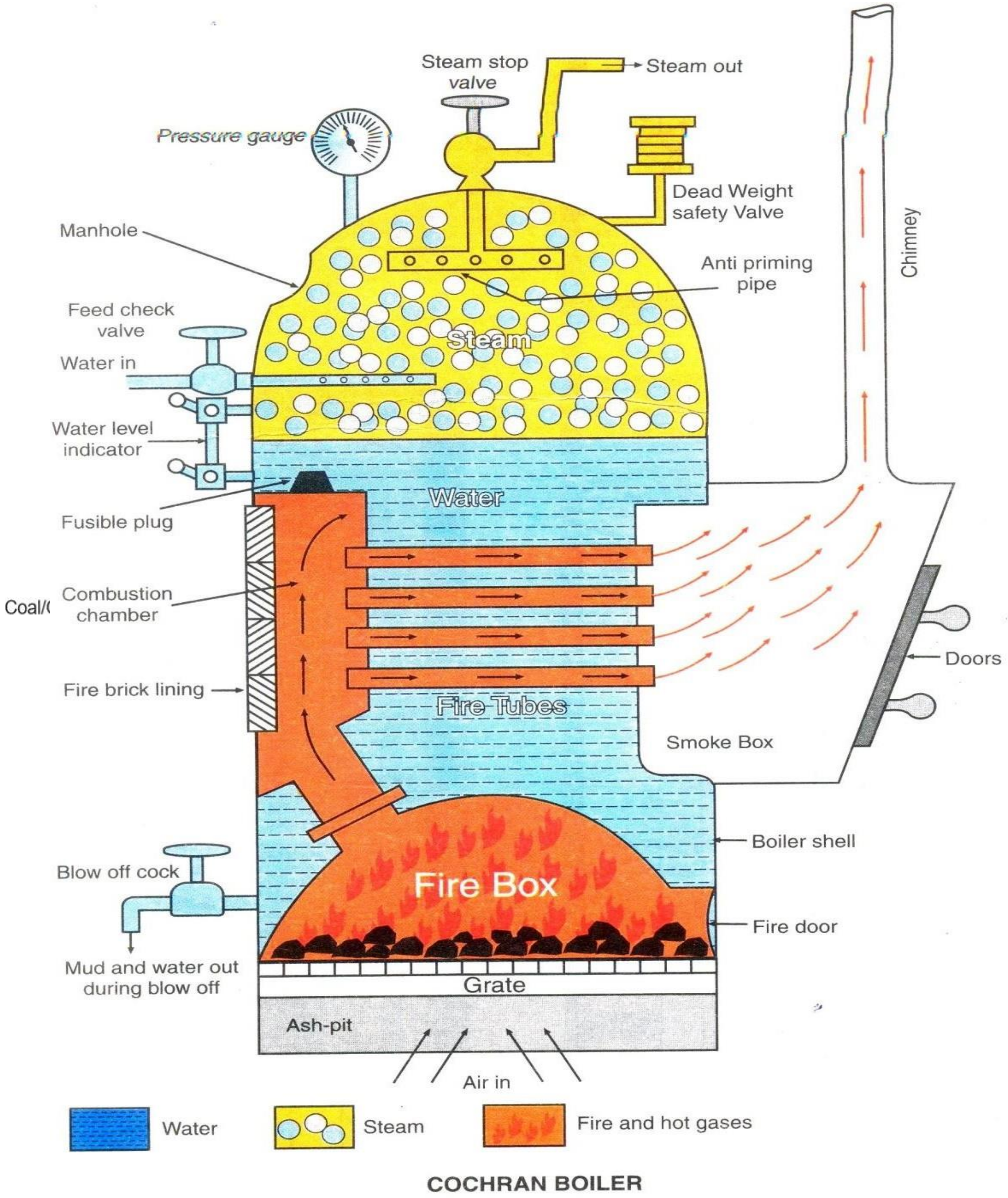


Fig-1.3: Steam Power Plant working on ranking Cycle.

- Cochran boiler is a vertical, multi tube boiler, commonly used for small capacity steam generation.
- Figure shows the arrangement of boiler. It consists of a cylindrical shell with the crown having hemispherical shape.

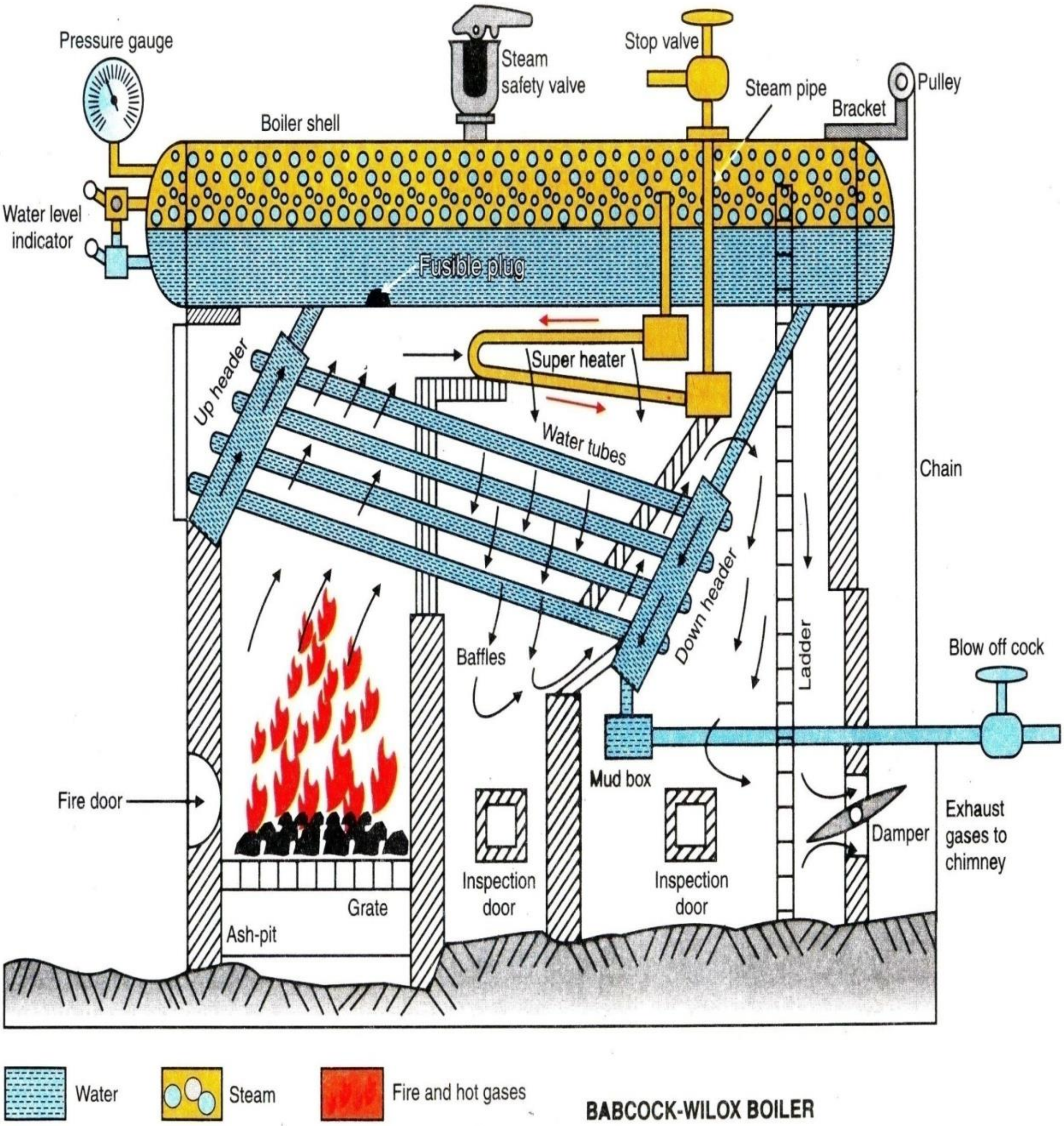
- The grate is placed at the bottom of the furnace and ash pit is below the grate.
- The furnace and the combustion chamber are connected through a pipe. The hot gases from the combustion chamber flow through the nest of horizontal fire tubes.
- The hemispherical crown of the boiler shell gives maximum strength.
- Coal or oil can be used as fuel. The smoke box is provided with doors for cleaning of the interior of the fire tubes.
- This boiler is very compact and requires minimum floor area.
- It gives 70% thermal efficiency.

2.2 Babcock and Wilcox Boiler:

Coal is fed to the grate through the fire door and is burnt in the furnace.

Flow of flue gases: The hot flue gases rise upward and pass across the left-side portion of the water tubes. The baffles deflect the flue gases and hence the flue gases travel in the zig-zag manner (i.e., the hot gases are deflected by the baffles to move in the upward direction, then downward and again in the upward direction) over the water tubes and along the super heater. The flue gases finally escape to atmosphere through chimney.

Water circulation: That portion of water tubes which is just above the furnace is heated comparatively at a higher temperature than the rest of it. Water, its density being decreased, rises into the drum through the uptake-header. Here the steam and water are separated in the drum. Steam being lighter is collected in the upper part of the drum. A continuous circulation of water from the drum to the water tubes and water tubes to the drum is thus maintained. A damper is fitted to regulate the flue gas outlet and hence the draught. The boiler is fitted with necessary mountings. Pressure gauge and water level indicator are mounted on the boiler at its left end. Steam safety valve and stop valve are mounted on the top of the drum. Blow-off cock is provided for the periodical removed of mud and sediments collected in the mud box.



BABCOCK-WILOX BOILER

3. Site Selection Criteria for steam Power Plant:

Following factors are to be consider for selection of site for steam power plant:

1. Availability of raw material & fuel.

2. Cost of land should be reasonable

3. Abundant quantity of cooling water.

5. Ash disposal facilities.

6. Near to distribution center.

7. Transport facilities.

2. Nuclear Power Plant:

Nuclear power is a clean and efficient way of boiling water to make steam, which turns turbines to produce electricity. The most common fuel for the electrical producing reactor plants is uranium. Nuclear power plants use low-enriched uranium fuel to produce electricity.

Nuclear Fission: The process of bombarding unstable heavy nuclear with high energy neutrons to produce several smaller fragments of fission products. 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.

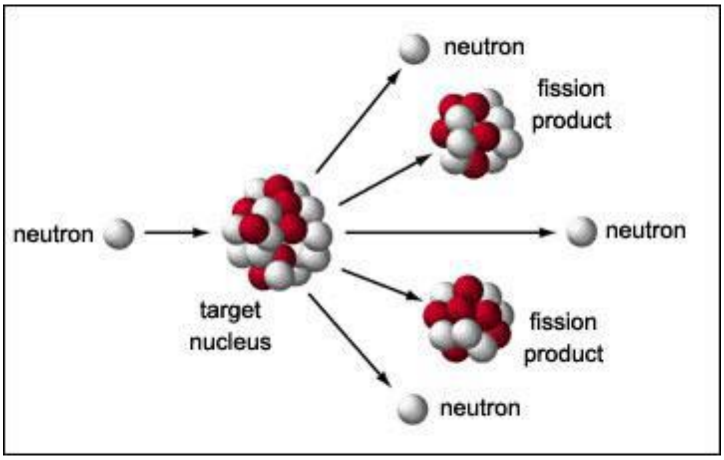


Figure 1.5: Nuclear Fission

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.

Controlled Nuclear Fission:

To maintain a sustained controlled nuclear reaction, for every 2 or 3 neutrons released, only one must be allowed to strike another (uranium) nucleus. If this ratio is less than one then the reaction will die out; if it is greater than one it will grow uncontrolled (an atomic explosion). A neutron absorbing element must be present to control the amount of free neutrons in the reaction space. Most reactors are controlled by means of control rods that are made of a strongly neutron-absorbent material such as boron or cadmium.

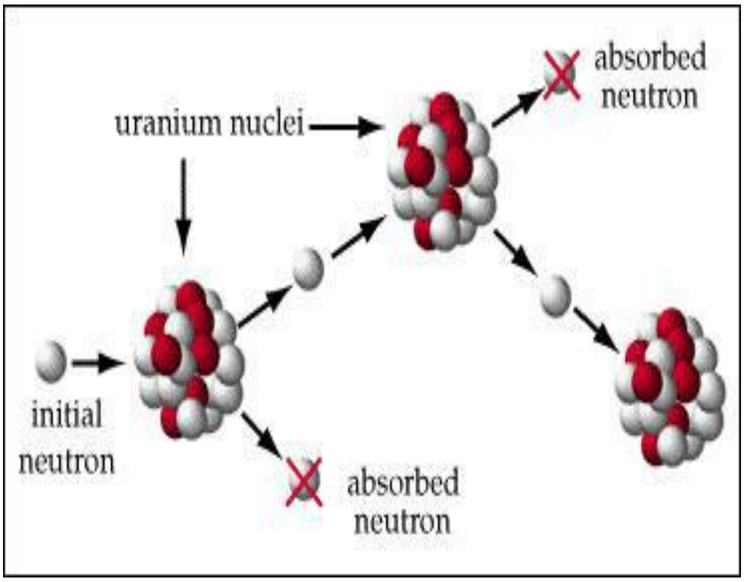


Figure 16: Controlled Nuclear Fission.

In addition to the need to capture neutrons, the neutrons often have too much kinetic energy. These fast neutrons are slowed through the use of a moderator such as heavy water and ordinary water. Some reactors use graphite as a moderator, but this design has several problems. Once the fast neutrons have been slowed, they are more likely to produce further nuclear fissions or be absorbed by the control rod.

Nuclear Fusion: The process by which multiple like – charged atomic nuclei join together to form a heavier nucleus.

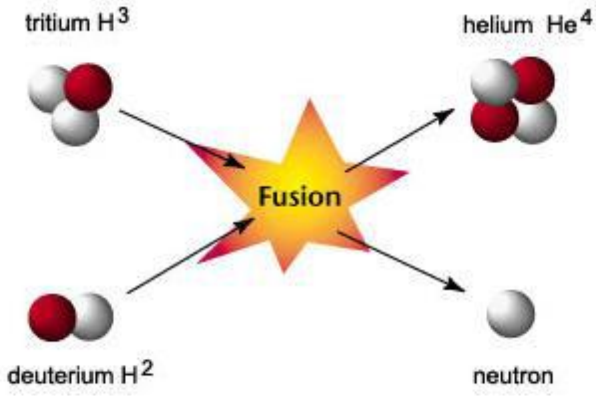


Figure 1.7: Nuclear Fusion.

Due to high demand of electricity, the need for establishing different types of power plant is increased. Nuclear power plant is one of the power generating modes. In this unit, we have learnt about nuclear fission and nuclear fusion. The nuclear chain reaction is unique since it releases several million times more energy per reaction than any chemical reaction. 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.

The process in which nuclear energy is produced in the result of a series of steps:

•Splitting of Atoms. Uranium atoms, in the form of ceramic-coated pellets, are placed in a reactor core.

•Absorption. Control rods are used to absorb the free floating neurons released during the fission process.

•Heat.

•Water and Piping .

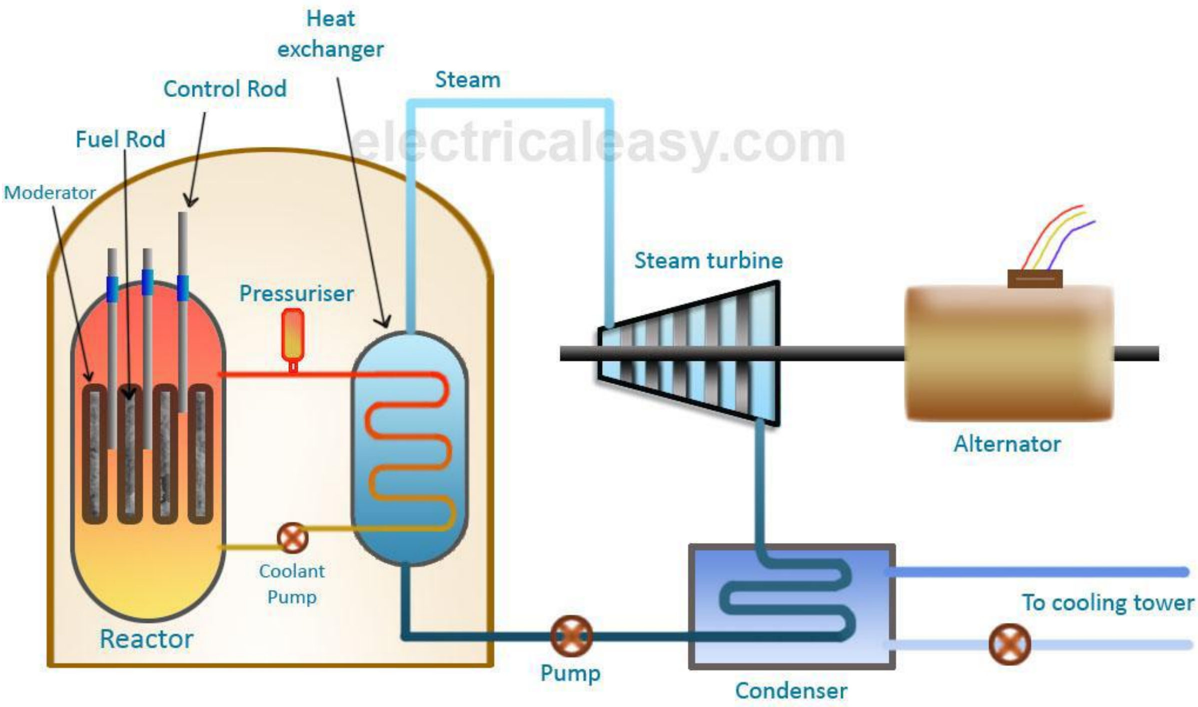


Fig1.8: Layout and Subsystems of Nuclear Power Plants.

A Nuclear Reactor: formerly known as an atomic pile, is a device used to initiate and control a self-sustained nuclear chain reaction. Nuclear reactors are used at nuclear power plants for electricity generation and in nuclear marine propulsion.

Component of Nuclear Reactor & its functions:

- **Moderators :**

In any chain reaction, the neutrons produced are fast moving neutrons. These are less effective in causing fission of **U235** and they try to escape from the reactor. It is thus implicit that speed of these neutrons must be reduced if their effectiveness is carrying out fission is to be increased. This is done by making these neutrons collide with lighter nuclei of other materials, which does not absorb these neutrons but simply scatter them. Each collision causes loss of energy and thus the speed of neutrons is reduced. Such a material is called a ‘Moderator. The neutrons thus slowed down are easily captured by the fuel element at the chain reaction proceeds slowly.

- **Reflectors**

Some of the neutrons produced during fission will be partly absorbed by the fuel elements, moderator, coolant and other materials. The remaining neutrons will try to escape from the reactor and will be lost. Such losses are minimized by surrounding (lining) the reactor core with a material called a reflector which will reflect the neutrons back to the core. They improve the neutron economy. Economy: Graphite, Beryllium.

- **Shielding**

During Nuclear fission ¥, b, g particles and neutrons are also produced. They are harmful to human life. Therefore it is necessary to shield the reactor with thick layers of lead, or concrete to protect both the operating personnel as well as environment from radiation hazards.

- **Cladding**

In order to prevent the contamination of the coolant by fission products, the fuel element is covered with a protective coating. This is known as cladding. Control rods are used to control the reaction to prevent it from becoming violent. They control the reaction by absorbing neutrons. These rods are made of boron or cadmium. Whenever the reaction needs to be stopped, the rods are fully inserted and placed against their seats and when the reaction is to be started the rods are pulled out.

- **Coolant**

The main purpose of the coolant in the reactor is to transfer the heat produced inside the reactor. The same heat carried by the coolant is used in the heat exchanger for further utilization in the power generation.

- **Pressure Vessel or Pressure Tubes :**

Usually a robust steel vessel containing the reactor core and moderator/coolant, but it may be a series of tubes holding the fuel and conveying the coolant through the moderator.

- **Steam Generator**

Part of the cooling system where the heat from the reactor is used to make steam for the turbine.

Classification of Nuclear Power Reactor on the basis of different criteria:

- **On the Basis of Neutron Energy:**

(a) Fast Reactor: In these reactors, fission is affected by fast neutrons without any use of moderators.

(b) Thermal Reactors: In these reactors, fission is affected by fast neutrons are slowed down with the use of moderators. The slow neutrons are absorbed by the fissionable fuel and chain reaction is maintained.

- **On the Basis of Fuel Used**

(a) Natural Fuel: In this reactor, natural Uranium is used as fuel and generally heavy water or graphite is used as moderator.

(b) Enriched Uranium: In this reactor, the Uranium used contains 5 to 10% U235 and ordinary water can be used as moderator.

- **On the Basis of Moderator Used**

(a) Water moderated

(b) Heavy water moderated

(c) Graphite moderated

(d) Beryllium moderated.

- **On the Basis of Coolant Used**

(a) Water cooled reactors

(b) Gas cooled reactors

(c) Liquid metal cooled reactors

(d) Organic liquid cooled reactors.

- **Classification by Use:**

(a) Electricity Nuclear Power Plant.

(b) Propulsion:

(i) Nuclear marine propulsion.

(ii) Various proposed forms of rocket propulsion.

(c) Other Uses of Heat:

(i) Desalination

(ii) Heat for domestic and industrial heating

(iii) Hydrogen production for use in a hydrogen economy

Types of Nuclear reactor:

- Pressurised Water Reactor
- Boiling Water Rector
- Pressurised Heavy Water Reactor
- Gas Cooled Reactor

1. Pressurised Water Reactor [PWR]:

There are two major systems utilized to convert the heat generated in the fuel into electrical power for industrial and residential use. The primary system transfers the heat from the fuel to the steam generator, where the secondary system begins. The steam formed in the steam generator is transferred by the secondary system to the main turbine generator, where it is converted into electricity. After passing through the low pressure turbine, the steam is routed to the main condenser. Cool water, flowing through the tubes in the condenser, removes excess heat from the steam, which allows the steam to condense. The water is then pumped back to the steam generator for reuse.

The pressurized water reactor (PWR) differs from the boiling water reactor in that steam is produced in the steam generator rather than in the reactor vessel. The pressurizer keeps the water that is flowing through the reactor vessel under very high pressure (more than 2,200 pounds per square inch) to prevent it from boiling, even at operating temperatures of more than 600F.

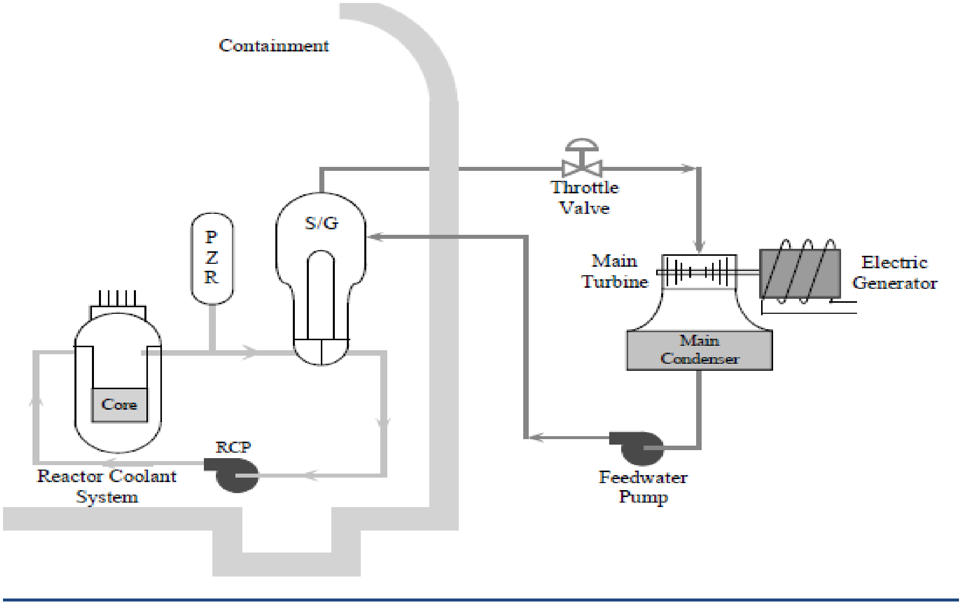


Fig: 1.9 Pressurised Water Reactors.

2. Boiling Water Rector:

Inside the boiling water reactor (BWR) vessel, a steam water mixture is produced when very pure water (reactor coolant) moves upward through the core absorbing heat.

The major difference in the operation of a BWR from other nuclear systems is the steam void formation in the core.

The steam-water mixture leaves the top of the core and enters the two stages of moisture separation, where water droplets are removed before the steam is allowed to enter the steam line.

The steam line, in turn, directs the steam to the main turbine causing it to turn the turbine and the attached electrical generator.

The unused steam is exhausted to the condenser where it is condensed into water.

The resulting water is pumped out of the condenser with a series of pumps and back to the reactor vessel.

The recirculation pumps and jet pumps allow the operator to vary coolant flow through the core and change reactor power.

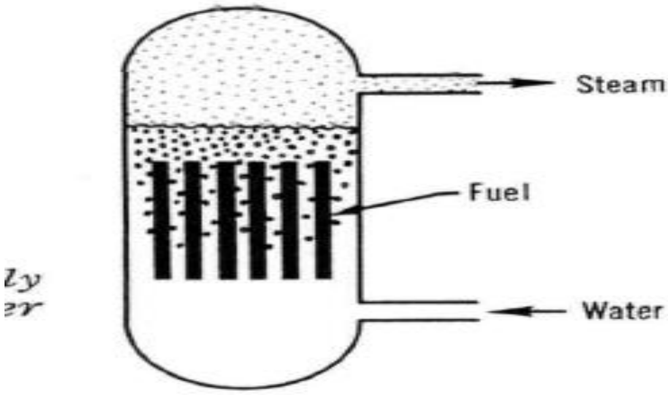


Fig 1.10: Boiling Water Reactor.[BWR]

3. Pressurised Heavy Water Rector.

A **pressurized heavy water reactor** (PHWR) is a nuclear power reactor, commonly using un-enriched natural uranium as its fuel, which uses heavy water (deuterium oxide D_2O) as its coolant and moderator.

The heavy water coolant is kept under pressure, allowing it to be heated to higher temperatures without boiling, much as in a typical pressurized water reactor.

While heavy water is significantly more expensive than ordinary light water, it yields greatly enhanced neutron economy, allowing the reactor to operate without fuel enrichment facilities (mitigating the additional capital cost of the heavy water) and generally enhancing the ability of the reactor to efficiently make use of alternate fuel cycles.

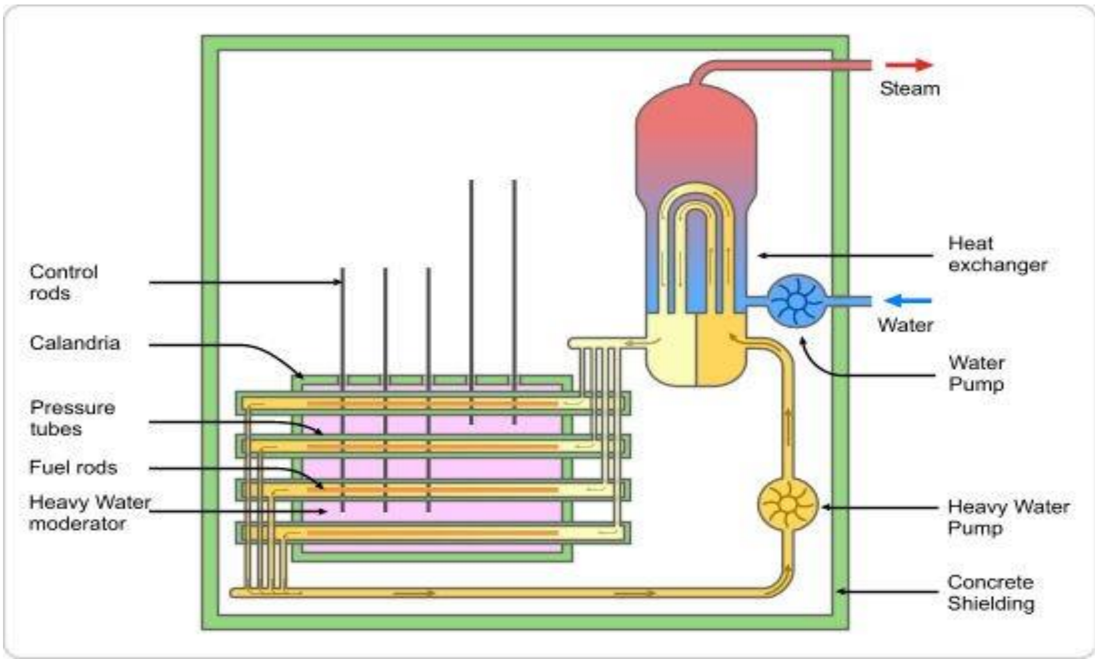


Fig1.11 (A) Pressurised Heavy Water Rector.

OR

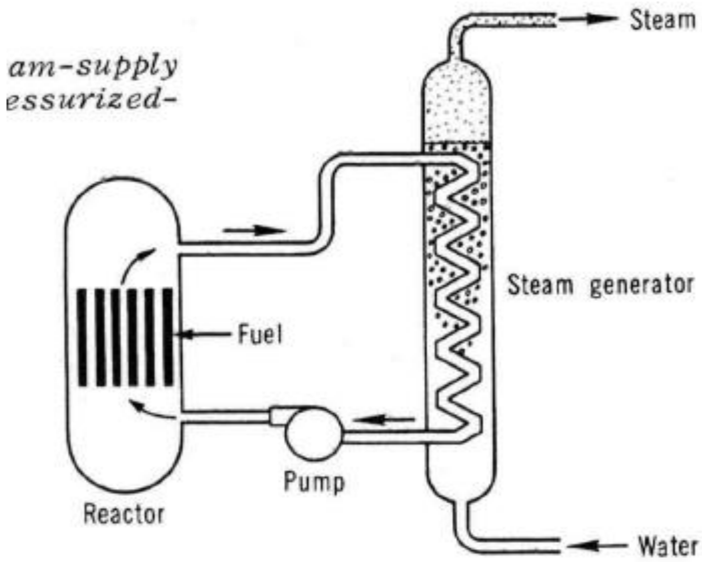


Fig 1.11(B) Pressurised Heavy Water Rector.

Use of natural uranium as a fuel

Example of [PHWR] is CANDU stands for "**CAN**ada **D**euterium **U**ranium".

It's a Canadian-designed power reactor of PHWR type (Pressurized Heavy Water Reactor) that uses heavy water (deuterium oxide) for moderator and coolant, and natural uranium for fuel.

CANDU is the most efficient of all reactors in using uranium: it uses about 15% less uranium than a pressurized water reactor for each megawatt of electricity produced

- Use of natural uranium widens the source of supply and makes fuel fabrication easier. Most countries can manufacture the relatively inexpensive fuel
- There is no need for uranium enrichment facility
- Fuel reprocessing is not needed, so costs, facilities and waste disposal associated with reprocessing are avoided
- CANDU reactors can be fuelled with a number of other low-fissile content fuels, including spent fuel from light water reactors. This reduces dependency on uranium in the event of future supply shortages and price increases

High Temperature Gas-Cooled Reactor

CO_2 as a primary coolant and had reactor inlet and outlet temperature of 280°C and 675°C, respectively.

Chemically inert helium flowing through the core removes the fission heat. The outlet temperature of the helium can be set to match the mission for the reactor. Designs with a 750°C outlet temperature of the helium are used to produce steam via an indirect Rankine cycle. The helium outlet temperature can approach 900°C for higher temperature process heat needs. The heat carried by the helium can be transferred to another fluid through an intermediate heat exchanger for subsequent process heat application and/or electricity.

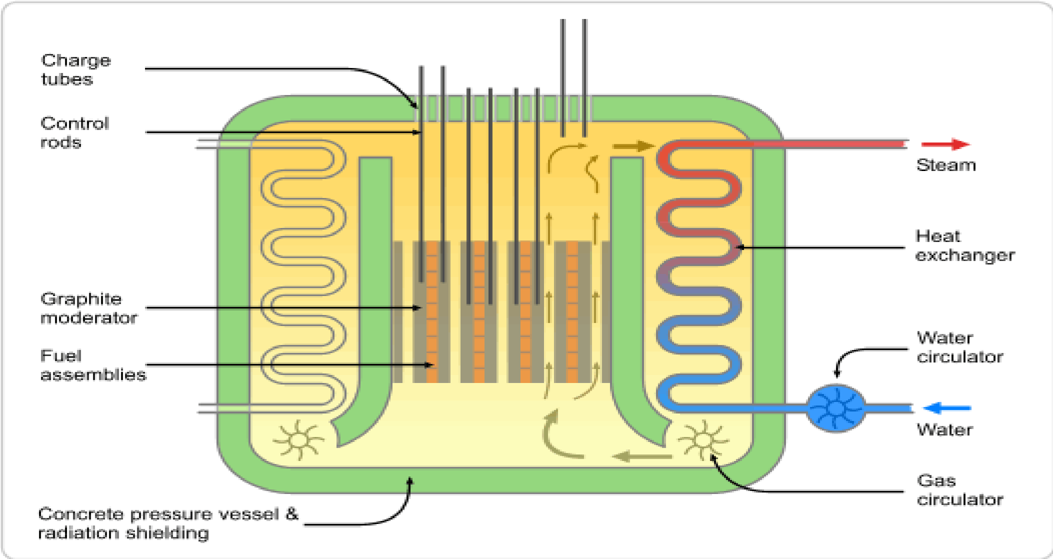


Fig.1.12(A): High Temperature Gas-Cooled Reactor.

OR

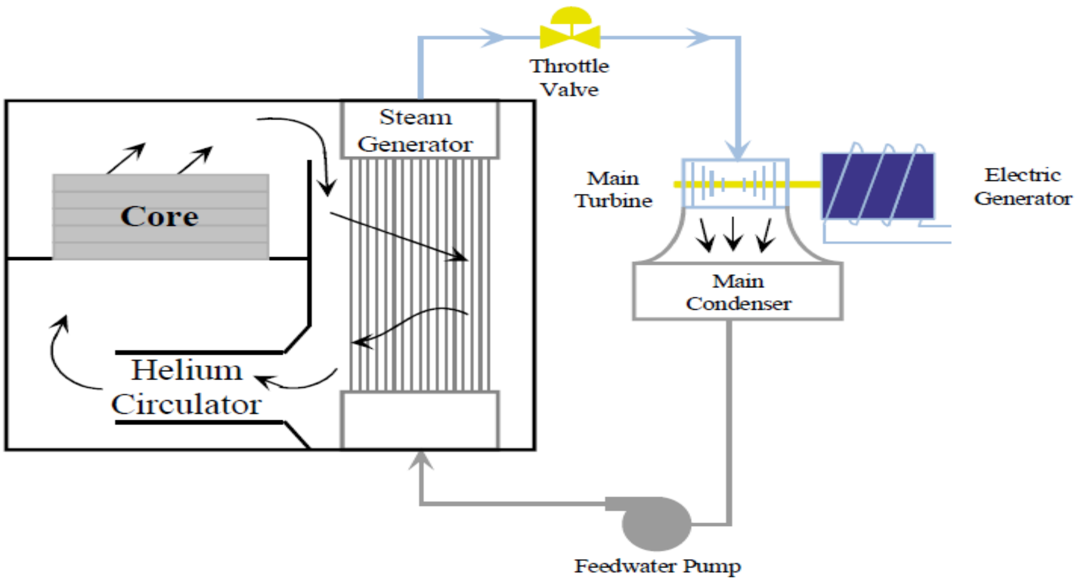


Fig. 1.12(B): High Temperature Gas-Cooled Reactor.

Some of the desirable properties of good coolant are listed below:

1. It must not absorb the neutrons.
2. It must have high chemical and radiation stability
3. It must be non-corrosive.
4. It must have high boiling point (if liquid) and low melting point (if solid)
5. It must be non-oxidising and non-toxic.

Advantages of Nuclear Power Plant:

1. It can be easily adopted where water and coal resources are not available.
2. The nuclear power plant requires very small quantity of fuel. Hence fuel transportation cost is less.
3. Space requirement is less compared to other power plants of equal capacity.
4. It is not affected by adverse weather conditions.
5. Fuel storage facilities are not needed as in the case of the thermal power plant.
6. Nuclear power plants will converse the fossils fuels (coal, petroleum) for other energy needs.
7. Number of workmen required at nuclear plant is far less than thermal plant.
8. It does not require large quantity of water.

Disadvantages of Nuclear Power Plant :

1. Radioactive wastes, if not disposed of carefully, have adverse effect on the health of workmen and the population surrounding the plant.
2. It is not suitable for varying load condition.
3. It requires well-trained personnel.
4. It requires high initial cost compared to hydro or thermal power plants.

Site selection criteria For Nuclear Power plant:

1. Land Availability.
2. Soil Type and its geology
3. Water availability.
4. Transportation
5. Disposal of nuclear waste.
6. Social issues
7. Labour

3. Gas Turbine Power Plants:

A gas turbine essentially brings together air that it compresses in its compressor module, and fuel, that are then ignited. Resulting gases are expanded through a turbine.

That turbine's shaft continues to rotate and drive the compressor which is on the same shaft, and operation continues.

A separate starter unit is used to provide the first rotor motion, until the turbine's rotation is up to design speed and can keep the entire unit running.

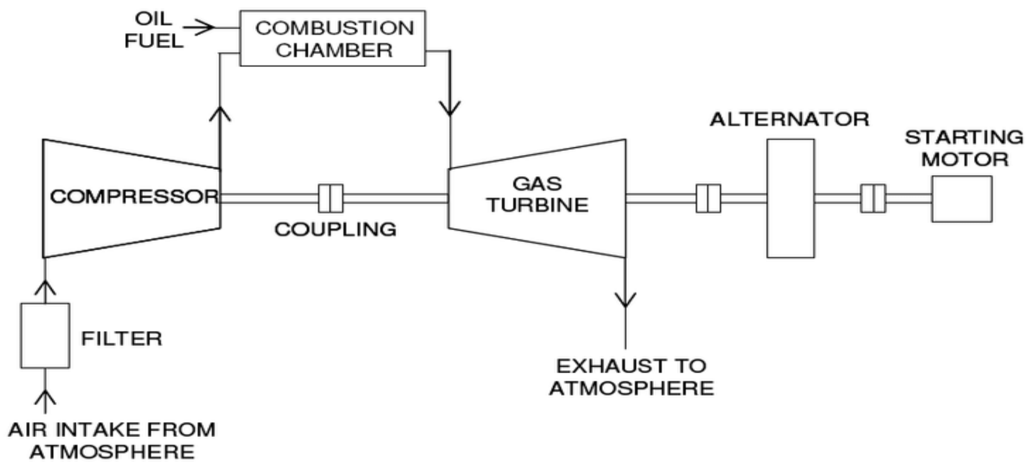


Fig No: 1.13 Gas Turbine Power Plants.

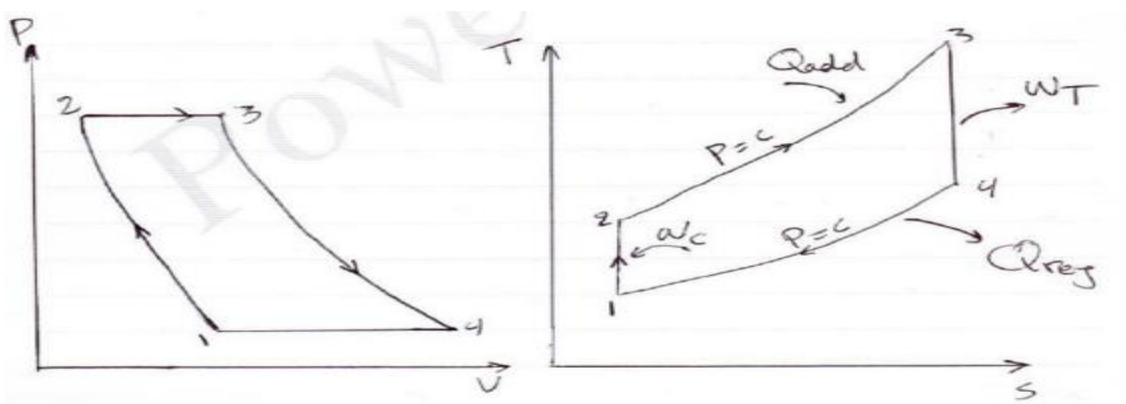


Fig No: 1.14 P-V and T-S diagram of GTPP.

A gas turbine, also called a Combustion Turbine, is a type of internal combustion engine. It has an upstream rotating compressor coupled to a downstream rotating turbine and in between a combustion chamber. The basic operation of the gas turbine is similar to that of the steam power plant except that air is used instead of water.

Fuels for Gas Turbine Plant:

A wide variety of fuel used from solid to gaseous can be used in gas turbine plant. The ideal fuel is *natural gas* but it is not always available. *Producer gas or Blast furnace* can also be used for these plants.

Liquid fuel such as Furnace oil, boiler fuel oil.

Solid fuel as Pulverised coal fuel for closed cycle plant.

The following the major fields & applications of gas turbines:

1. Aircraft field
2. Electrical power generation
3. Marine propulsion
4. Oil & gas industry

The gas turbines have the main following benefits (Advantages):

1. Very high power-to-weight ratio.
2. Smaller space requirements than the most reciprocating engines of the same power rating.
3. Fewer moving parts than the reciprocating engines.
4. Less vibration due to perfect balancing.
5. Very low toxic emissions.
6. Lower installation & maintenance costs.

The gas turbines have the main following limitations (disadvantages):

1. The cost is very high.
2. Short life & non-reversibility.
3. The efficiency is less than that of the reciprocating engines at idle speed.
4. It is very sensitive to the changes of the components.
5. Special metal & alloys are required for different components of the plants.
6. Special cooling techniques are required for cooling the turbine blades.

4. Hydro-Electric Power Plant:

Hydro power plants convert the potential energy of falling water into electricity. Since there are very few water-falls which could be used as a source of potential energy, hydro power plants are associated with dams.

In order to produce hydel electricity, high-rise dams are constructed on the river to obstruct the flow of water and thereby collect water in larger reservoirs. The water level rises and in this process the kinetic energy of flowing water gets transformed into potential energy. The water from the high level in the dam is carried through pipes, to the turbine, at the bottom of the dam.

India has a history of about 120 years of hydropower. The first small hydro project of 130 kW commissioned in the hills of Darjeeling in 1897 mark the development of hydropower in India.

The Sivasamudram project of 4500 kW was the next to come up in Mysore district of Karnataka in 1902, for supply of power to the Kolar gold factory [KGF]. Following this, there were number of small hydro projects set up in various hilly areas of the country.

Till the Independence (1947), the country had an installed capacity of 1362 MW, which included 508 MW hydropower projects, mainly small and medium. As per MNRE, the estimated potential of small hydro power plant is 20 GW across the country.

General Hydroelectric Power Plant:

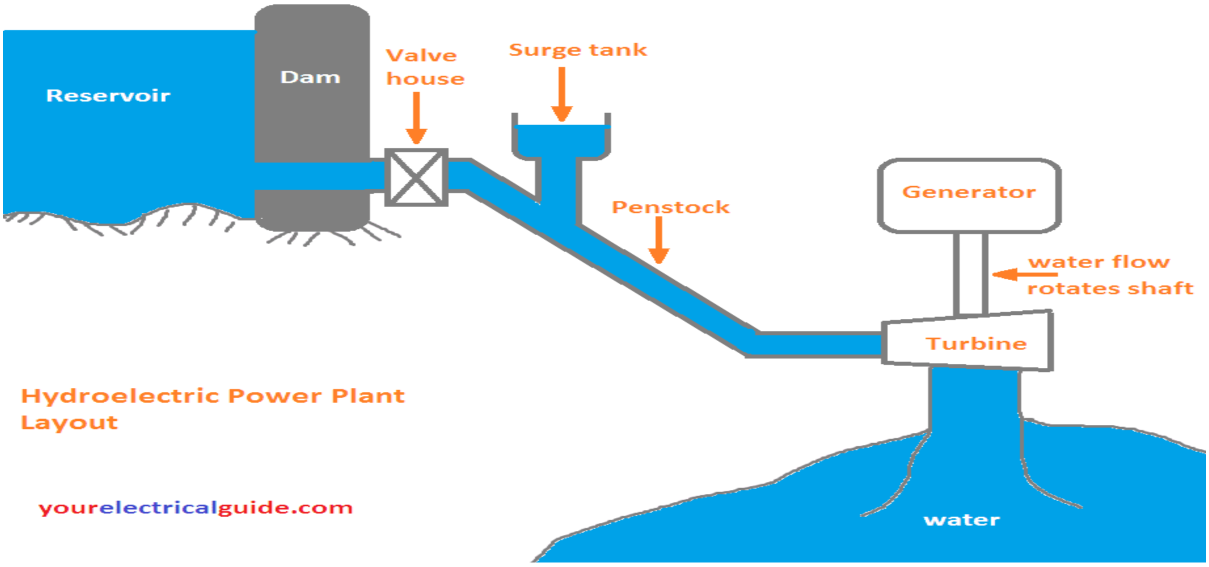


Fig 1.15 General Hydro Electric Power Plant.

- Potential energy of water used to rotate the hydraulic turbines.
- Hydro power plant located near water bodies having enough head (for potential).
- Power develop is depend on amount of water and water head.[H]
- Potential energy of water in the reservoir convert into kinetic energy when is flows.
- High velocity water strikes of turbine blade where KE converted into mechanical work.
- Turbine is coupled with generator which converts mechanical energy to electrical energy.

$$P = Q * \rho * g * H \qquad \text{(Watt)}$$

Where Q = Discharge water (m^3/sec)

H= Head (m)

ρ = Density of water (Kg/m^3)

g= Gravity (m^2/sec)

Component of Hydro- Electric Power Plant:

1. Reservoir
2. Dam
3. Gate
4. Penstock
5. Turbine
6. Turbine governing mechanism.
7. Surge Tank.

Surge tank:

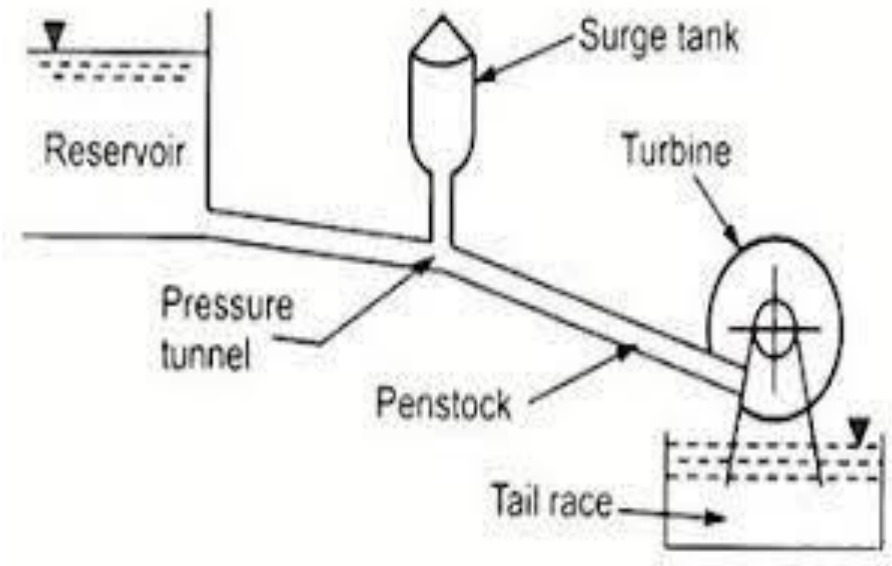


Fig: Surge tank,

Surge tanks are applied in hydropower plants with long water conduits to **reduce pressure forces during the acceleration of the large water masses**. They are constructed as intermittent water reservoirs close to the turbines, either with open access to atmospheric air or as a closed volume filled with pressurized air.

A surge tank (or surge drum or surge pool) is a standpipe or storage reservoir at the downstream end of a closed aqueduct, feeder, dam, barrage pipe to absorb sudden rises of pressure, as well as to quickly provide extra water during a brief drop in pressure.

Detailed Solution. Surge tank: It (or sur ge chamber) is a device introduced within a hydropower water conveyance system having a rather long pressure conduit to absorb the excess pressure rise in case of sudden valve closure. (i.e. **To protect the pipeline against water hammer**

Classification of Hydroelectric Power Plant According to available Head:

1.Low Head Power plant:

A plant operating under head of 30 meters.

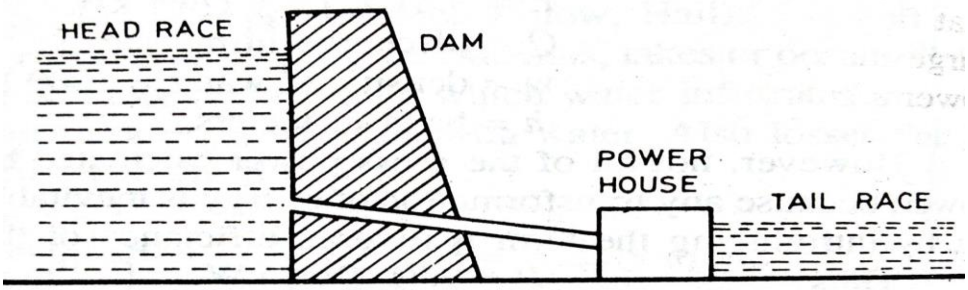


Fig. 3.1. A low head plant.

2.Medium Head Plant:

A palnt is operationg between 30 to 300 meters head.

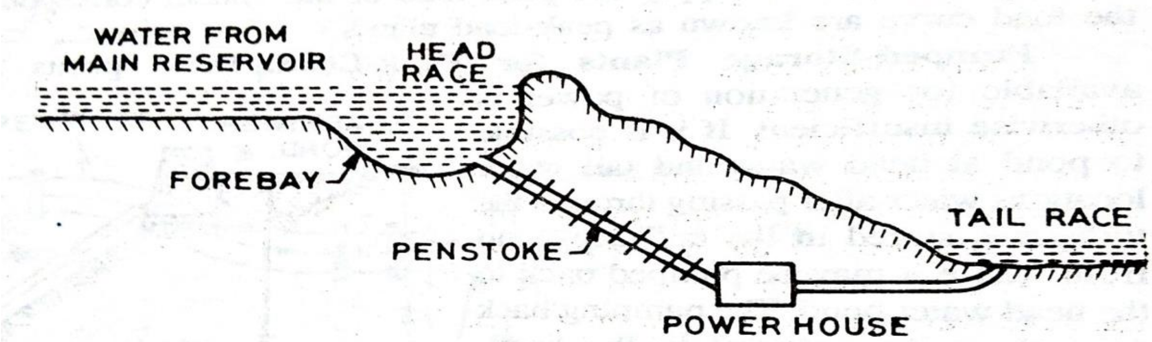


Fig. 3.3. A medium head plant.

3.High Head Plant:

If the operating head is **abive 300 meters** then the plant is High head plant.

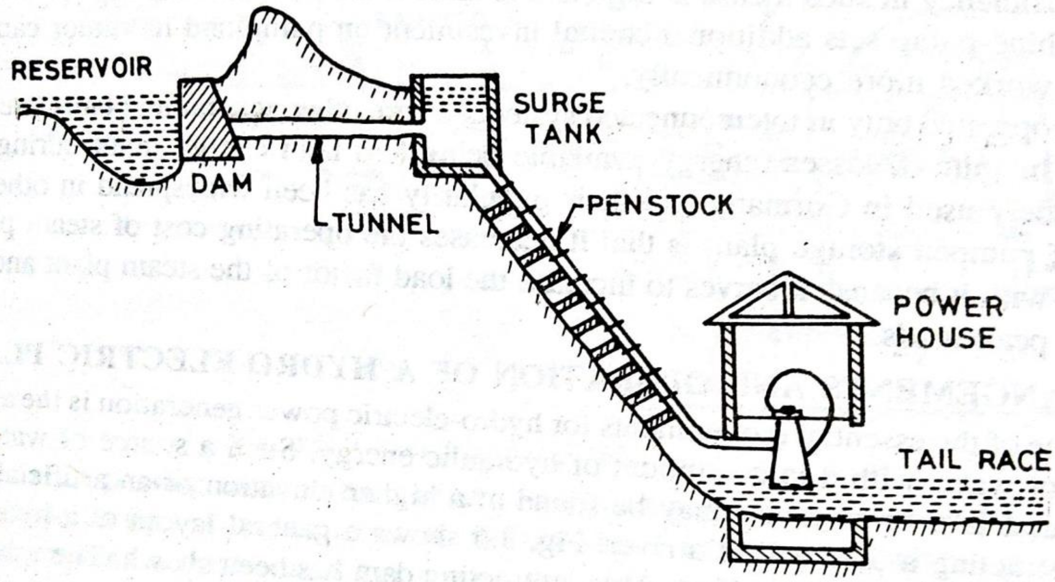


Fig. 3.4. A high head plant.

Site Selection Criteria for Hydro-Electric Power Plant:

1. Water Head

2. Land Slop

3. Sedimentation

4. Economical issue

5. Archaeological and Historical Site.

6. Water pollution level.

Advantages of hydro power generation are:-

- Hydropower is a fuelled by water, so it's a clean fuel source.
- Hydropower doesn't pollute the air like power plants that burn coal natural gas,

- **Hydroelectric power is flexible**. Some hydropower facilities can quickly go from zero power to maximum output. Because hydropower plants can generate power to the grid immediately, they provide essential backup power during major electricity outages or disruptions.
- Hydropower provides benefits beyond electricity generation by providing flood control, irrigation support, and clean drinking water.
- Hydroelectricity promotes guaranteed energy and price stability.
- River water is a domestic resource which, contrary to fuel or natural gas, is not subject to market fluctuations. In addition to this, it is the only large renewable source of electricity and its cost-benefit ratio, efficiency, flexibility and reliability

Disadvantages of hydro power generation are:-

- 1. High investment costs
- 2. Dependent on precipitation
- 3. Sometimes messes up wildlife
- 4. Loss of fish species
- 5. Change in river or stream quality
- 6. Cost for construction
- 7. Hydroelectric power production require flooding of entire valleys and scenic areas

5. Thermoelectric Generation: Or [Seebeck Power Generation]

Thermoelectric generators (TEG) are solid-state semiconductor devices that **convert a temperature difference and heat flow into a useful DC power source**.

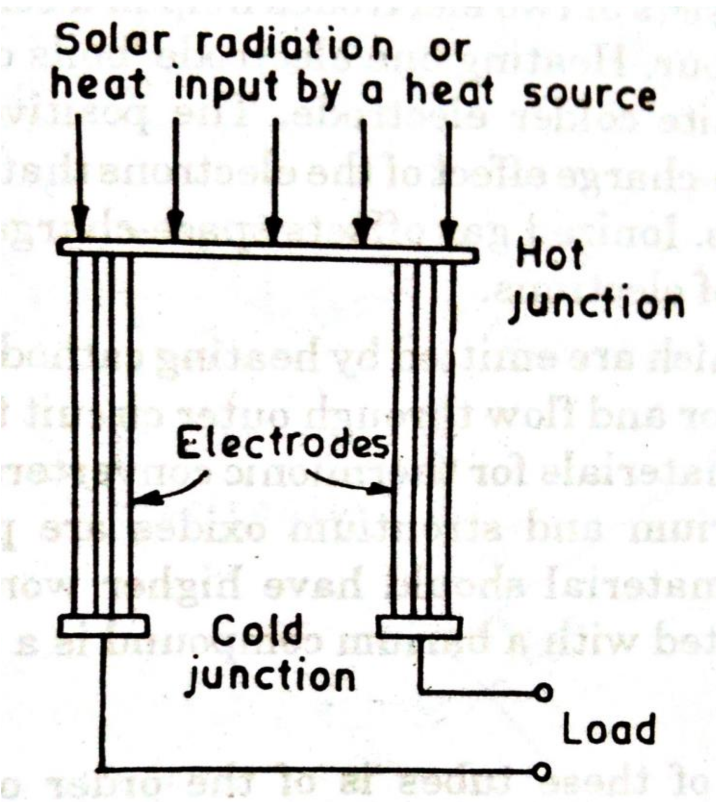


Fig. No 1.16 Thermoelectric Generator.

Thermoelectric generators are solid state heat engines made of two primary junctions, known as the p-type (high concentration of positive charge) and n-type (containing a high concentration of negative charge) elements.

The p-type elements are doped in such a way to have a high number of positive charge or holes giving them a positive Seebeck coefficient. The n-type elements are doped to contain a high concentration of negative charge or electrons that give them a negative Seebeck coefficient.

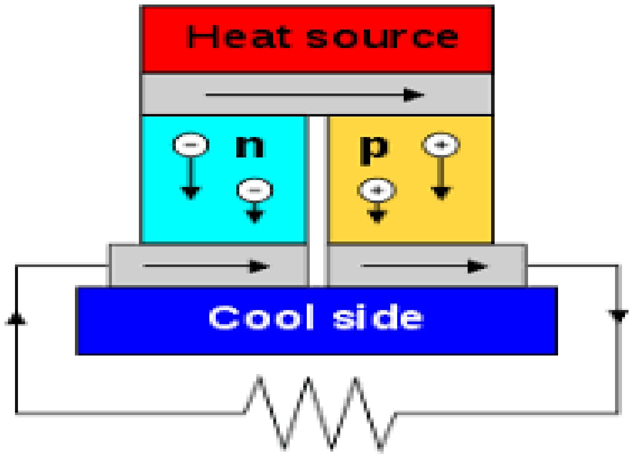


Fig.1.16 Seebeck effect principle of thermal couple.

Working of TEG:

Thomas J. Seebeck tested this law by interpreting it differently. He brought two dissimilar metals where the junctions at which the metals touch are of different temperatures. He noticed that a voltage developed between the junctions proportional to the difference in the heat. The current generated due to the difference in temperature at the junction of two different metals is known as the **Seebeck effect**. The Seebeck Effect produces measurable amounts of voltage and current.

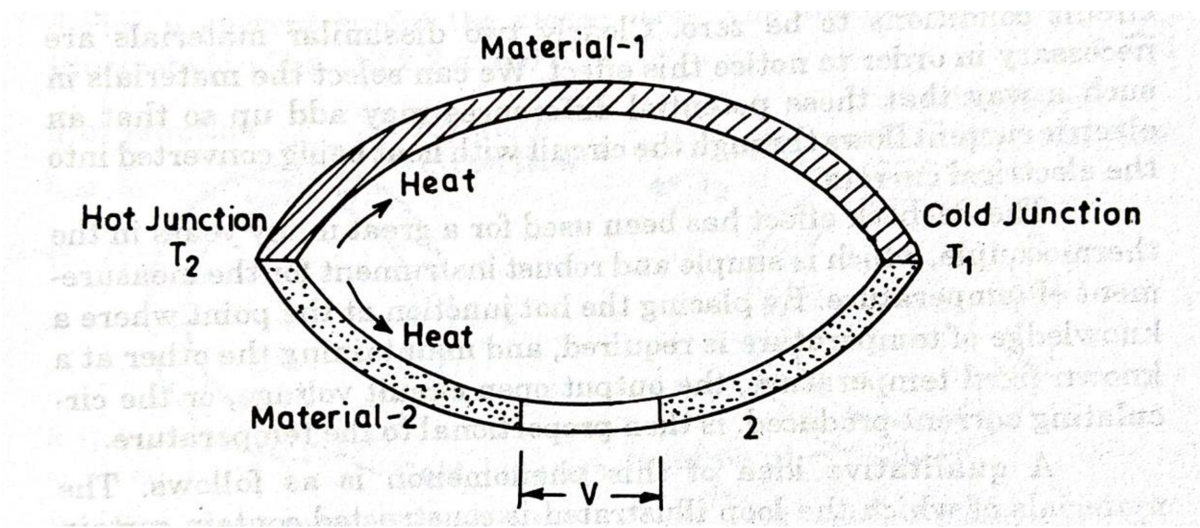


Fig: Seebeck effect principle of Thermal couple.

The voltage produced by TEGs or Seebeck generators is proportional to the temperature difference between the two metal junctions.

$$\Delta T = T_2 - T_1$$

$$V = \int_{T1}^{T2} \propto_{S_{1-2}} \Delta T$$

Where $\propto_{S_{1-2}}$ = coefficient of seebeck.

Two important thermoelectric materials are Bismuth Telluride (Bi_2Te_3) at room temperature 9K (acting as the cold side) and Lead Telluride (PbTe), which is at 500K to 600K (acting as the hot side).

The efficiency of the current generation in a thermoelectric generator is around 5-8%.

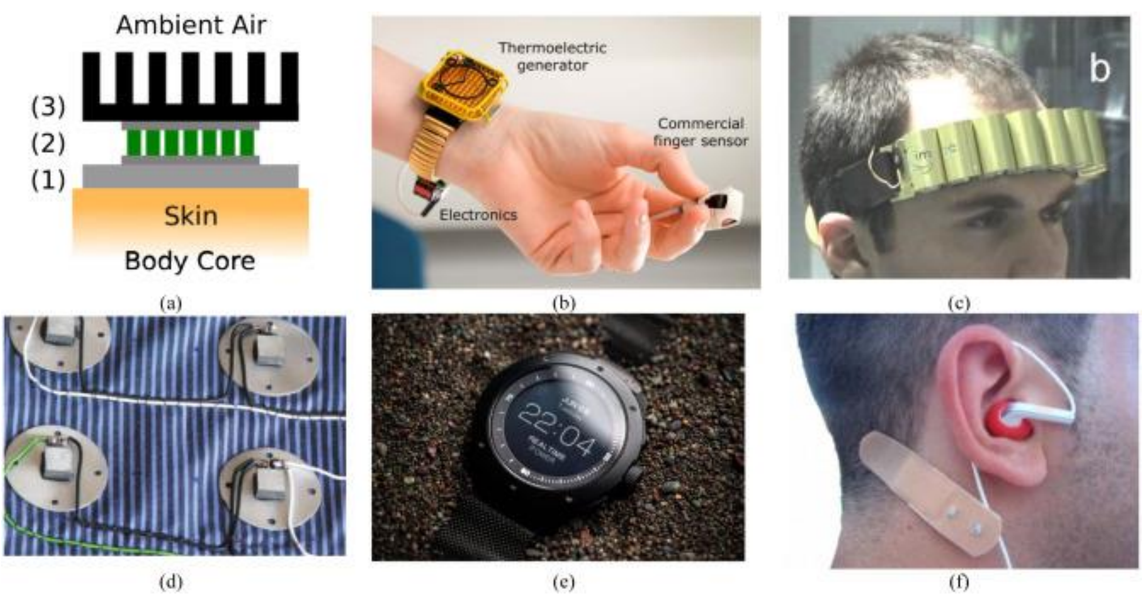


Fig.1.17 Application of Thermo electric Power,

The first thermoelectric wristwatch powered by converting body heat into electrical power was marketed by Seiko and Citizen and dates back to 1999.

6. Thermionic Generation:

Thermionic power converter also called thermionic generator, thermionic power generator, or thermoelectric engine**,** any of a class of devices that convert heat directly into electricity using Thermionic emission rather than first changing it to some other form of energy.

Working of Thermionic Energy Generator:

A thermionic power converter has two electrodes. One of these is raised to a sufficiently high temperature to become a thermionic electron emitter, or "hot plate." The other electrode, called a collector because it receives the emitted electrons, is operated at a significantly lower temperature. The space between the electrodes is sometimes a vacuum but is normally filled with a vapour or gas at low pressure.

The energy required to extract an electron –from the metal is an important parameter, known as the *work function* of the metal.

Note that the rate of emission increases rapidly with emitter temperature and decreases exponentially with the work function. It is therefore desirable to choose an emitter material that has a small work function and that operates reliably at high temperatures.

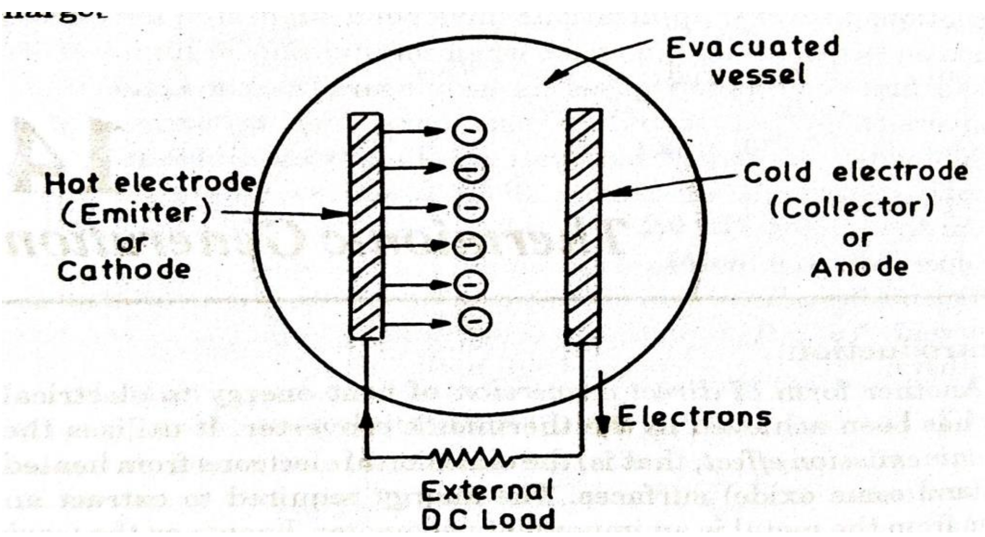


Fig 1.18: Thermionic Convertor.

The thermal energy may be supplied by chemical, solar, or nuclear sources. Thermionic converters are solid-state devices with no moving parts. They can be designed for high reliability and long service life. Thus, thermionic converters have been used in many spacecraft.