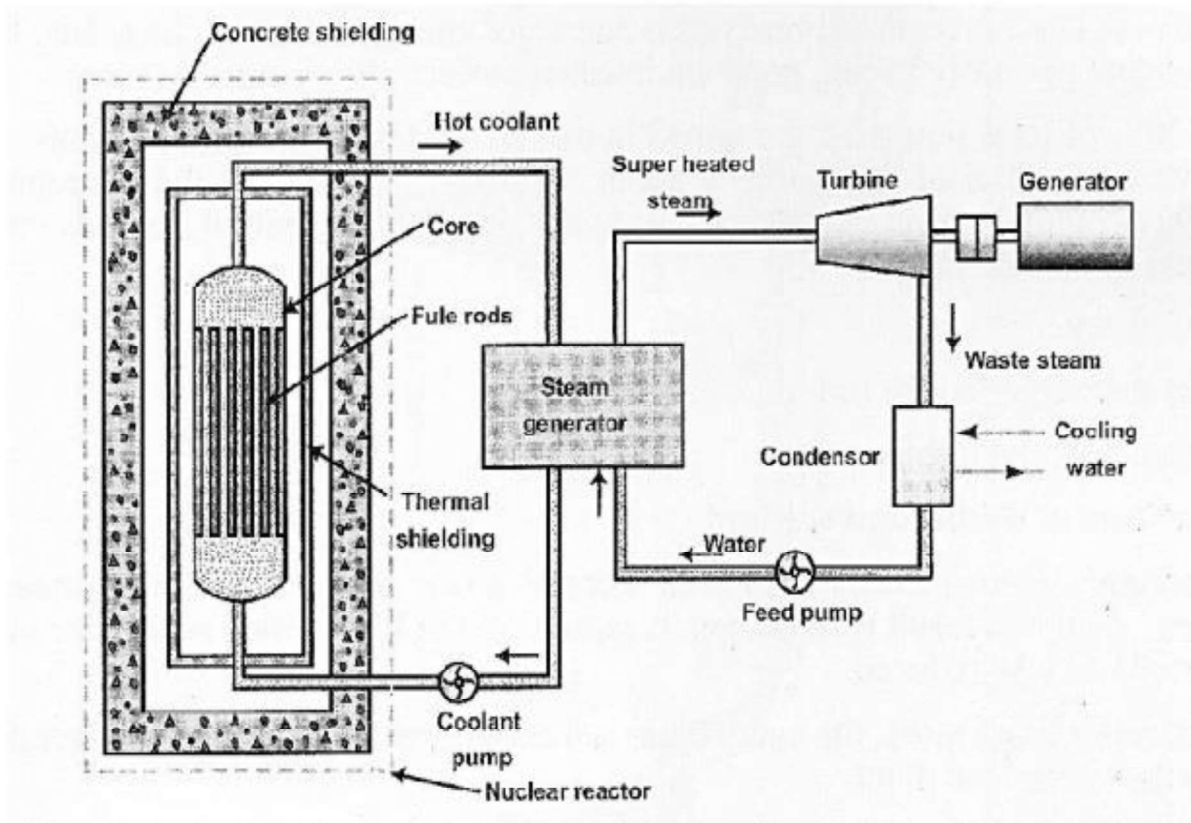


Nuclear Power Plant

Main components of nuclear power plants: Working

i) Moderators

In any chain reaction, the neutrons produced are fast moving neutrons. These are less effective in causing fission of U^{235} and they try to escape from the reactor. It is thus implicit that speed of these neutrons must be reduced if their effectiveness in 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.



ii) 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.

iii) Shielding

During Nuclear fission α , β and γ 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.

iv) 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.

v) 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.

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-oxidizing and non-toxic.

The above-mentioned properties are essential to keep the reactor core in safe condition as well as for the better functioning of the content.

6. It must also have high density, low viscosity, high conductivity and high specific heat. These properties are essential for better heat transfer and low pumping power.

The water, heavy water, gas (He, CO₂), a metal in liquid form (Na) and an organic liquid are used as coolants.

The coolant not only carries large amounts of heat from the core but also keeps the fuel assemblies at a safe temperature to avoid their melting and destruction.

vi) Nuclear Reactor

A nuclear reactor may be regarded as a substitute for the boiler fire box of a steam power plant. Heat is produced in the reactor due to nuclear fission of the fuel U^{235} . The heat liberated in the reactor is taken up by the coolant circulating through the core. Hot coolant leaves the reactor at top and flows into the steam generator (boiler).

Radiation hazards and Shieldings

The reactor is a source of intense radioactivity. These radiations are very harmful to human life. It requires strong control to ensure that this radioactivity is not released into the atmosphere to avoid atmospheric pollution. A thick concrete shielding and a pressure vessel are provided to prevent the escape of these radiations to atmosphere.

vii) Steam generator

The steam generator is fed with feed water which is converted into steam by the heat of the hot coolant. The purpose of the coolant is to transfer the heat generated in the reactor core and use it for steam generation. Ordinary water or heavy water is a common coolant.

viii) Turbine

The steam produced in the steam generator is passed to the turbine and work is done by the expansion of steam in the turbine.

ix) Coolant pump and Feed pump

The steam from the turbine flows to the condenser where cooling water is circulated. Coolant pump and feed pump are provided to maintain the flow of coolant and feed water respectively.

Advantages of Nuclear Power Plant

The various advantages of a nuclear power plant are as follows:

1. Space requirement of a nuclear power plant is less as compared to other conventional power plants is of equal size.

2. A nuclear power plant consumes very small quantity of fuel. Thus fuel transportation cost is less and large fuel storage facilities are not needed. Further the nuclear power plants will conserve the fossil fuels (coal, oil, gas etc.) for other energy need.

3. There is increased reliability of operation.

4. Nuclear power plants are not affected by adverse weather conditions.

5. Nuclear power plants are well suited to meet large power demands. They give better performance at higher load factors (80 to 90%).

6. Materials expenditure on metal structures, piping, storage mechanisms are much lower for a nuclear power plant than a coal burning power plant.

For example for a 100 MW nuclear power plant the weight of machines and mechanisms, weight of metal structures, weight of pipes and fittings and weight of masonry and bricking up required are nearly 700 tonnes, 900 tonnes, 200 tonnes and 500 tonnes respectively whereas for a 100 MW coal burning power plant the corresponding value are 2700 tonnes, 1250 tonnes, 300 tonnes and 1500 tonnes respectively. Further area of construction site required for 100 MW nuclear power plant is 5 hectares whereas for a 100 MW coal burning power plant the area of construction site is nearly 15 hectares.

7. It does not require large quantity of water.

Disadvantages

1. Initial cost of nuclear power plant is higher as compared to hydro or steam power plant.

2. Nuclear power plants are not well suited for varying load conditions.

3. Radioactive wastes if not disposed carefully may have bad effect on the health of workers and other population. In a nuclear power plant the major problem faced is the disposal of highly radioactive waste in form of liquid, solid and gas without any injury to the atmosphere. The preservation of waste for a long time creates lot of difficulties and requires huge capital.

4. Maintenance cost of the plant is high.

5. It requires trained personnel to handle nuclear power plants.