

1.3 NUCLEAR POWER PLANT

A 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^{235}) or Thorium (Th^{232}) are subjected to nuclear fission in a special apparatus known as a reactor. The heat energy thus released is utilized 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 alternator which converts mechanical energy into electrical energy. Complete fission of 1 kg of Uranium (U^{235}) can produce as much energy as can be produced by the burning of 4,500 tons of high grade coal.

Schematic Arrangement of Nuclear Power Plant:

The schematic arrangement of a nuclear power station is shown in fig.1.6. The whole arrangement can be divided into the following main stages: Nuclear reactor, Heat exchanger, Steam turbine and Alternator.

(i) Nuclear reactor:

It is an apparatus in which nuclear fuel (U^{235}) is subjected to nuclear fission. It controls the chain reaction that starts once the fission is done. If the chain reaction is not controlled, the result will be an explosion due to the fast increase in the energy released.

A nuclear reactor is a cylindrical stout pressure vessel and houses fuel rods of Uranium, moderator and control rods (See fig.1.7). The fuel rods constitute the fission material and release huge amount of energy when bombarded with slow moving neutrons. The moderator consists of graphite rods which enclose the fuel rods. The moderator slows down the neutrons before they bombard the fuel rods. The control rods are of cadmium and are inserted into the reactor. Cadmium is strong neutron absorber and thus regulates the supply of neutrons for fission.

- When the control rods are pushed in deep enough, they absorb most of fission neutrons and hence few are available for chain reaction which, therefore, stops. Thus, output power gets decreased.

- When they are being withdrawn, more and more of these fission neutrons cause fission and hence the intensity of chain reaction (or heat produced) is increased. Thus, output power gets increased

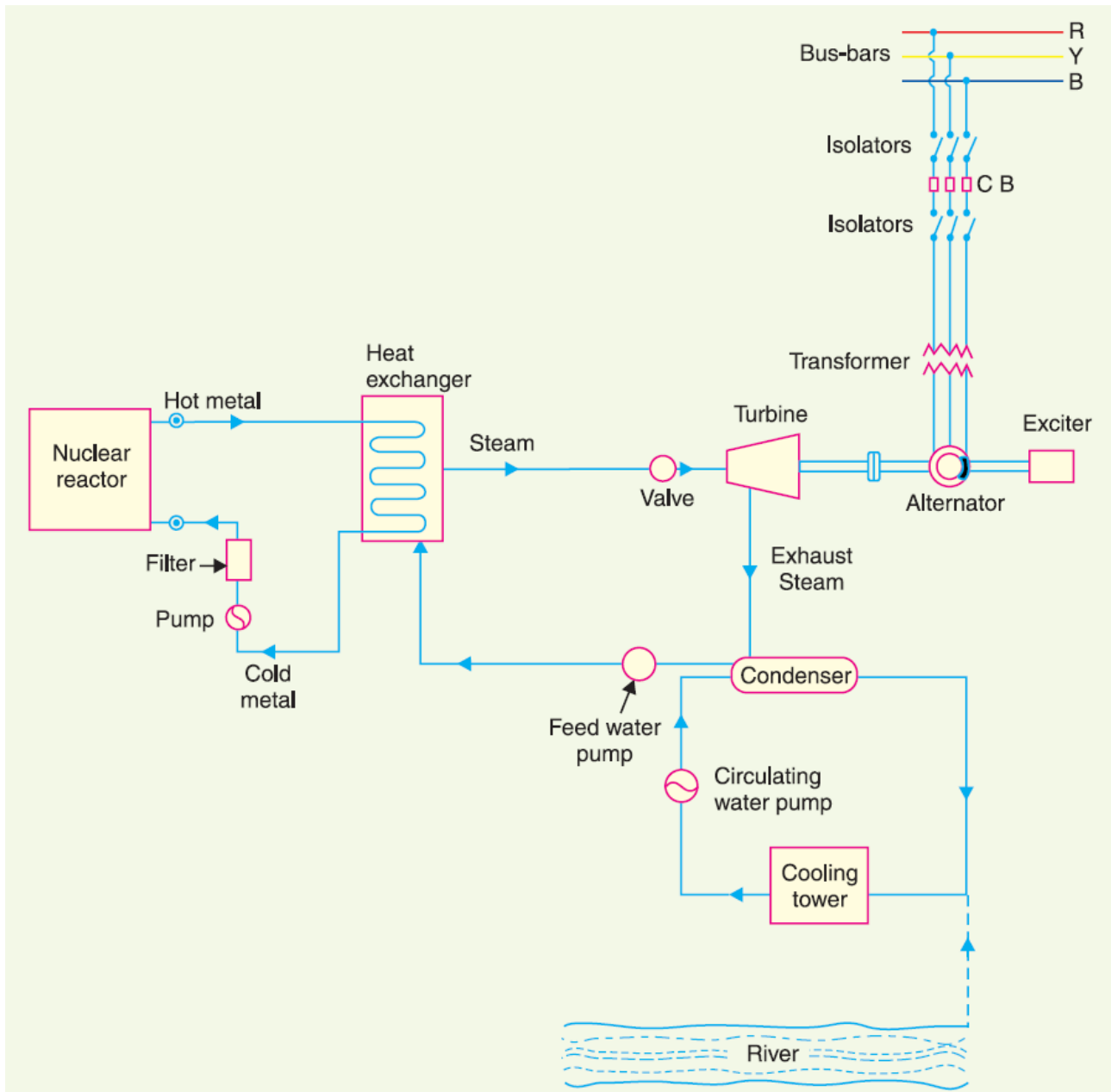


Fig 1.6 Schematic Arrangement of Nuclear Power Plant

(Source: 'Principles of power system,' V.K.Mehta, Rohit Mehta)

In actual practice, the lowering or raising of control rods is accomplished automatically according to the requirement of load. The heat produced in the reactor is removed by the coolant, generally a sodium metal. The coolant carries the heat to the heat exchanger.

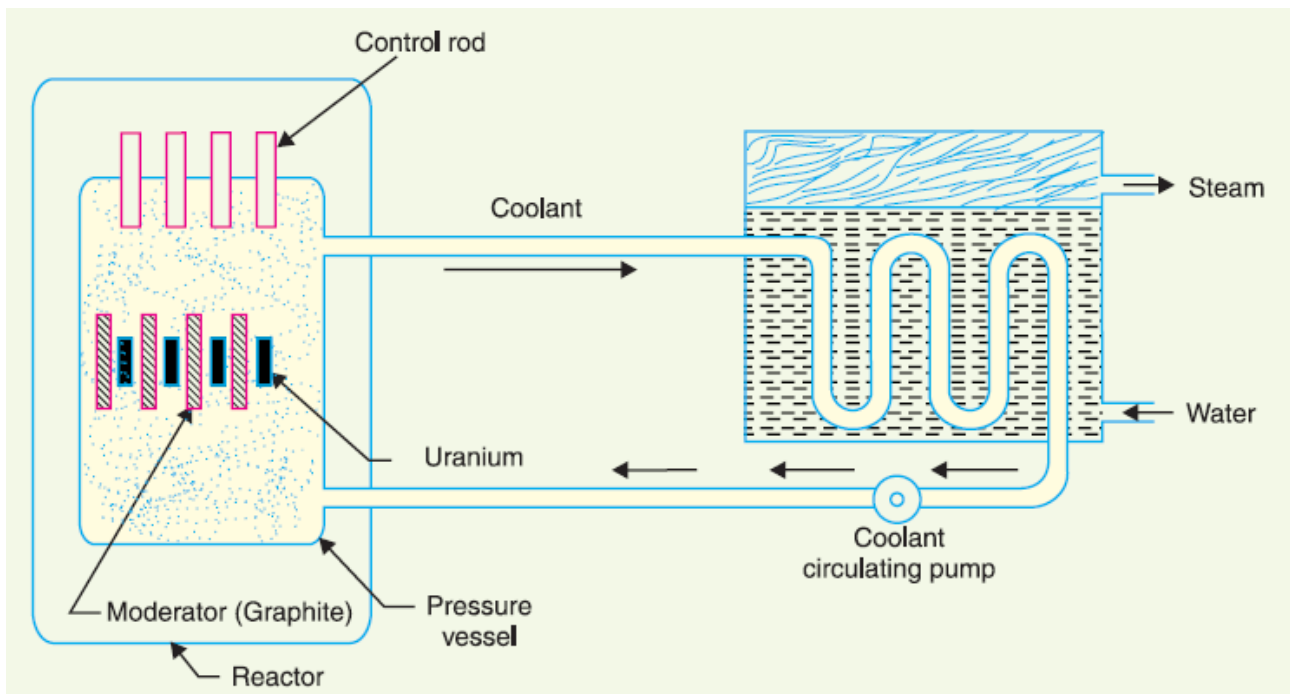


Fig 1.7 Nuclear Reactor

(Source: 'Principles of power system,' V.K.Mehta, Rohit Mehta)

(ii) Heat exchanger:

The coolant gives up heat to the heat exchanger which is utilized in raising the steam. After giving up heat, the coolant is again fed to the reactor.

(iii) Steam turbine:

The steam produced in the heat exchanger is led to the steam turbine through a valve. After doing a useful work in the turbine, the steam is exhausted to condenser. The condenser condenses the steam which is fed to the heat exchanger through feed water pump.

(iv) Alternator:

The steam turbine drives the alternator which converts mechanical energy into electrical energy. The output from the alternator is delivered to the bus-bars through transformer, circuit breakers and isolators.

Selection of Site for Nuclear Power Station

The following points should be noted when selecting a site for a nuclear power station:

- **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.

- **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. Therefore, the site selected for such a plant should have adequate arrangement for the disposal of radioactive waste.
- **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.
- **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.

Advantages:

1. Amount of fuel required is quite small.
2. The plant requires less space as compared to any other type of the same size.
3. Low running charges
4. Economical for producing bulk electric power.
5. It can be located near the load centres.
6. There are large deposits of nuclear fuels available all over the world.
7. It ensures reliability of operation.

Disadvantages:

- (i) Fuel used is expensive and is difficult to recover.
- (ii) Capital cost on a nuclear plant is very high as compared to other types of plants.
- (iii) Erection and commissioning of the plant requires greater technical know-how.
- (iv) The fission by-products cause a dangerous amount of radioactive pollution.
- (v) Maintenance charges are high due to lack of standardization.
- (vi) High salaries of specially trained personnel employed to handle the plant further raise the cost.
- (vii) Nuclear power plants are not well suited for varying loads as the reactor does not respond to the load fluctuations efficiently.
- (viii) The disposal of the by-products, which are radioactive, is a big problem.

Table 1.1: Comparison of Conventional Power Plants

S.No.	Item	Steam Power Station	Hydro-electric Power Plant	Nuclear power Plant
1.	<i>Site</i>	Such plants are located at a place where ample supply of water and coal is available, transportation facilities are adequate	Such plants are located where large reservoirs can be obtained by constructing a dam e.g. in hilly areas.	These plants are located away from thickly populated areas to avoid radioactive pollution.
2.	<i>Initial cost</i>	Initial cost is lower than those of hydroelectric and nuclear power plants.	Initial cost is very high because of dam construction and excavation work.	Initial cost is highest because of huge investment on building a nuclear reactor.
3.	<i>Running cost</i>	Higher than hydroelectric and nuclear plant because of the requirement of huge amount of coal.	Practically nil because no fuel is required.	Except the hydroelectric plant, it has the minimum running cost because small amount of fuel can produce relatively large amount of power.
4.	<i>Limit of source of power</i>	Coal is the source of power which has limited reserves all over the world.	Water is the source of power which is not dependable because of wide variations in the rainfall every year.	The source of power is the nuclear fuel which is available in sufficient quantity. It is because small amount of fuel can produce huge power.
5.	<i>Cost of fuel transportation</i>	Maximum because huge amount of coal is transported to the plant site.	Practically nil.	Minimum because small quantity of fuel is required.
6.	<i>Cleanliness and simplicity</i>	Least clean as atmosphere is polluted due to smoke.	Most simple and clean.	Less cleaner than hydroelectric and diesel power plants.