Science and Technology Class 05

14th July, 2023 at 9:00 AM

INTRODUCTION (09:06 AM)

- A Brief Review Of the previous class.

NUCLEAR TECHNOLOGY (09:08 AM)

- **Nuclear technology is the application of nuclear reactions** in a chemical reaction.
- Nuclei do not participate.
- However in nuclear reactions nuclei, nucleons and elementary particles participate.
- Nuclear technology has applications in energy production, agri, medicine, space, defence, and industry among others.
- **Nuclear tech for energy productions:**
- There are 2 very famous reactions which can be used to produce nuclear energy:
- Nuclear fission and Nuclear fusion.
- In nuclear fission reaction a heavy nucleus which is not very stable is bombarded neutrons.
- This makes the nucleus even more unstable.
- This leads to the disintegration of heavy nucleus into 2 or more lighter nuclei.
- Energy produced in the reaction can be calculated using Einsteins' mass-energy equivalence relationship.
- E=MC*2.
- Fission reaction produces an excess of neutrons thus we only have to induce the reactions.
- Because of the extra neutron in every successive reaction.
- More and more nuclei will undergo fission.
- This is called an uncontrolled chain reaction.
- Such uncontrolled fission produces huge amounts of energy in a very short period which is a **mechanism behind nuclear bombs.**
- If we can observe an excess of neutrons, then it becomes a controlled fission reaction.
- Energy output can be controlled.
- This is the mechanism behind nuclear reactors.

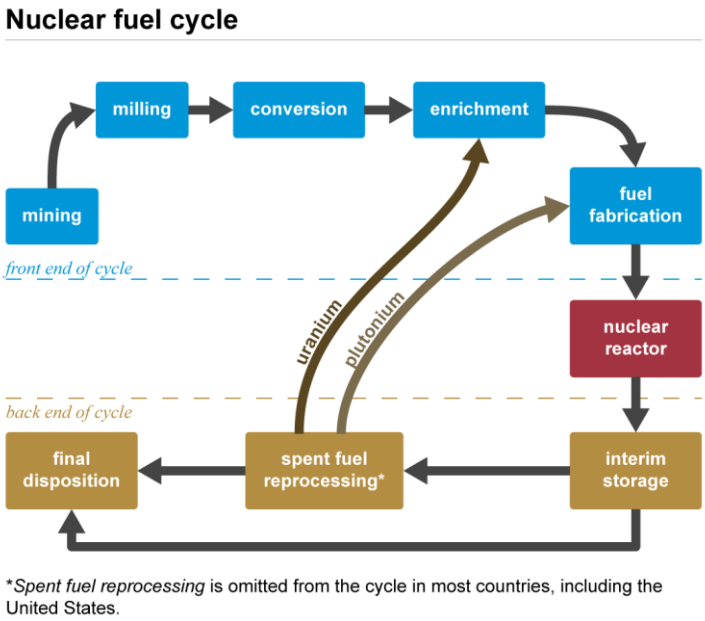
NUCLEAR REACTORS (10:09 AM)

- A nuclear reactor is used for controlled fission.
- It has the following major components:
- Fissile material: Materials which can undergo fission easily. Example U 235, U233, P239.
- Control rod: To absorb excess neutrons. Ex: Boron, Cadmium.
- **Moderator:** To slow down the speed of neutrons.
- Slow neutrons are better at causing fission. Ex: Water, Heavy water(D2O)
- **Coolant:** They maintain the temperature of coal by removing the excess heat from the core of the reactor, often moderators and coolants are the same.
- **Example: H20, D20.**
- Liquid sodium: It is a good coolant but not a good moderator.
- Nuclear power reactor:

TYPES OF NUCLEAR REACTOR (10:25 AM)

- **Boiling water:** BWRs are another type of nuclear reactor used for power generation.
- Like PWRs, they use enriched uranium fuel, but they have a different design.
- BWRs directly boil the water in the reactor core, and the resulting steam is used to drive a turbine and generate electricity.
- **Pressurised water reactor:** PWRs are the most common type of nuclear reactor used for commercial electricity generation.
- They use enriched uranium fuel and pressurized water as both coolant and moderator.
- The water remains in a liquid state under high pressure to transfer heat from the reactor core to a steam generator, where it produces steam to drive a turbine and generate electricity.
- **Pressurized heavy water reactor:** PHWRs use heavy water (deuterium oxide) as both a coolant and moderator.
- The presence of heavy water allows these reactors to use natural uranium or lower-enriched uranium fuel.
- **Fast breeder reactor:**
- A Fast Breeder Reactor (FBR) is a type of nuclear reactor that is designed to produce more fissile material (such as plutonium-239) than it consumes.
- It achieves this through the use of fast neutrons, which have higher energy levels compared to thermal neutrons used in conventional reactors.

NUCLEAR FUEL CYCLE (10:31 AM)



- It involves all the steps from miming to the final disposal of waste.
- It consists of the following steps:
- **Mining: Uranium ore has been recovered after mining.**
- **Milling:** Using physical and chemical separation methods, natural Uranium is recovered.
- **Enrichment:** Natural Uranium comprises more than 99% U238 and less than 1% of U235.
- In the enrichment process using the isotopic separation method we increase the percentage of U235 up to 3 to 5 %.
- The enrichment requirement for nuclear weapons is in the range of 90%.
- **Fabrication:** Enriched uranium is converted into pellets and embedded into a metallic tube which is called a fuel rod.
- About 200 rods are kept together called fuel assembly.
- Fission at reactor: Nuclear fission can continue for 2 to 3 years without any refuelling.
- **Interim Storage:** Nuclear waste is removed from the core and kept in a deep pool of water for years.
- This is done to ensure water absorbs dangerous nuclear radiation.
- **Spent fuel Reprocessing:** From Nuclear waste useful material such as fissile material for the next set of fission.
- In a permanent underground repository.

THREE STAGES OF THE NUCLEAR PROGRAMME (11:31 AM)

- 3 stage programme was envisaged by homi jahangir Bhabha to effectively utilise both uranium reserve(Limited supply)
- And Thorium reserve in abundance found in western ghats specially in the Monazite sand of Kerala.
- In the first stage PHWR will use enriched uranium as fissile material, heavy water as moderator and coolant while U235 undergoes fission U 238 captures a neutron and converts it into Pu 239.
- That is why U238 is called fertile uranium.
- In The second stage Fast breeder reactor with liquid sodium as a coolant and no moderator will be used.
- PU 239 recovered from the first stage will be the main fissile material and Thorium will also be introduced in the same stage which can convert into U 233.
- This stage does not use a moderator because even though fast neutrons are not good at fission, they can easily convert thorium to uranium.
- It is called fast breed because it produces Uranium faster than the fission of plutonium.
- The first fast breeder reactor in India will become operational in Kalpakkam Tamilnadu.
- In the Third stage U33 recovered from the second will be the fissile material.
- We still will have a lot of thorium left which will be used in 3rd stage itself to convert into uranium and fission that uranium.

CHALLENGES (11:40 AM)

- Spent fuel reprocessing is technologically challenging.
- India does not have high-grade uranium.
- India even today is not a member of the nuclear supplier group, although as of now India has a special NSG waiver that it can enter into bilateral deals with other countries.
- There is a powerful pressure group in India which opposes nuclear energy because of fear associated with it as well as environmental concerns.
- The accidents from the past such as the Chornobyl disaster in 1986, in Ukraine, and the Fukushima disaster, in Japan in 2011 have led to even more opposition to nuclear energy in India.
- Last decade the cost of renewable energy such as solar and wind has reduced significantly.
- However, Nuclear energy remains expensive.
- **Question:** With the growing energy need should India keep on expanding its nuclear energy programme? Discuss the facts and fears associated with nuclear energy in this regard(150 words/10 marks)

(TOPIC FOR THE NEXT CLASS: CONTINUATION OF NUCLEAR ENERGY)