

Science & Tech



Sample topic · Nuclear Reactors & India's Nuclear Programme

Nuclear Technology

Components of Nuclear Reactor

1. Core

- It is the main area where the fission reaction takes place.
- It contains the fuel rods and control systems. Fuel rods are made up of Zirconium metal.

2. Coolant

- This is the material which pass through the core and captures the heat and transfers it to turbine.
- Important Coolants:
 - i. Water (H₂O)
 - ii. Heavy Water (D₂O)
 - iii. Liquid Sodium
 - iv. Helium

3. Moderator

- It slows down the speed of neutrons to a level appropriate to cause the fission of uranium atom.
- It increases the neutron efficiency.
- Important Moderator:
 - i. Graphite
 - ii. Heavy Water (D₂O)
 - iii. Beryllium

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Components of Nuclear Reactor

4. Controlling Rods

- Fission reaction releases lot of neutrons, if unchanged, it can cause the reaction to go out of control and may cause explosion.
- Controlling Rods are used to control the rate of reaction by absorbing the excess neutrons.
- Example: Boron and Cadmium

5. Containment Structure

- It is the structure that separates the reactor from the environment
- It is made up of high density steel reinforced concrete.
- In case of a nuclear accident, it will prevent the radiation from going out.
- It is usually dome shaped.

Note: There are 22 nuclear reactors in India

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Types of Nuclear Reactor

1. Pressurised Heavy Water Reactor

- PHWR is a nuclear power reactor, commonly using unenriched natural uranium as its fuel. It uses **heavy water** (Deuterium oxide D₂O) as its coolant and moderator.
- The heavy water coolant is **kept under pressure**, allowing it to be heated to higher temperatures without boiling, much as in a typical pressurized water reactor.
- While heavy water is significantly **more expensive** than ordinary light water, it yields greatly enhanced neutron economy, allowing the reactor to operate without fuel enrichment facilities.

2. Light Water Reactor

- The light water reactor is a type of thermal-neutron reactor that utilizes **normal water** as opposed to heavy water.
- It is fuelled by **Low Enriched Uranium**.
- It uses water as both a **coolant and a neutron moderator**.
- It produces heat by controlled nuclear fission.

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Types of Nuclear Reactor

3. Fast Breeder Reactors

- A breeder reactor is a nuclear reactor that generates more fissile material than it consumes. These are designed to extend the nuclear fuel supply for electric power generation.
- Breeder reactors achieve this because their neutron economy is high enough to create more fissile fuel than they use, by irradiation of a fertile material, such as Uranium- 238 or Thorium- 232 that is loaded into the reactor along with fissile fuel.
- In these reactors, neutrons are not slowed down. They are allowed to move fast and hence the name fast breeder reactors.
- PFBR is a 500 MWe fast breeder nuclear reactor presently being constructed at the Madras Atomic Power Station in Kalpakkam (Tamil Nadu).

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India's 3 staged Nuclear Power Programme

Stage 1. Pressurised Heavy Water Reactors

- In the first stage, Pressurised Heavy Water Reactors would be developed.
- These reactors use unenriched natural uranium oxide as the fuel and heavy water as the moderator and coolant.
- In these reactors, coolant is kept under pressure and hence its name is Pressurised Heavy Water Reactors.
- In 1st stage, the residual fuel (spent fuel) would be treated. Uranium-238 and Plutonium-239 would be chemically separated. Rest of the fuel would be disposed-off after being subject to proper treatment.

Stage 2. Fast Breeder Reactors

- In these reactors, Plutonium-239 (obtained from 1st stage or from Transmutation of Uranium-238) is used as fuel and liquid sodium is used as the coolant.
- No Moderator is there in fast breeder reactors.

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- In the 2nd stage, a wall made up of Thorium-238 is made to hit by the electrons because of which Thorium (fertile material) transmutes into Uranium-233 (fissile material)
- This newly formed Uranium-233 is to be utilised in 3rd stage of India's Nuclear Programme.

Stage 3. Advanced Nuclear Power Systems

- In these reactors, Uranium-233 is used as a fuel (obtained from 2nd stage)
- Bhabha Atomic Research Center (BARC) is working on research and development of Advanced Nuclear Power Systems.
- It is a thorium fuel based (technically Uranium-233), heavy water moderated and boiling light water cooled reactor
- It is a 300MW capacity reactor intended to serve as a technology demonstrator for a range of technologies for thorium utilisation as well as several advanced safety features that have been incorporated.
- This reactor will provide impetus for the development of technologies for 3rd stage of India's Nuclear Power Programme.

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Nuclear Reactors in India

- Total: 22 operational nuclear reactors in India
- They have an installed capacity of 6780 MW
- Nuclear Power contributes 2-3% in total electricity generation.
- India's Nuclear Reactors
 - Tarapur: 2 reactors (Boiling Water Reactors)
 - Rajasthan: 6 reactors (PHWR)
 - Madras: 2 reactors (PHWR)
 - Kudankulam: 2 reactors (PWR)
 - Narora: 2 reactors (PHWR)
 - Tarapur: 2 reactors (PHWR)
 - Kaiga: 4 reactors (PHWR)
 - Kakrapur: 2 reactors (PHWR)
- Nuclear Reactors comes under jurisdiction of NPCIL (Nuclear Power Corporation of India Limited) which is a PSU under Department of Atomic Energy