

Prototype Fast Breeder Reactor

Posted at: 06/03/2024

Context:

In a historic milestone marking entry into the vital second stage of India's three stage nuclear program, Prime Minister, Shri Narendra Modi witnessed , commencement of "Core Loading" at India's first indigenous Fast Breeder Reactor (500 MWe) at Kalpakkam, Tamil Nadu.

Background:

The government had approved in 2003, the creation of Bharatiya Nabhikiya Vidyut Nigam Ltd (BHAVINI) to construct and operate India's most advanced nuclear reactor-Prototype Fast Breeder Reactor (PFBR).

About PFBR and Indias Three stage nuclear program:

1. The PFBR is a machine that produces more nuclear fuel than it consumes. Its core-loading event is being hailed as a "milestone" because the operationalisation of the PFBR will mark the start of stage II of India's three-stage nuclear power programme.
2. In the first stage, India used pressurised heavy water reactors (PHWRs) and natural uranium-238 (U-238), which contains minuscule amounts of U-235, as the fissile material.
3. In nuclear fission, the nucleus of an atom absorbs a neutron, destabilises, and breaks into two while releasing some energy. If the destabilised nucleus releases more neutrons, the reactor's facilities will attempt to use them to instigate more fission reactions.
4. The heavy water in PHWR - water molecules containing the deuterium isotope of hydrogen - slows neutrons released by one fission reaction enough to be captured by other U-238 and U-235 nuclei and cause new fission. The heavy water is pressurised to keep it from boiling. The reactions produce plutonium-239 (Pu-239) and energy.
5. Only U-235, not U-238, can sustain a chain reaction but it is consumed fully in stage I. In stage II, India will use Pu-239 together with U-238 in the PFBR to produce energy, U-233, and more Pu-239.
6. In stage III, Pu-239 will be combined with thorium-232 (Th-232) in reactors to produce energy and U-233. Homi J. Bhabha designed the three-stage programme because India hosts roughly a quarter of the world's thorium. The three stages are expected to allow the country complete self-sufficiency in nuclear energy.

How does the PFBR work?

1. PHWRs use natural or low-enriched U-238 as the fissile material and produce Pu-239 as a byproduct. This Pu-239 is combined with more U-238 into a mixed oxide and loaded into the core of a new reactor together with a blanket. This is a material the fission products in the core react with to produce more Pu-239.
2. A breeder reactor is a nuclear reactor that produces more fissile material than it consumes. In a 'fast' breeder reactor, the neutrons aren't slowed, allowing them to trigger specific

fission reactions.

3. The PFBR is designed to produce more Pu-239 than it consumes. It uses liquid sodium, a highly reactive substance, as coolant in two circuits. Coolant in the first circuit enters the reactor and leaves with (heat) energy and radioactivity. Via heat-exchangers, it transfers only the heat to the coolant in a secondary circuit. The latter transfers the heat to generators to produce electricity.



AKKA IAS ACADEMY
www.akkaids.com