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Reactors or Atomic Pile

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The chain reaction is a self sustaining process. The fission by the chain reaction may be controlled by absorbing a desired number of neutrons, so that on the average, one neutron from each fission is left to excite further fission. The number of fissions occuring per second & thus remains constant. The energy thus liberated does not get out of control. Such a system in which the arrangement for absorption of neutrons is provided so that the chain reaction may proceed in a controlled manner is called nuclear reactor and it is a source of useful energy.

Numerous reactors of different designs have been constructed for variety of purposes. In spite of numerous possible variations in the design and components of reactor systems, there a number of general features which all reactor possess in common to greater or lesser extent.

A nuclear reactor consists of thick blocks of carbon in which long cylindrical holes have been drilled. Fissionable material and control rods are inserted through these holes. The basic part of a reactor are as follows:

(1) Fuel :- The fuel consists of a certain mass of a fissionable material taken in the form of rods. These rods are tightly sealed in a aluminium containers and inserted in alternate rows of blocks.

(2) Moderator :- Its purpose is to slow down the neutrons. Suitable materials used as moderator are heavy water or carbon taken in the form of pure graphite.

(3) Reactor coolant :- The material employed, to remove the heat that is generated in the reactor core as a result of fission taking place, are known as coolants. These materials are circulated

through the core for the purpose of abstracting the heat and transferring it to the outside of the core. An ideal coolant should have as little effect on the neutron as possible, should not react chemically with the other materials which it contacts in the system. The materials proposed for coolants are ordinary water, heavy water, liquid metals, organic liquid & gases. Each type has its advantages & disadvantages.

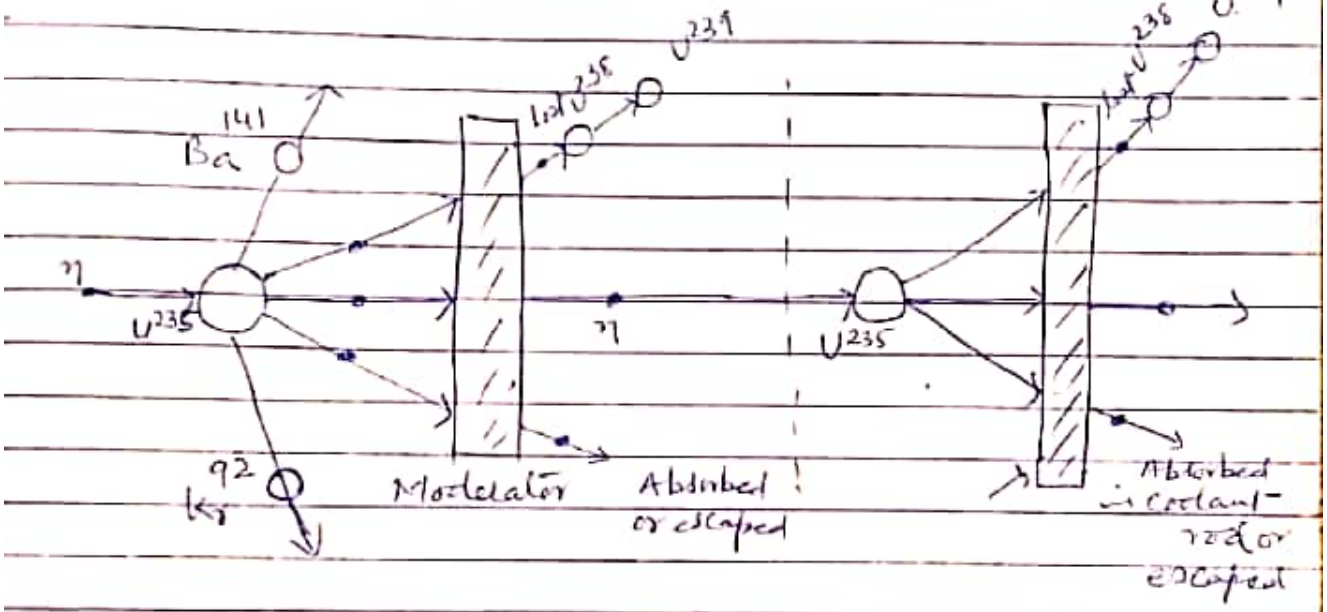
(4) Controlled rod :- In thermal reactors control is achieved by means of a neutron absorbing materials. The material should not become radioactive as a neutron capture. Because of its availability Cadmium was used as early reactors. It can be utilized at low temp work only, because it has low melting point. The most common neutron absorber used for reactor controlled is boron. This element has very high melting point and large cross sections for neutron absorption. The control elements are commonly located in the core in the form of either rods or plates.

(5) Reactor Shielding :- All nuclear reactors, except those operating at very low powers, are sources of intense neutron and γ-radiation and, therefore, represent hazard to persons in immediate vicinity of the reactors. Provisions for their health protection are made by surrounding the reactor core with a radiation shield. This shield is generally known as biological shield.

Working :- Neutrons produced by the action of α-particles or β from polonium or beryllium are slowed down and are used initially to bring fission of U^{235} nuclei. The neutrons emitted through fission are again slowed down by the passage through the moderator to split further U^{235} and

Thus chain reaction sets in. The chain reaction is said to steady if the effective multiplication factor k_e is 1, where

$$k_e = \frac{\text{Rate of emission of neutrons}}{\text{Rate of loss of neutrons}}.$$



The loss of neutrons may take place either by their absorption in U^{238} (which is present in U^{235} as its isotope) or by their in controlled rods or by escaping through furnish walls. In case of the liberation of three neutrons per fission of U^{235} nucleus, one is lost by escape or absorption, second is captured by U^{238} and the third splits a new U^{235} nucleus, thus making $k_e = 1$. It keeps the chain reaction self-sustained without explosion.

Classification of reactors :-

Reactors may be classified in a variety of ways:-

(i) the manner in which the fuel & the moderator are fixed

(ii) according to the energy of the neutrons that cause fission

(iii) according to their purpose. This type of reactors are

(a) Research reactors :- It is used primarily to supply neutrons for physical research and radio isotope manufacture. In these reactors the total energy liberated is comparatively small, In these cases cooling is required only to prevent overheating. There are five types of research reactors

(i) Graphite - moderated research reactor (ii) Water - boiler - type reactor (iii) Swimming pool reactor - the Indian reactor Apsara belongs to this type. It was designed and built by Indian scientist & engineers under the guidance of late Late Dr H. J Bhaba

(iv) Light - water - moderator, Tank type reactor

(v) Heavy - water - moderator, Tank type reactor. Cirus and Zerlina are the second & third research reactor of India.

(b) Production reactors :- The purpose of a production reactor is to convert fertile into fissile material

(c) Power reactor :- The primary purpose of power reactor is the utilization of fission energy produced in the reactor core and to convert it into useful power. Heat generated in fission process is used, either directly or indirectly to produce steam at high temp & pressure or to heat a compressed gas. The steam or heated gas is used as a working substance in turbine, The turbine can be connected to an electric generator or can be used as the source of mechanical power.