NUCLEAR POWER STATION

UNIT-2

Introduction :-

The generating station in which nuclear energy is converted into electrical energy is known as a nuclear power station.

In nuclear power station, heavy elements such as Uranium (U^{23} or Thorium (Th^{232}) are subjected to nuclear fission in a special apparatus known as reactor. The heat energy thus released is utilised in raising steam at high temperature and pressure. The steam runs the steam turbine which converts steam energy into mechanical energy. The turbine drives the alternat which converts mechanical energy into electrical energy.

The most important feature of a nuclear power statio is that huge amount of electrical energy can be produced from a relatively small amount of nuclear fuel as compared to other conventional types of power stations. It has been found that complete fission of 1kg of Uranium (U^{235}) can produce as much energy as can be produced by the burning of 4,500 tons of high grade coal.

Advantages of a Nuclear Power Station :-

1. The amount of fuel required is quite small. There fore, there is a considerable saving in the cost of fuel transportation
2. A nuclear power plant requires less space as compared to any other type of the same size.

3. It has low running charges as a small amount of fuel is used for producing bulk electrical energy.

4. This type of plant is very economical for producing bulk electri power.

5. It can be located near the load centres because it does not require large quantities of water and need not be near coal mine Therefore, the cost of primary distribution is reduced.

6. There are large deposits of nuclear fuels available all over the world. Therefore, such plants can ensure continued supply of electrical energy for thousands of years.

7. It ensures reliability of operation.

Disadvantages of a Nuclear Power Station :-

1. The fuel used is expensive and is difficult to recover.

2. The capital cost on a nuclear plant is very high as compared to other types of plants.

3. The erection and commissioning of the plant requires greater technical know-how.

4. The fission by-products are generally radioactive and may cause a dangerous amount of radioactive pollution.

5. Maintenance charges are high due to lack of standardisation. Moreover, high salaries of specially trained personnel employed to handle the plant further raise the cost.

6. Nuclear power plants are not well suited for varying loads as the reactor does not respond to the load fluctuations effic -iently.

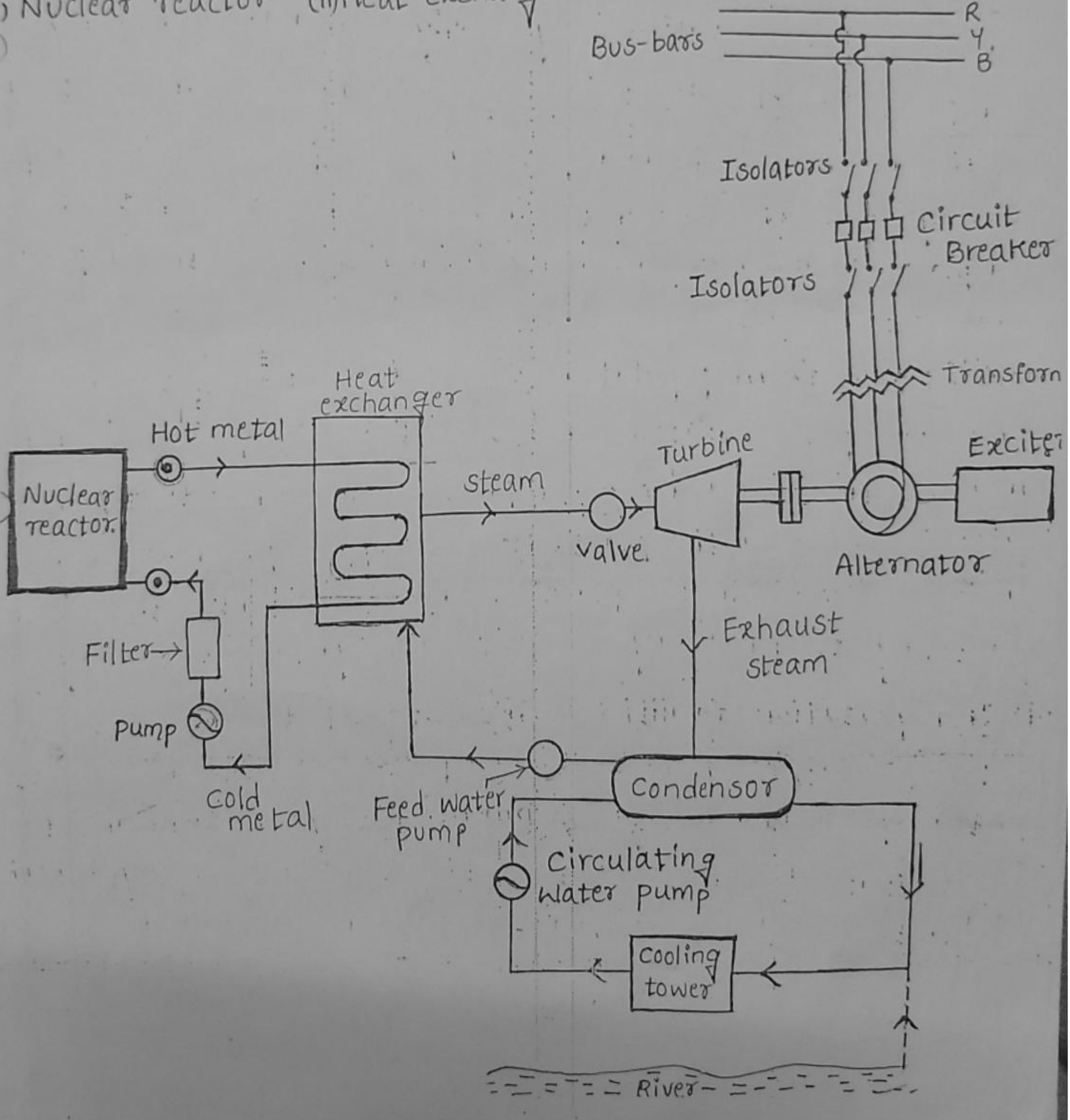
7. The disposal of the by-products, which are radioactive, is a big problem. They have either to be disposed off in a deep trench or in a sea away from sea-shore.

(2)

Schematic Arrangement of Nuclear Power station :-

The schematic arrangement of a nuclear power station is shown in below figure. The whole arrangement can be divided into the following main stages.

(i) Nuclear reactor (ii) Heat exchanger (iii) Steam turbine (iv) Alternator



Selection of site for Nuclear Power Station :-

The following points should be kept in view while selecting the site for a nuclear power station :

(1) Availability of water :- As sufficient water is required for cooling purposes, therefore, the plant site should be located where ample quantity of water is available, e.g., across a river or by sea-side.

(2) Disposal of waste :- The waste produced by fission in a nuclear power station is generally radioactive which must be disposed off properly to avoid health hazards. The waste should either be buried in a deep trench or disposed off in sea quite away from the sea shore. There fore, the site selected for such a plant should have adequate arrangement for the disposal of radioactive waste.

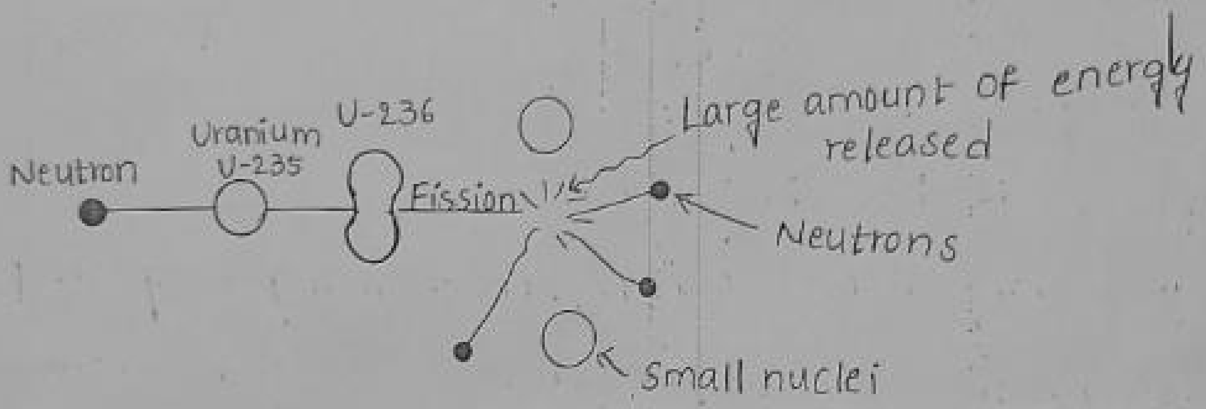
(3) Distance from populated areas :- The site selected for a nuclear power station should be quite away from the populated areas as there is a danger of presence of radioactivity in the atmosphere near the plant. How ever, as a precautionary measure a dome is used in the plant which does not allow the radio-activity to spread by wind or underground waterways.

(4) Transportation facilities :- The site selected for a nuclear power station should have adequate facilities in order to transport the heavy equipment during erection and to facilitate the movement of the workers employed in the plant.

Nuclear Fission Reaction :-

This is the process of splitting heavy nucleus in to two or more neutron when it is bombarded with high energy particles such as protons, neutrons etc., a large amount of energy accompained by the high speed nucleus is released.

The release of energy in fission process can be explained with the help of following figure:-



Fig(i):-Fission Process

In the fig(i), when a heavy atomic nucleus like uranium is bombarded with neutron, it splits into two equal parts of neutro The minimum nucleus captures a slow neutron first to form an unstable compound nucleus then this compound nucleus is split into two daughter nuclei accompained by the large amount of energy. During this fission process the various products like fission fragments, neutrons and electromagnetic radiations or gamma rays are released. This product absorbs most of the energy released by the fission as kinetic energy which is converted into heat as the nuclei collides.

Most of the energy released as heat is close to the fission site and is released into the surroundings.

The maindisadvantage of this process is disposal of nuclear waste.

Advantages :-

. The energy released during this process can be controlled easily.

2. This process gives rise to chain reaction.

3. There are number of developed techniques to control the fission process.

Example of Nuclear Fission :-

A given large nucleus can fission in many ways to produce vast energy. Thus the fission of U^{235} occurs in about 35 ways. One possible fission reaction of U^{235}

$$U^{235} + n^{1} \longrightarrow U^{236} \longrightarrow La^{148} + Br^{85} + 3n \quad \text{--------(1)}$$

i.e, $Uranium^{235}$ + Neutron $\longrightarrow$ $Uranium^{236}$

$Uranium^{236} \longrightarrow Lanthanum^{148} + Bromine^{85}$ + 3 free neutrons

The mass equation of the reaction is

$$235.124 + 1.009 \longrightarrow 147.961 + 84.938 + 3.027 \quad \text{--------(2)}$$

The mass of fission products on the right hand side of eq'n(2) is 0.207 a.m.u less than mass on the left hand sine.

Equivalent energy released = 0.207 X 931 (1 a.m.u = 931 MeV)

= 193 MeV (Mev = Million election Volt)

$= 193 \times 10^6 \times 1.6 \times 10^{-19}$

(1 electron volt $= 1.6 \times 10^{-19}$ Joules)

$= 3.08 \times 10^{-11}$ Joule or watt-sec

Nuclear Fusion Reaction :-

It is the process of combining of two or more light nuclei in a single nuclei (i.e., a heavier nucleus) with liberation of large amount of energy at very high temperature. when positively charged two or more nucleui brought together, they repel one another with electro force of repulsion. Therefore, fusion is possible only when the kinetic energy of each of the nuclei is large enough to overcome their force of repulsion. Thus, the force of repulsion must be small to produce power from nuclear Fusion. The energy required to create the fusion reaction is less than the energy released.

The main drawback of this reaction is, the huge amount of uncontrolled energy is released at very high temperatures.

Advantages :-

1. The cost of raw material of fuel is moderate.
2. The fuel required for reaction is very low.
3. This process is free from radio active wastes and radiation.

Example of Nuclear Fusion :-

Considering fusion of two heavy hydrogen atoms $_1H^2$ to produce a helium atom as shown in Fig. The reaction can be as follows.

$_1H^2 + _1H^2 \longrightarrow He^3 + n + energy$

$$2.01473 + 2.01473 \longrightarrow 3.016997 + 1.00898 \quad \cdots\cdots (3)$$

The mass fusion product on the right hand side of eq'n(3) is 0.003453 a.m.u less than mass on the left hand side. Hence

Equivalent energy released $= 0.003483 \times 931$

$= 3.2426$ MeV

$= 3.2426 \times 10^6 \times 1.6 \times 10^{-19}$

$= 5.188 \times 10^{-13}$ Joules or Watt-sec

Chain Reaction :-

A chain reaction is a self propagating process in which number of neutrons goes on multiplying during fission until most of the original nuclei in given fissile material are fissioned.

Example :-

When a Uranium U^{235} nucleus is hit by a neutron undergoes a fission reaction produces three neutrons. The third neutrons in turn may cause fission in three Uranium nuclei producing 9 neutrons. This 9 neutrons in turn may cause fission in 9 Uranium nuclei producing 27 neutrons. This process continuous till the neutrons released in the reaction are used in propagation the chain reaction as shown in below figure.

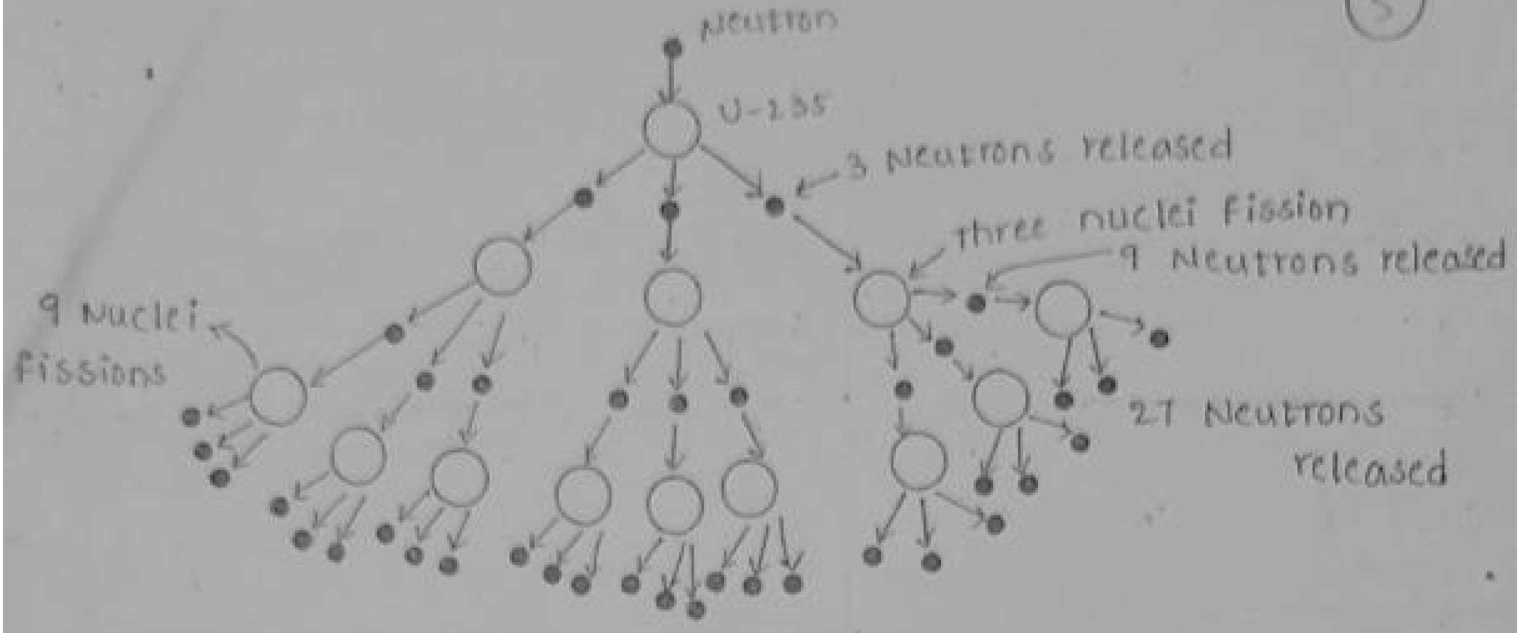


Fig:- Chain Reaction

Using the formation of chain reaction some of the neutron lose their energy and some of them are lost to the surroundings due to which the chain breaks. Thus for a chain reaction to occur, the sample of fissile material should be large enough to capture the neutron internally. The minimum mass of material required to sustain the chain reaction is caused critical mass. The chain reaction produces number of fiesion reactions which generates the enormous energy.

NUCLEAR FUELS AND PROPERTIES :-

Radioactive materials, mainly the rate earth elements can be easily transmitted.

* The fuels generally used in Nuclear power Generation are

1. Uranium (U^{235}, U^{238}, U^{234})
2. Thorium (Th^{232})
3. plutonium (Pu^{239})

Elements (or) isotopes whose nuclei can be caused to undergo nuclear fission by nuclear bomboredment and sustain chain reaction is called "Nuclear Fuel".

→ The main fuels used in nuclear reactors are uranium, thorium and plutorium. The commonly uranium fuel used are natural uranium, uranium oxide and uranium carbide.

properties :- The following are the some of the properties of the fuel elements.

1. Uranium :-

It occurs in nature, in small quantities about 1 in 14(parts of the ore. The Uranium deposits are in Canada, Belgium, Czechoslovakia and in U.S.A. The natural Uranium ($_{92}U^{238}$) contains only 0.7% of fission. The present reactor use enriched Uranium ($_{92}U^{235}$) and dilluted along with aluminium or Zirconium.

The physical properties of Uranium are :

(a) Density : 19.14 gm/cm^3

(b) Melting point : 1150 ± 1°C

(c) Boiling point : about 4000°C

(d) Electric Resistivity : 2 to 5 × 10^4 $\mu\Omega$-cm

(e) Thermal conductivity : 0.063 at 75°C

: 0.078 at 400°C

2. Thorium :-

It occurs mainly in Monazite sands near sea costs Particularly, India has large reserves or monazite sands on the Kerala coasts. It is of low strength and has poor resistance to corrosion. Because of high cost it has not been very popular. When the nucleus of Thorium $_{90}Th^{232}$ is bombared with a neutron it undergoes a reaction to form $_{90}Th^{233}$ which can be caused to fission and useful at atomic fuel.

The physical properties of Thorium are:

(a) Density	: 11.72 gm/cm^3
(b) Melting point	: 1700 ± 10°C
(c) Boiling point	: about 3000°C
(d) Electric Resistivity	: 18.5 $\mu\Omega$-cm at 20°C
(e) Thermal conductivity	: 0.091 at 800°C
	: 0.109 at 65°C

3. Plutonium :-

It is even rare in nature, but can be made in nuclear reactor by distintegration of Uranium U^{235} in presenc of a moderator, generally graphite or heave water. In fact the nuclear reactor produces U^{239}, which distintegrates into plutonium, a fissile material.

Properties of plutonium :

(a) Density : 19.84 gms/cm^3

(b) Melting point : 641°C

(c) Boiling point : 3232°C

Requirements :- The nuclear fuel elements must have the following requirements.

1. It must be very strong at any condition of temperature and external loading etc.
2. It must be able to resist the corrosion caused by coolant, and any other neighboring materials.
3. It must be stable under high operating temperature conditions.
4. It should not capture neutrons.
5. It should have better heat transfer properties.
6. The removal of fuel element should be easy when ever required.
7. It should not be expensive.
8. It should be resistant to radiation damage.

NUCLER REACTOR - MAIN PARTS AND THEIR FUNCTIONS :-

Nuclear reactor is the heart of the nuclear power station, where tremendous amount of heat energy is released as a result of nuclear fission of radio-active materials. This heat is utilized to heat the coolant which in turn generates steam. Nuclear reactor consists of the following basic components which are shown in below figure.

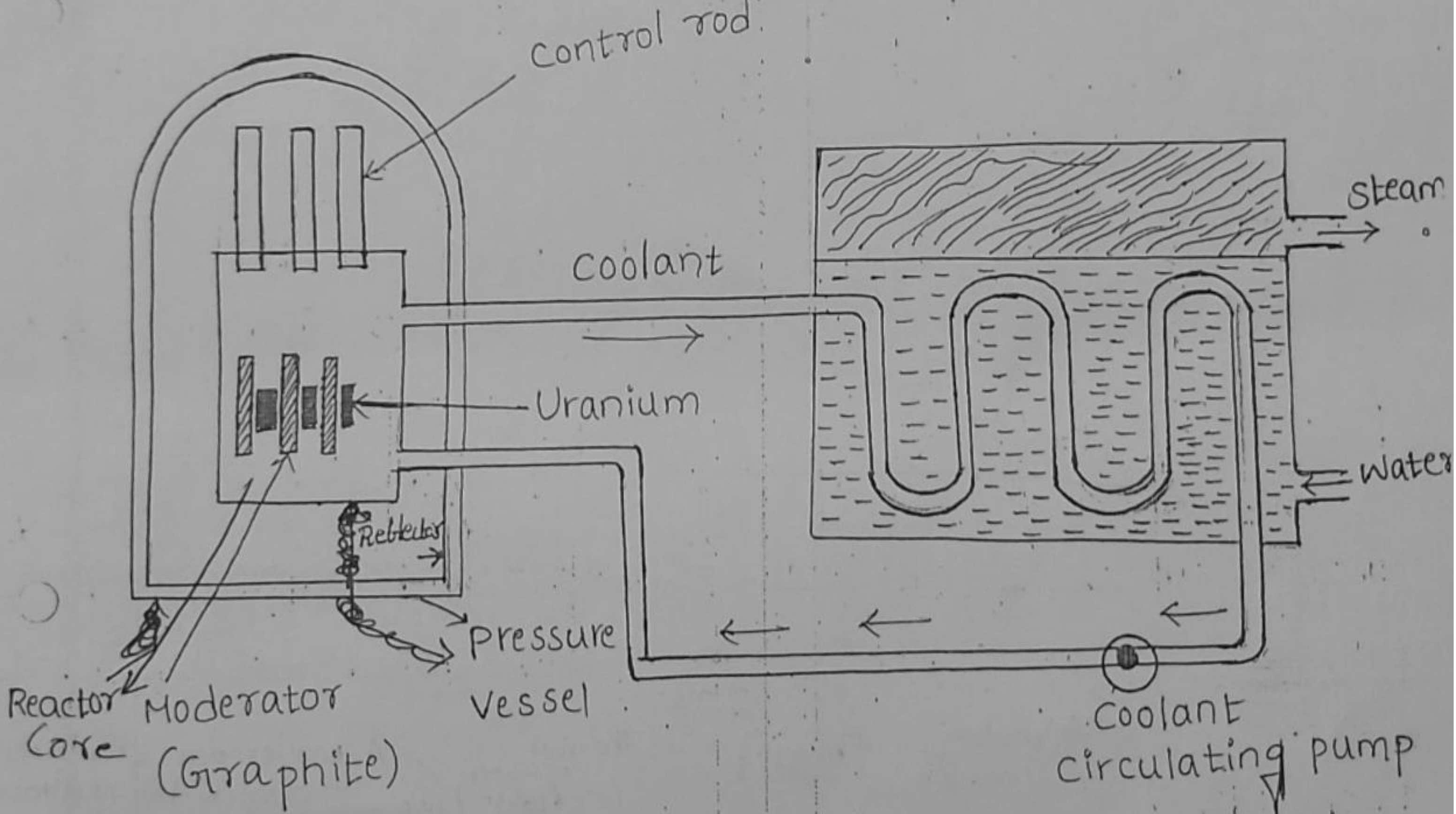


Fig :- Basic Components of Nuclear Reactor

1. Fuel : The fuels generally used in the reactor are $_{92}U^{235}$, $_{92}U^{233}$, $_{94}Pu^{239}$, $_{92}U^{238}$, $_{90}Th^{232}$ etc. Fuel should be so shaped and located in the reactor such that uniform heat should be produced. by cladeng the Uranium pilates with Aluminium(or) Zerconium

2. Reactor core : It is built of graphite bricks, having channels machined through them. The core is cylindrical in shape and is placed on a large pressure vessel totally enclosed in a thick walled shielding structure of concrete about 2.3 meters thick. The size of the core is just sufficient to maintain a chain reaction.

3. Moderator : The purpose of moderator is to moderate or slow down neutron speed to a value that increases the probability of fission process. Graphite, Heavy water are most commonly used as moderator. Beryllium and ordinary water can also be used as moderator with natural uranium and enriched uranium respectively. It is the central part of the core. Fast neutron 1.5×10^{7} m/s → Moderator → Thermal neutron (2.2×10^{3}) m/sec. A moderator should not absorb the neutrons.

4. Shielding : The purpose of shielding is to prevent the escape or leak of neutrons (fast and slow), α, β particles and γ-rays from reactor as these radiations are harmful to human being. Lead iron or Concrete shields are used for this purpose.

5. Control Rods :- These are Used to Control rate of reactions by absorbing neutrons. therefore output power Can also be Controlled by Control rods.

The control of chain reaction inside the reactor is Obtained by inserting control rods into the reactor core. The control rods are made with cadmium (or boron), because cadmium is a strong neutron absorber. when control rods are pushed into the core they absorb some of the neutrons and hence few neutrons are available for chain reaction. However, when they are pulled out from the reactor core more neutrons are available for fission process. Therefore by pulling out and pushing them in supply of neutrons for fission purpose can be regulated. These rods are in practice suspended from the top of the reactor in the channel of core, and are lowered or raised by special mechanism according to the load requirements.

6. Reflector :-

In order to avoid the leakage or escape of neutrons from the reactor, it is essential to surround the reactor with material acting as a Reflector. As the name indicates, the function of reflector is to reflect as many leakage neutrons are possible back into the reactor. The reflector gets heated due to collision of neutrons with its atoms, hence cooling is essential. The materials used for reflector is same as that of the materials used for moderator i.e. Graphite, Heavy water.

7. Coolant :- In nuclear reactor, Coolant is recirculated

A coolant is a medium through which heat produced in the reactor is transferred to the heat exchanger for further utilization in power generation. Liquid sodium is generally (into steam in the) as coolant. when water is used as a coolant it takes up heat and gets converted into steam in the reactor itself. which is directly used to drive the turbine. The commonly used coolants are gas (CO_2, air, hydrogen, helium) and some Organic liquids.. liquid metal may find good future as a coolant

8. Reactor Vessel :-

The Reactor vessel encloses the reactor core. reactor core, reflector & shield. It is a strong walled container generally cylindrical in shape and provides the exit for passage of coolant. It should withstand high pressures. The holes are provided at the top of the vessel to inert the control rods:

* Boiling Water Reactor (BWR) :-

In this reactor fuel used is enriched uranium. Water is used as both the moderator and coolant. In this case the steam is generated in the reactor itself. Feed water enters the reactor tank at the bottom and takes up the heat generated due to the fission of fuel and gets converted into steam. Steam leaves the reactor at the top and flows into the turbine. Uranium fuel elements are arranged in a particular lattice from inside the pressure vessel containing water. Feed water passes through the fuel elements in the core as coolant and also as moderator.

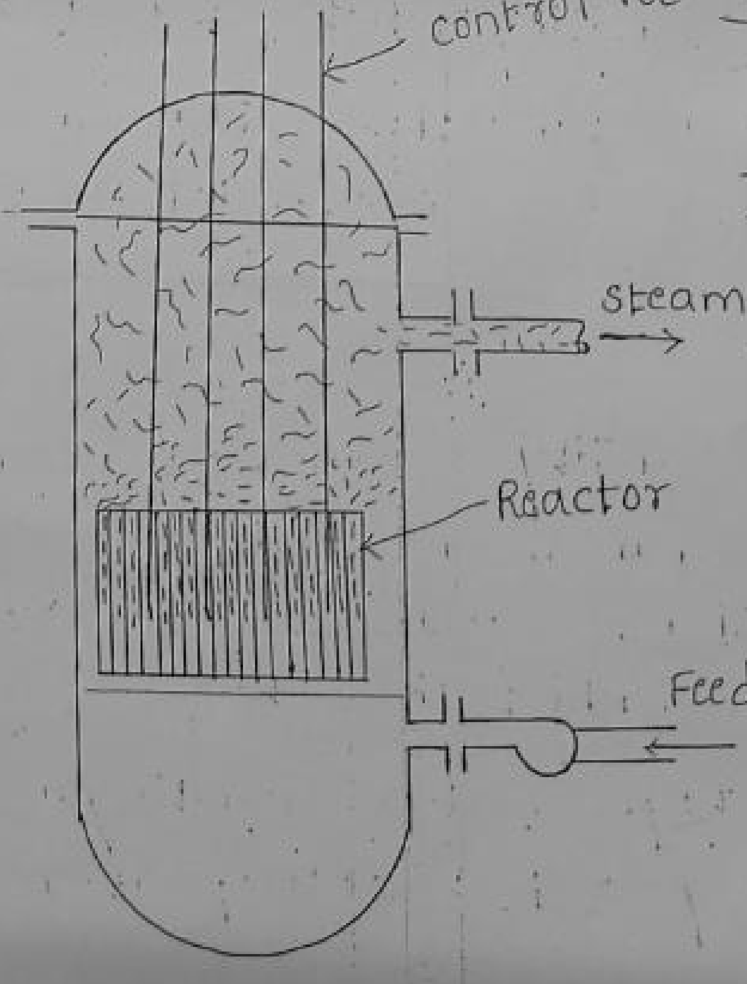


Fig:- A boiling water reactor (BWR)

Advantages :-

1. Heat exchanger circuit is eliminated and as a result there is reduction in cost and gain in thermal efficiency (30% in comparison to 20% for a PWR reactor).

2. As water is allowed to boil inside the reactor the pressure insid the reactor vessel is considerably lower than in the case of a PWR. As a result the reactor vessel can be made much lighter reducing its cost considerably.

3. The BWR cycle is more efficient than the PWR cycle since for a given containment pressure the outlet temperature of steam is appreciably higher in a BWR.

4. The metal surface temperature is lower than in the case of a PWR since boiling of water is inside the reactor.

5. A BWR is more stable than a PWR. (In fact BWR is commonly known as a self-controlled reactor.)

Disadvantages :-

1. There is a possibility of radio-active contamination in the turbine mechanism should there occur any failure of fuel elements. Therefore more elaborate safety measures are needed. These add to the cost.

2. There is wastage of steam resulting in lowering of thermal efficiency on part load operation.

3. Since the power density of BWR is nearly half of that of a PWR the size of vessel will be considerably large in comparison to that of a PWR.

4. As boiling of water on the surface of fuel is allowed the possibility of burn-out of fuel is more in the case of a BWR in comparison to that in a PWR.

5. A BWR cannot meet a sudden increase in load.

* Pressurized Water Reactor (PWR) :-

A pressurized water reactor is shown in below figure. The line arrangement of such a reactor with heat exchanger in circuit is shown in below figure. The fuel used is enriched uranium clad with stainless steel or zirconium alloy and water under pressure is used as both moderator and coolant. This type of reactor is designed to prevent the boiling of water coolant in the uranium core. A pump circulates water at high pressure (as high as 140 kg/cm^2) round the core so that water in liquid state absorbs heat from the uranium and transfers it to the secondary loop - the boiler. The boiler has a heat exchanger and a steam drum.

A pressuriser and surge tank tapped into the pipe loop maintain constant pressure in the water system throughout the load range.

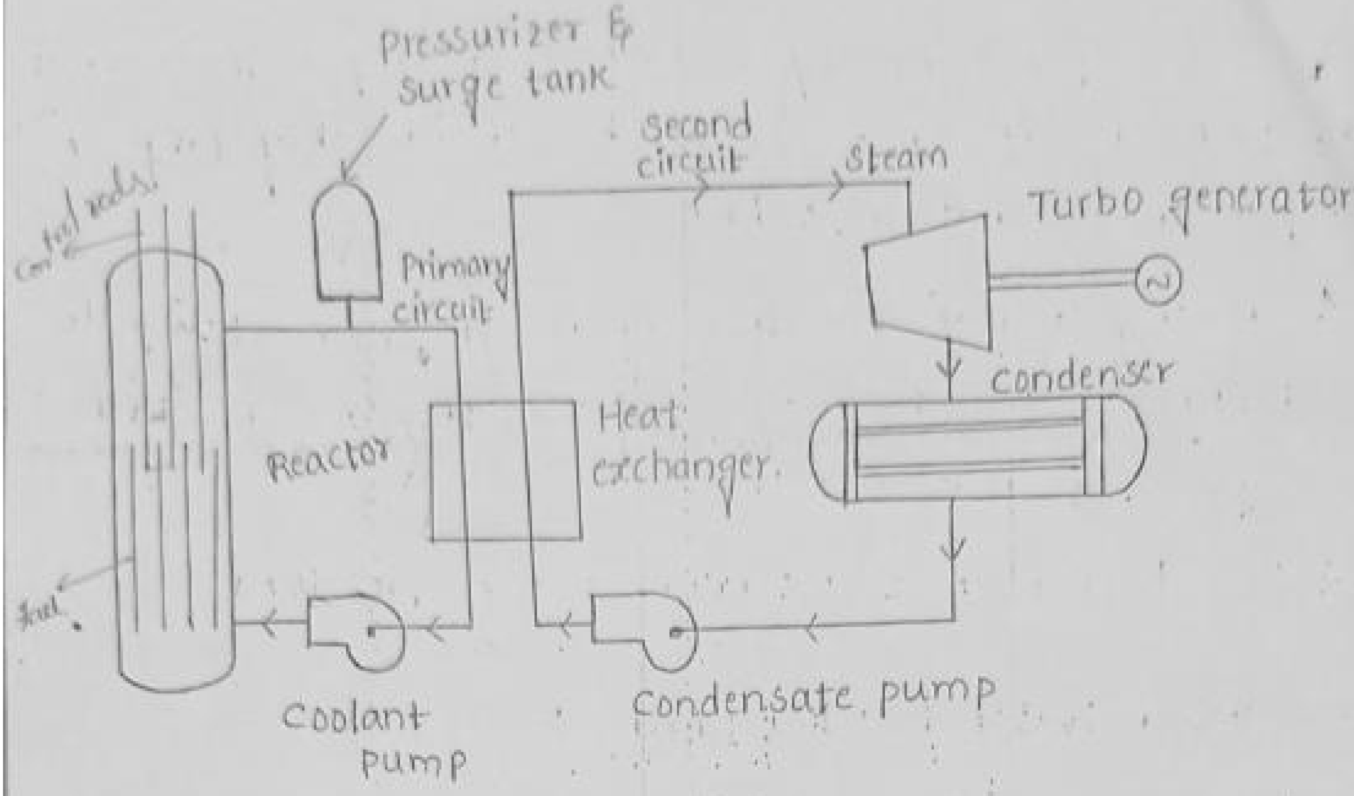


Fig - Line arrangement of a PWR with heat exchanger in circuit.

An electric heating coil in the pressuriser boils the water to form steam which is collected in the dome; this steam pressurises the entire coolant circuit. Water spray is used to condense the steam when pressure is desired to be reduced.

Since water in passing through the reactor becomes radio-active the entire primary circuit including heat exchanger has to be shielded.

Advantages :-

1. A PWR is relatively compact in size compared with other types.
2. There is a possibility of breeding plutonium by providing a blanket of U-238.

3. The reactor has a high power density.
4. Due to use of heat exchanger containment of fission products is possible.
5. An inexpensive substance (light water) can be used as moderator-cum-coolant-cum-reflector.
6. The reactor responds the supply more power when the load increases. (The positive power demand co-efficient makes this almost automatic).

Disadvantages :-

1. The moderator remains under high pressure; a strong pressure vessel is required.
2. Expensive cladding material is required to prevent corrosion
3. There is heat loss due to use of heat exchanger.
4. In comparison to other types more elaborate safety devices are required.
5. The reactor lacks flexibility; this requires the reactor to be shunt down for recharging of there is difficulty in fuel element design of fabrication.
6. The thermal efficiency of a PWR is a low as 20%.

* Fast Breeder Reactor :-

A fast breeder reactor is a small vessel in which the necessary quantity (corresponding to critical mass) of enriched uranium or plutonium is kept without a moderator. The vessel is surrounded by a fairly thick blanket of depleted fertile uranium. The fertile material absorbs neutrons from the fissile material and gets converted into fissile material. The reactor core is cooled by liquid metal. U-238 can be converted to Pu-239 (or Th-232 to U-233); the latter can be used in other thermal or fast breeder reactors.

In fast breeder reactors neutron shielding is provided by the use of boron, light water, oil or graphite. Gamma-ray shielding is effected by lead, concrete, concrete with added magnetite or barium etc.

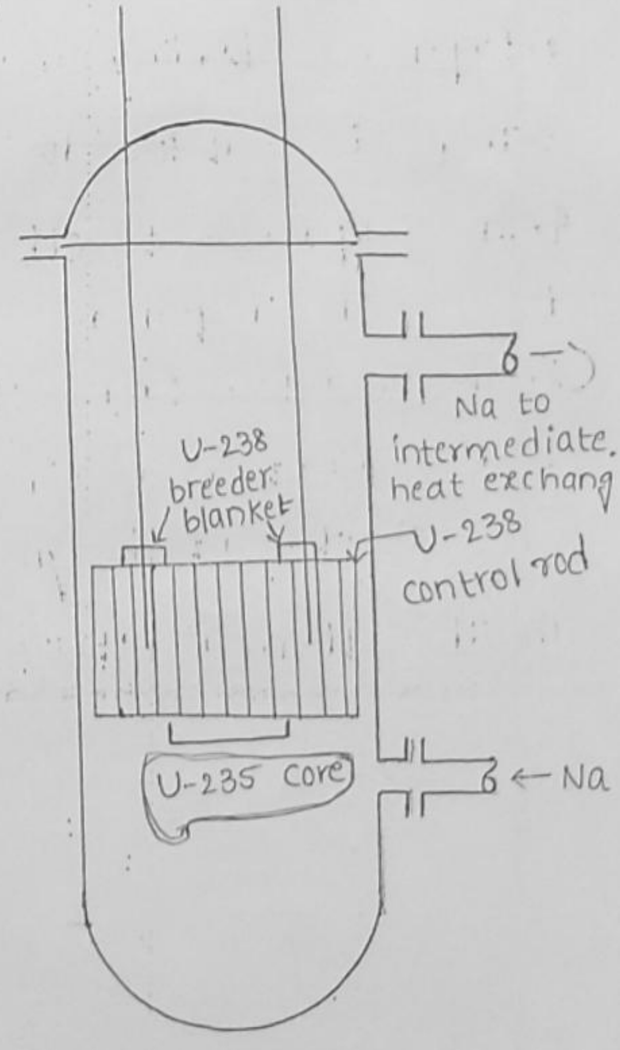


Fig :- A Fast Breeder Reactor

Advantages :-

1. It does not require Moderator
2. It gives high power density than any other reactor.
3. High breeding is possible
4. High burn-up of fuel is achievable.
5. The parasite absorption of neutrons is low.

Disadvantages :-

1. The specific power of the reactor is low
2. It requires highly enriched (15%) Fuel
3. The control is difficult and Expensive as neutron flux is high and neutron lifetime is short.
4. Safety must be provided against melt-down
5. The handling of sodium is a Major problem as it becomes excessively hot and radioactive.

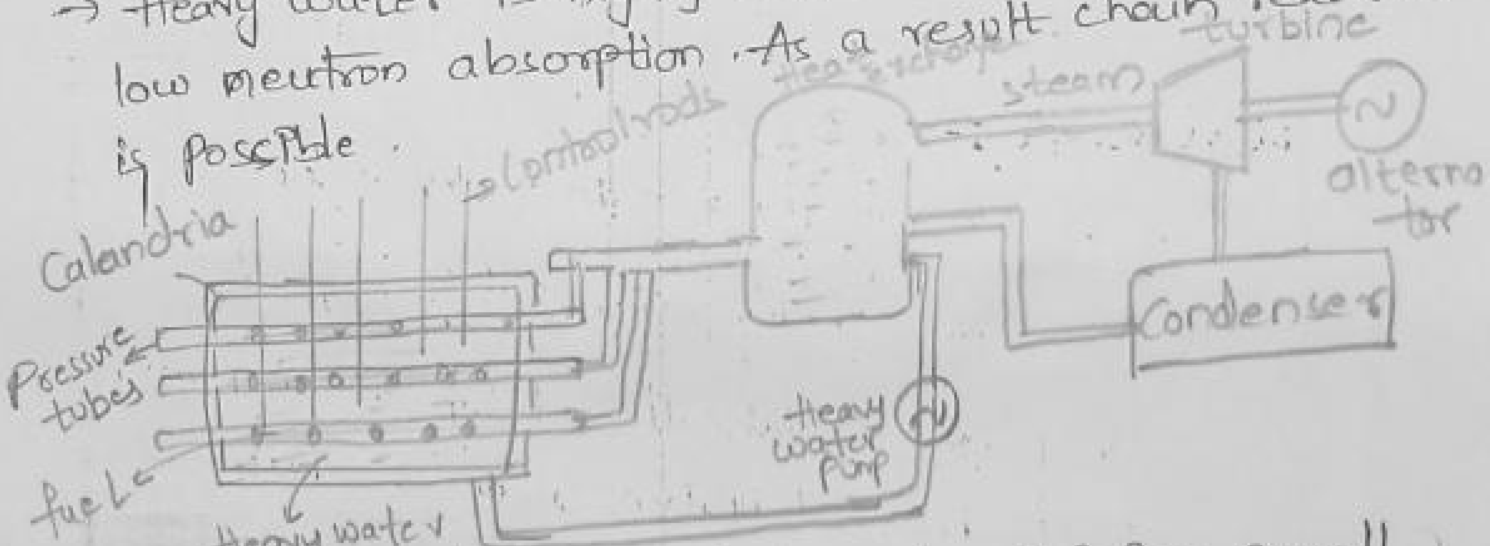
CANDU REACTOR:

CANDU stands for Canada deuterium Uranium.

It is a Canadian designed power reactor of PHWR type that uses heavy water (deuterium Oxide) for moderator and coolant and natural Uranium for fuel.

→ CANDU is most efficient of all reactors in Using 15% less Uranium, and Uses natural Uranium without enrichment facility.

→ Heavy water is highly effective because of its low neutron absorption. As a result chain reaction is possible.



Reactor Core Comprising small diameter fuel channels rather than one large pressure vessel. It allows on power refueling & extremely high capability factors are possible.

The moveable fuel bundles in pressure tubes allow maximum burn up of all fuel in reactor Core. Thus extends life expectancy of the reactor.

Explanation & Types of radation hazards

Radiation hazards are caused due to the harmful rays released from the nuclear power plants. The radioactive wastes of nuclear power plants pollute land, river and the atmosphere. The rays released from the radioactive isotope have high penetration power, causing irreparable damage to tissues when exposed to them. The radiation hazards are classified as,

1. Internal Hazards
2. External Hazards.

* 1. Internal Hazards :-

Internal radiation hazards are caused if a radioactiv material is inhaled, swallowed or absorbed through the wounc Nuclear wastes remain radioactive for thousands of years and these radioactive wastes are buried deep into the earth. The buried radioactive wastes might dissolve into the ground water and internal hazards.

Expressing the tolerance of the body due to internal hazards is very difficult, as it depends on many variables. They are discussed below.

(i) Degree of Retention of Radioactive Material in the Body:

A person contaminated with radioactive material wil receive radiation exposure until the source of radiation is removed.

More harm will be caused if the radioactive material is retained for a long time.

(ii) Radio Sensitivity of the Tissues :-

The tissues exposed to the radiation must be less sensitive to the radiation, as the tissues like lymph glands, bones etc. are very sensitive to the radiations. If the tissue effected is more sensitive one, then the harm caused will be more.

(iii) Size of the Organ :-

If the size of the organ exposed to the radiation small, then the concentration of the radiation will be more, resulting in more damage to the body.

(iv) Fraction of Radioactive Material :-

The amount of fraction of radioactive material is considered to be the most important factor. If the fraction of radioactive material, passed to the critical tissues by the blood stream is more, then the harm to the tissues will be more.

(v) Type of Organ Effected :-

If the organ effected is more essential to the body then the damage of the organ can cause early death of the victim.

(vi) Type of Radiation :-

The best example of internal hazards is alpha radiation because of their low penetrating power.

Alpha radiation is the most destructive form of ionizing radiation. It is estimated that chromosome damage from alpha particle is 100 times greater than that caused by an equivalent amount of other radiation.

* 2. External Hazards :-

External radiation hazards are caused if a person is externally contaminated i.e., when the body is bombarded by the radiation from radioactive materials. The radiations which cause external hazards are gamma radiations, beta radiations and neutrons.

Gamma radiations are most dangerous form of radiations emitted by a nuclear explosion, because of the difficulty in stopping them. Gamma radiations readily penetrate most materials and may travel many inches in human tissues. High cumulative doses of gamma rays exposed to whole body may cause the death of the person due to leukemia, lung, liver, skeletal and other cancers. Gamma rays also produce thermal burning injuries and induce an immuno-suppressive effect.

Beta radiations can penetrate human skin to the "germinal layer", where new skin cells are produced. If high level of beta-emitting contaminants are allowed to remain on the skin for a prolonged period of time, they may cause skin injury. Neutrons give rise to the fission reaction in which many different types of radiations are released and the leakage of these radiations causes the environment pollution leading to external hazards. In the case of nuclear workers, who receive an average doze, the risk of dying from cancer increases by '2' percent. Accidents occuring in nuclear power plants may damage a part of the core of a reactor which may result in fire or explosion releasing large quantity of radioactivity within the installation.

The main cause of internal and external hazards is due to the radioactive pollution. Some of the common effects of internal & external hazards due to the effects of radioactive pollution are listed below.

* **Effects of Radioactive Pollution :-**

Many investigations have been carried out to stu y the effects of radioactive pollutants to the environment. Some of the effects of radioactive pollutants are described as under.

1. Exposure to radioactive material causes damage to the gene pool of the individuals. In a simpler sense, the genetic makeup of all the living species is altered, which is carried over life times and subsequent generations.
2. Extended exposure to low doze of radiations has proved to be carcinogenic, causing damage to immune system, leukemias miscarriages, still births, deformities and fertility problems

(sterility); in other sense damages all life forms.

3. The ionizing radiation from radioactive material can cause cell alternation. The altered cell can produce a slightly different harmone or enzyme, which is different from the original. In due course of time, this can lead to chromic diseases.

4. Exposure to ionizing radiation leads to cessation of fertility. Exposure of raditions by a pregnant woman can cause damage to embryo or foetus leading to a condition called teratogenic damage or a congential malformation. Investi-gation have revealed that the carcinogeic component of cigarettes is polonium-210, a radioactive daughter product of radio gas which is released from uranium mining. It is also responsible for causing respiratory problems.

* Measures to Control Radioactive pollution :-

1. The nuclear power plants should be designed in such a manner that there is no leakage of radioactive material.

2. The radioactive wastes should be stored in deep undergound facilities or underground caverns called nuclear was repositions.

3. The burial site of the radioactive wastes should be carefully selected so that it doesn't get leached into underground water and drinking water supplies.

4. The gaseous wastes of nuclear power plants particularly the isotopes of krypton, xenon, and iodine are first filtered the passed through adsorption system and dispersed via a chimney stack

Effects of Radiation on Human Beings and Atmosphere :-

Radiation is the process of emission of energy through space in the form of waves having frequency of an electro-magnetic spectrum corresponding to electromagnetic radiatio Radiation produces α-rays, β-rays, γ-rays and secondary neutrons which are capable of causing considerable damag to the human organs, if injected directly or exposed.

Although, some amount of radiation will always be present in the atmosphere, the human intervention such as minimum and using it is in the nuclear fission chain reaction process, can increase the levels of radiation in the atmosphere. The residues radioactive material left in the mines, which is called as tailings, increases the levels of radiation in the atmosphere during the extraction of uranium.

In nuclear reactors, the nuclear fission chain reactior doesn't release harmful effluents in the atmosphere. But isotopes formed at the end of the process are poisonous and can cause considerable increase in the level of radiation, which can be prevented by safely disposing them

→ The following can cause the adverse biological effects due to radiation.

1. Excessive ingestion of radiations.
2. Long time exposure to radiation.
3. It reduces the sensitivity & recovery of recipient organism.

4. It causes the distribution of active material within the body.

Prevention :-

1. The residual radioactive material in the nuclear material should be disposed in the deep salt mines. The radio active wastes can also be sunk in Ocean floors by filling in a container.

2. The auxilliary buildings, not related to the nuclear power plant, should not be allowed to build in the vicinity of the power plant.

3. Necessary shielding should be provided for the working personnel on the power plant and the levels of radiation in the power plant should be checked at regular intervals.