

**CAI335 SOLAR AND WIND ENERGY SYSTEM**

**UNIT V NOTES**



## 5.5 Nuclear energy

Nuclear energy is a form of energy released from the nucleus, the core of atoms, made up of protons and neutrons. This source of energy can be produced in two ways: fission – when nuclei of atoms split into several parts – or fusion – when nuclei fuse together.

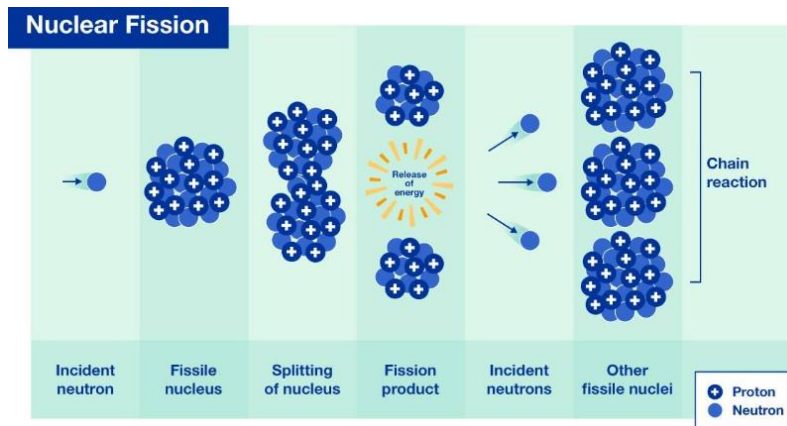
### 5.5.1 Nuclear Fission

Nuclear fission is a reaction where the nucleus of an atom splits into two or more smaller nuclei, while releasing energy.

For instance, when hit by a neutron, the nucleus of an atom of uranium-235 splits into two smaller nuclei, for example a barium nucleus and a krypton nucleus and two or three neutrons. These extra neutrons will hit other surrounding uranium-235 atoms, which will also split and generate additional neutrons in a multiplying effect, thus generating a chain reaction in a fraction of a second.

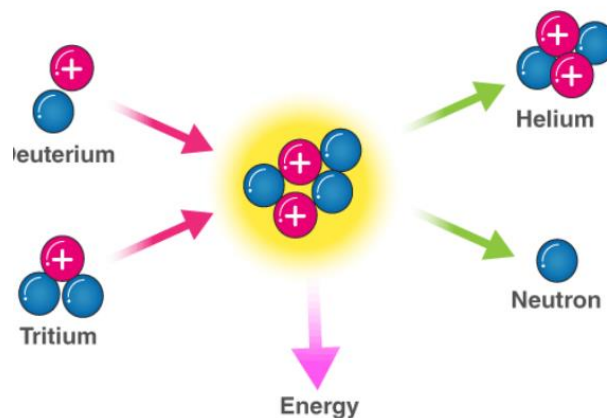
Each time the reaction occurs, there is a release of energy in the form of heat and [radiation](#).

The heat can be converted into electricity in a nuclear power plant, similarly to how heat from fossil fuels such as coal, gas and oil is used to generate electricity



### 5.5.2 Nuclear Fusion

Nuclear fusion is a reaction through which two or more light nuclei collide to form a heavier nucleus. The nuclear fusion process occurs in elements that have a low atomic number, such as hydrogen. Nuclear Fusion is the opposite of nuclear fission reaction, in which heavy elements diffuse and form lighter elements. Both nuclear fusion and fission produce a massive amount of energy.



### 5.5.3 Nuclear reactors

A nuclear reactor is an apparatus in which nuclear fission is produced in the form of a controlled self-sustaining chain reaction. In other words, it is a controlled chainreacting system supplying nuclear energy. It may be looked upon as a sort of nuclear furnace which

burns fuels like U235, U233 or Pu239 and, in turn, produces many useful products like heat, neutrons and radioisotopes.

**Mechanism of heat production.** Most of the energy is imparted to the two fission fragments into which the nucleus divides causing them to move at high speed. However, because they have taken birth in a dense mass of metal, they are rapidly slowed down and brought to rest by colliding with other atoms of the metal. In so doing, their energy is converted into heat in much the same way as energy given up by a slowing motor can be converted into heat in the brake lining. In this way, the mass of uranium metal gets heated up.

#### **5.5.4 Essential Components of a Nuclear Reactor**

The essential components of a nuclear reactor are as follows: 1. Reactor core 2. Reflector 3. Control mechanism 4. Moderator 5. Coolants 6. Measuring instruments 7. Shielding

##### **1. Reactor core:**

The reactor core is that part of a nuclear power plant where fission chain reaction is made to occur and where fission energy is liberated in the form of heat for operating power conversion equipment. The core of the reactor consists of an assemblage of fuel elements, control rods, coolant and moderator. Reactor cores generally have a shape approximating to a right circular cylinder with diameters ranging from 0.5 m to 15 m. The pressure vessels which houses the reactor core is also considered a part of the core. The fuel elements are made of plates or rods of uranium metal. These plates or rods are usually clad in a thin sheath of stainless steel, zirconium or aluminium to provide corrosion resistance, retention of radioactivity and in some cases, structural support. Enough space is provided between individual plates or rods to allow free passage of the coolant.

##### **2. Reflector:**

A reflector is usually placed round the core to reflect back some of the neutrons that leak out from the surface of the core. It is generally made of the same materials as the moderator.

### **3. Control mechanism:**

It is an essential part of a reactor and serves the following purposes: (i) For starting the reactor i.e., to bring the reactor up to its normal operating level. (ii) For maintaining at that level i.e., keep power production at a steady state.

The control system is also necessary to prevent the chain reaction from becoming violent and consequently damaging the reactor. The effective multiplication factor of the reactor is always kept greater than unity in order that the number of neutrons keeps on increasing in successive generations. As the number of neutrons and hence the neutron flux density increases, the temperature also increases. Unless the growth is checked at some point, the reactor is likely to be damaged as a result of too rapid liberation of energy.

### **4. Moderator:**

In a nuclear reactor the function of a moderator is:

To slow down the neutrons from the high velocities and hence high energy level, which they have on being released from the fission process. Neutrons are slowed down most effectively in scattering collisions with nuclei of the light elements, such as hydrogen, graphite, beryllium etc. (ii) To slow down the neutrons but not absorb them.

### **5. Coolants:**

The function of a coolant is to remove the intense heat produced in the reactor and to bring out for being utilised. The desirable characteristics for a reactor coolant are: 1. Low parasite capture. 2. Low melting point. 3. High boiling point. 4. Chemical and radiation stability. 5.

Low viscosity. 6. Non-toxicity. 7. Non-corrosiveness. 8. Minimum induced activity (short half-lives, low energy emission). 9. High specific heat (reduces pumping power and thermal stresses). 10. High density (reduces pumping power and physical plant size). Commonly used coolants: Santiwax R (organic, Hg, He, CO<sub>2</sub>). The most widely-used gaseous coolant is CO<sub>2</sub> particularly in large-power reactors. It is (i) cheap, (ii) does not attack metals at reasonable temperatures, and (iii) has small cross-section for neutron capture.

### **6. Measuring instruments:**

Main instrument required is for the purpose of measuring thermal neutron flux which determines the power developed by the reactor.

### **7. Shielding:**

Shielding is necessary in order to: (i) protect the walls of the reactor vessel from radiation damage, and also to (ii) protect operating personnel from exposure to radiation. The first known as thermal shield is provided through the steel lining, while the other called external or biological shield is generally made of thick concrete surrounding the reactor installation.

