Nuclear powerplant

Introduction :-

As large amount of coal and petroleum being used to produce energy, time may come when their resource may not be able to meet the energy requirement. Thus there is tendency to seek alternative source of energy the discovery that energy can be liberated by nuclear fission of materials like uranium (U), plutonium (Pu) has opened up a new sources power.

→ the heat produce due to fission of U and Pu is used to heat water to generate steam which is used for running turbo generator.

→ It has been found that one kg of U produce as much as energy of
∧ 4500 tonnes of high grade coal.

Some factors which go infavour nuclear energy as follows

(i) Hydro-electric powerplant is a storage type and largely dependent on monsoons.

(ii) Oil is mainly needed for transportation fertilizers and petrochemicals thus can't be used in large quantities.

(iii) coal is available in some parts of country and transportation of coal requires big investment.

(iv) Nuclear power is independent geographical factor, the only requirement is reasonably good supply of water. fuel transportation and large storage is not required and nuclear powerplant is a clean source of power.

(v) Large quantity of energy released with consumption only a small amount of fuel.

Advantages of Nuclear power plant

(i) It minimizes the ecological effect of power generation.

(ii) space requirement of a nuclear powerplant is less as compared to other conventional powerplant of equal size.

(iii) A nuclear powerplant consume very small quantity fuel. Thus fuel ~~consumption~~ transportation and large fuel ~~fac~~ storage facilities are not needed.

(iv) There is increased reliability of operation

(v) Nuclear powerplant is not affected by adverse weather condition

(vi) Material requirement on metal structures, Piping storage mechanism are much lower for a nuclear powerplant than a coal based power plant.

(vii) It doesnot require large quantity of water

Disadvantage

(i) Intial cost of nuclear powerplant is higher as compared to hydro or steam power plant.

(ii) Nuclear powerplant are not well suited for varying load condition

(iii) Radio active waste if not disposed carefully may have bad effect on the health of workers and other population

(iv) Maintenance cost of the plant is high.

(v) It requires trained personnel to handle nuclear power plant.

Comparision with steam power plant

(i) The number of workman required for the operation of nuclear power plant is much less than a steam power plant. This reduces cost of operation

(ii) The capital cost of nuclear power plant fall sharply if the size of the plant is increased. The capital cost such as structural materials, piping, storage mechanism etc. is much less in nuclear power plant than the steam power plant.

(iii) There are no fuel transportation, handling and storage charges and also there is no problem of ash disposal.

(iv) Nuclear power plant occupies less space in comparision to thermal plants, thus civil construction cost is also less.

(v) The nuclear plant is more economical compared with thermal plant in areas which are remote from coal fields.

Site selection :-

For establishing a nuclear power plant, the following points have to be kept in view

(i) Availability of water:-

At the powerplant site, an ample quantity of water should be available for cooling and make up water required for steam generation

(ii) Distance from load centre

The plant should be located near the load centre. This will minimize the power losses in transmission lines

(iii) Distance from populated area:-

The plant should be located far away from the populated area to avoid radioactive hazard.

(iv) Accessibility to site:-

The powerplant should have rail and road transportation facilities.

(v) Waste Disposal

The wastes of a nuclear powerplant are radio active and there should be sufficient space near the plant site for the disposal of the waste.

(vi) safe guard against earthquakes:-

The site is classified into its respective seismic zones 1, 2, 3, 4 or 5. The zone 5 being the most seismic one unsuitable for nuclear power plant. About 300 km of radius area around the proposed site is surveyed for its past history of tremors.

(vii) Foundation condition

The substrata must be strong enough to support the heavy reactor which may weigh as 100,000 tons and imposed bearing pressure of around 50 tons per square meter.

Nuclear Fuel

→ Nuclear fuel may be defined as a material in which the nuclei of the material undergo nuclear fission by nuclear bombardment and to produce a fission chain reaction.

→ It can be one or all of the following U^{233}, U^{235} and Pu^{239}.

→ Natural uranium found in earth crust contains 3 isotopes namely U^{234}, U^{235}, U^{238} and their percentage as follows

U^{238} – 99.3%, U^{235} – 0.7%, U^{234} – Trace.

→ out of these U^{235} is most unstable and is capable of sustaining chain reaction and has been given name of primary fuel.

- U^{233} and Pu^{239} are artificially produced from Th^{232} and U^{238} respectively and called as secondary fuel.

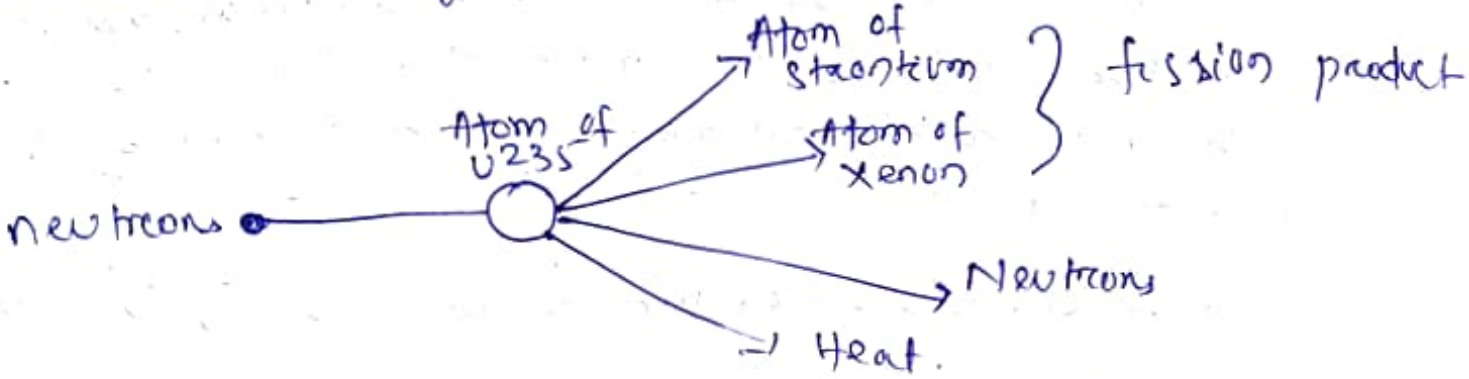
Fertile fuel

It is defined as the material which absorbs neutron and undergoes spontaneous changes which lead to formation of fissionable material.

→ U^{238} and Th^{232} are fertile material, and when they absorb neutron, they produces fissionable material Pu^{239} and U^{233} respectively

Nuclear Fission

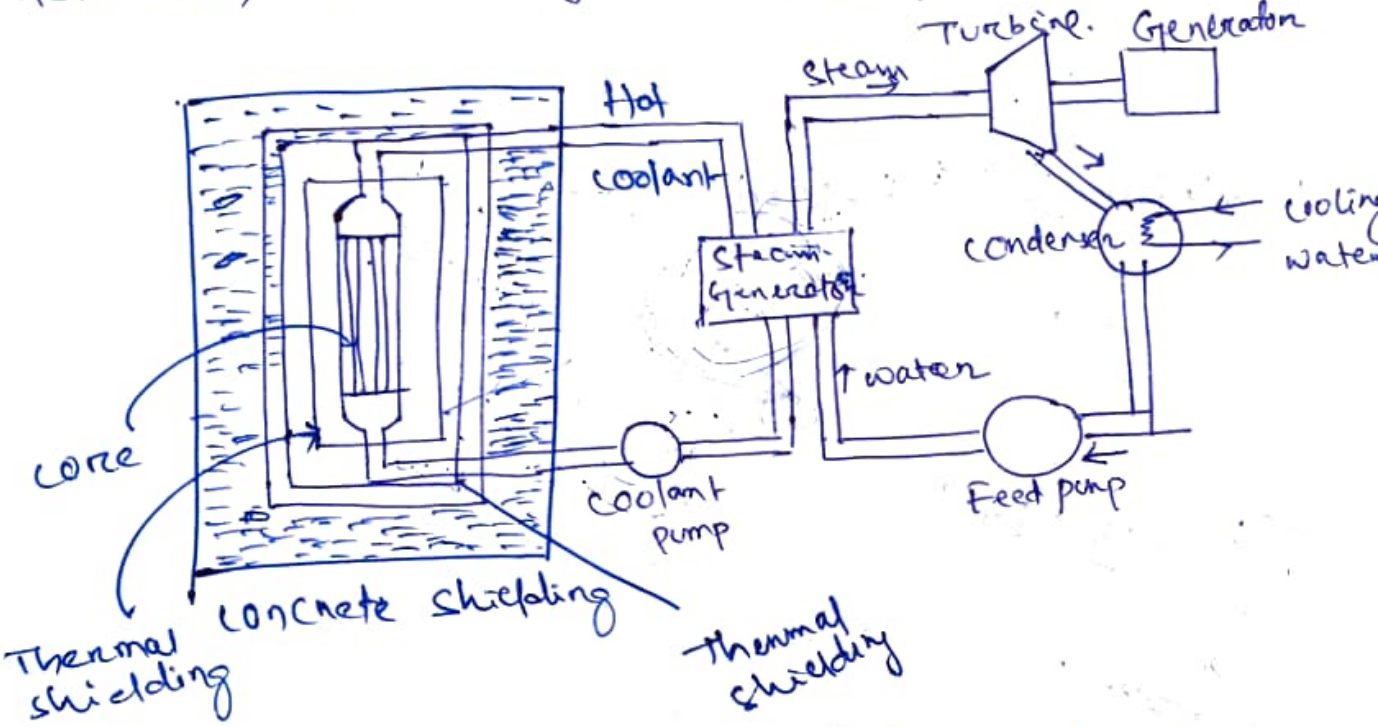
Nuclear fission is the process in which heavy nucleus is split when it is bombarded by certain particles. some of the isotopes of heaviest elements, U^{235} U^{233} and Pu^{239} can upon absorbing neutron, be readily fission of → this fission produce 2 or rarely 3, fragments moving at high speeds, two or ~~three~~ three neutrons and considerable energy



→ Uranium exist as isotopes of U^{238}, U^{234} and U^{235}, out of these isotopes U235 is most unstable. when a neutron is captured by a nucleus of an atom of U235, it splits up roughly into two equal fragments and about 2-5 neutrons are released and a large amount of energy is produced. the neutrons so produced are very fast moving neutrons and can be made to fission other nuclei of U235 thus enabling a chain reaction to take place.

Main components of a Nuclear power plant

The main component of a nuclear power plant are Nuclear reactor, heat exchanger (steam Generator), turbine, electric generator and condenser.



→ Reactor of Nuclear powerplant is similar to the furnace of the steam powerplant. The heat liberation in the reactor due to the nuclear fission of the fuel taken up by the coolant circulating through the reactor core.

→ Hot coolant leaves the reactor at top and then flows through the tubes of the ~~reactor core~~ of steam generator (boiler) and passes on its heat to the feed water.

→ Then the steam produced is passed through the turbine and passes on its heat to the feed water.

→ The steam produced is passed through the turbine and after work has been done by the expansion

(III) Control rod

control rod are helpful in controlling the following functions

(i) To start the nuclear chain reaction when the reactor is started from cold.

(ii) The chain reaction should be maintained at steady condition at the required level

(iii) To shut down the reactor automatically under emergency condition.

→ The control and operation of nuclear reactor is different from fossil or fuel based furnace. In furnace is fed continuously and the heat in the is controlled by regulating fuel feed and combustion of air whereas the nuclear reactor contains as much fuel as is sufficient to operate large power plant for some months. The consumption of this fuel and power level of the reactor depends upon the neutron flux in the reactor core.

→ The energy produced in the reactor due to fission of nuclear fuel during chain reaction is so much that if it not controlled properly the entire core and surrounding structure may melt and radio-active fission product may come out from the reactor thus making it's uninhabitable.

→ control rods are in the cylindrical or sheet form are made of boron or cadmium. These rods can be moved in and out of the holes in the reactor core assembly. their insertion absorbs more neutrons and damps down the reaction and their withdrawal absorbs less neut Thus power of reactor is controlled by shiftin control rods which may be done manually or automatically.

control rod should poneses following properties

(i) They should have adequate heat transfer properties
(ii) They should be stable under heat and radiation
(iii) The should be corrosion resistant
(iv) The should have sufficient cross sectional area for the absorption

Reflector

The neutrons produced during the fission process will be partly absorbed by the fuel rods, moderator, coolant or structural material etc.

~~- the unal neutrons which are not~~

→ the unabsorbed neutrons will try to leave the reactor core never to return to it and will be lost. such losses should be minimised.
it is done by surrounding the reactor core by a material called reflector which will send the neutrons back into the core. These neutrons can then cause more fission and improve

the economy of the reactor

Reactor vessel / pressure vessel

It is a strong walled container housing the core of the power reactor. It contains moderator, reflector, thermal shielding and control rods.

Biological shielding

shielding the radio-active zones in the reactor from possible radiation hazard is essential to protect the operating men from harmful effects.

→ During fission reaction, alpha, beta particles, gamma (deadly) particles and neutrons are produced. out of these neutrons and gamma rays are of main significance. A protection must be provided against them.

→ Thick layers of lead or concrete are provided all around the reactor for stopping the gamma rays.

coolant

→ ~~coolants~~ coolant flows through and around the reactor core. It is used to transfer the large amount of heat produced in the reactor core during chain reaction. The coolant either transfers heat to another medium or the coolant used. ~~as~~ water it takes up the heat and gets converted into steam in the reactor which is directly sent to the turbine.

→ the various coolant used are (light water, or heavy water) gas (Air, CO_2, hydrogen, helium) and liquid metal such as sodium or mixture of sodium & potassium

Nuclear Waste Management

Waste from atomic energy installations are radioactive, create radioactive hazard and require strong control to ensure that radio-activity is not released into the atmosphere to avoid atmospheric pollution.

- The waste produced in a nuclear power plant may be in the form of liquid, gas or solid and each is treated in different manner.

Liquid waste

The liquid waste disposal is done in 2-ways

a) Dilution

The liquid waste is diluted with large quantity of water and then released into the ground.

b) Concentration to small volumes and storage

When the dilution of radio-active liquid waste is not desirable due to amount or nature of isotopes, the liquid waste are concentrated to small volume and stored in underground tanks.

→ The tank should be ensured long term strength and leakage of liquid from the tanks should not take place.

Gaseous waste

Gaseous waste can most easily pollute the atmosphere. Gaseous waste are diluted with air, passed through the filters and then released to atmosphere through large stack (chimney).

Solid waste

solid waste consist of scrap materials contaminated with radio-active matter. These waste, if combustible are burnt and the radioactive matter is mixed with concrete, drummed and shipped for burial. Non-combustile solid waste are always buried deep in the ground.

List of Nuclear powerstation

In various developing and developed countries, the nuclear powerplant contribute 5% to 75% of total electrical powergeneration. In France 75% of powergeneration is by nuclear powerplant but in India it is 5% and expected to rise by 8%.

The various Nuclear powerplant in India are follow:

(i) Tarapur Nuclear powerplant

- It is India's 1st nuclear powerplant. It has been built at Tarapur 100km, north of Bombay with American collaboration. It has 2 boiling water reactor each of 200MW capacity and uses enriched uranium as fuel.

(2) Rawatbhata (Rajasthan) Atomic power station

- It was been built at about 65 km south-west of Kota in Rajasthan on the right bank of Rana Pratap Sagar dam on Chambal river. With its canadian collaboration.

- It has 2 reactor each of 200mw capacity and uses natural uranium in the form oxide as fuel and heavy water as moderator.

(3) Kalpakkam Nuclear power-station

- It is the 3rd nuclear powerstation of india built about ~ 60km from chennai. It has bees ~~~~ design and constructed by Indian scientist and engineers.
- It has 2 reactor each 235 mw capacity and uses natural uranium as fuel.

(4) Narora nuclear power-station

- This is the 4th nuclear power-station of India and is built at Narora at Bulandshahar Distruct of Uttar pradesh.
- This plant has 2-reactor of ~~~~ (CANDU- PHW (canadian-deutrium-uranium pressurised heavy water) system and uses natural uranium as fuel. This plant is wholly designed and constructed by Indian scientist and engineers.

(5) Kakrapar nuclear powerplant

This is the 5th nuclear powerplant of India and is located at Kakrapur near sonat in Gujarat.

- This power station have 2-reactor each of 235 MW capacity. The reactor constructed at Kakrapar are of candu type. natural uranium fuelled and heavy water as moderator.

(6) Kaiga atomic powerplant

- It is the 6th atomic powerplant located on left bank of Kali river at Kaigad in Karnataka.

- It has 2 reactor each 235 MW. This nuclear reactor is candu type reactor, these reactor have modern ~~traffic~~ system to prevent accident.