FUSION AS FUTURE NUCLEAR ENERGY SOURCE

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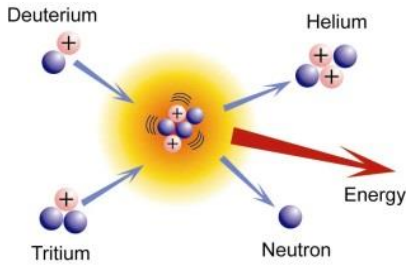
What is Nuclear Fusion

As oppose to nuclear fission, nuclear fusion merge two light nuclei together to release energy the process. Two light nuclei are hydrogen isotopes deuterium ${}^{2}_{1}H$ and tritium ${}^{3}_{1}H$ are merged to form helium ${}^{4}_{2}He$ and neutron and released energy which has the potential to be harness for commercial purposes.

Fusion is not uncommon in nature. The solar energy is powered by fusion process. At the centre of the sun, where its pressure is million of times more than the surface of the earth and the temperature reaches more than 15 million Kelvin, every second, 600 million tons of hydrogen are being converted into helium though fusion process. The fusion process at the centre of the sun releases a tremendous amount of heat and energy which reaches the earch to warm and activates life on earth



An Illustration of nuclear fusion process.

Why is nuclear fusion so viable as the source of energy for the future? Its fuel i.e. hydrogen is so abundant in ordinary sea water as to make it effectively inexhaustible, it not has no radioactive waste in fuel cycle, it is inherently is safe and it does not emit greem house gasses.

Tokamak

To duplicate the fusion process in a laboratory, scientists and engineers have developed and built devices such as tokamak and dense plasma focus to study the fusion process. A tokamak (Russian: токамáк) is a device that uses a powerful magnetic field to confine plasma in the shape of a torus. Tokamak in Russian means "toroidal chamber with magnetic coils", in conjunction with two Russian researchers who, in 1968, succeeded in attaining temperature levels and plasma confinement times. Examples of tokamak devices in the world are as follows:

- ADITYA (tokamak), Institute for Plasma Research, India
- Alcator C-Mod, Massachusetts Institute of Technology, United States
- ASDEX Upgrade (Axialsymmetrisches Divertorexperiment), Max-Planck-Institut für Plasmaphysik, Garching, Germany
- COMPASS, Institute of Plasma Physics AS CR, Czech Republic, Prague

- DIII-D, General Atomics, United States
- EAST (Experimental Advanced Superconducting Tokamak), Hefei, People's Republic of China
- JT-60, JAERI, Japan
- JET (Joint European Torus), Culham, UK
- KSTAR, National Fusion Research Institute, Republic of Korea

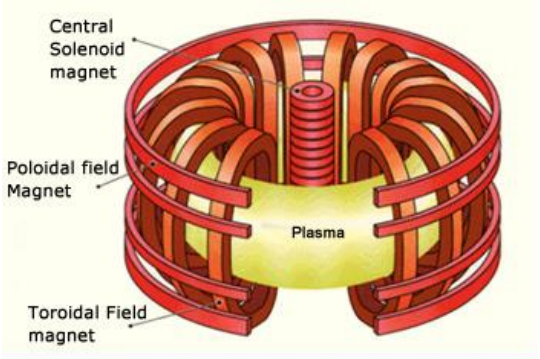


Figure 1 : Tokamak configuration. The toroidal and the poloidal field magnets as well as current in the plasma itself produce the main magnetic field. The central solenoid drives the current in the plasma through transformer action

Source: https://www.iter-india.org/fusion-energy/fusion_experiments_2.htm

Dense Plasma Focus

A Dense Plasma Focus (DPF) is a device that can generate, accelerate and pinch a plasma by electromagnetic forces. Dense Plasma Focus Device is considered a small fusion device when the deuterium gas inside its chamber is pinched by electromagnetic field to form fusion reaction at high temperature in pulse mode.

The DPF is driven current from the energy released by a capacitor operating at high voltage. When the capacitor charge is maximum, it will release its energy that will drive the current into the electrode inside the gas chamber of the device. The deuterium ${}_{1}^{2}H$ gas that is compressed in its gas chamber were fused together to produced helium, neutron and energy during the pinch.

Dense plasma focus (DPF) device of Mather type at Malaysian Nuclear Agency

Technical Meeting on Fusion

The Second Technical Meeting on Fusion Data Processing, Validation and Analysis was held on 30 May 2017 - 2 June 2017 at Massachusetts Institute of Technology (MIT), Cambridge, Massachusetts, United States of America. The objective of the meeting was to dicuss on the

current advances of research on nuclear fusion technology. The meeting was attended by more than 55 participants from around the world. Various aspects on data validation, processing and modeling of the the tokamaks were presented and discussed by experts.

The Plasma Sceince and Fusion Center (PSFC) of MIT was the local organizer of the meeting. FSFC host the tokomak Alcator C-Mod, an experimental device considered future fusion reactors in carrying out research on nuclear fusion since 1993. C-Mod is the world's only compact, high-magnetic field, diverted tokamak,. The C-Mod holds the record for highest volume average plasma pressure in a magnetic confinement device. It could go up to 160,000 times the Earth's magnetic field to create the dense, hot plasmas, which are greater than 100 million degrees. Following completion of operations at the end of September, 2016, the facility has been placed into safe shutdown. There is a wealth of data archived from the more than 20 years of operations for the experimental and theoretical teams to continue to analyze the results and publish them in the scientific literature.

Participants of IAEA TM Meeting on Fusion at Samberg Conference Center, MIT

View of Charles River from the Samberg Conference Center, MIT

Plasma Science and Fusion Center, MIT, in Albany Street, Cambridge MA

MIT Museum, showcasing success projects from MIT graduates.

University Park @ MIT

William Baron Rogers Fowler MIT Building in Massachusetts Avenue Street, Cambrige

Related Links:

1) 3D tour at Alcator Mod at Plasma Sceince and Fusion Center (PSFC), MIT, pls go the following url: http://news.mit.edu/2016/alcator-c-mod-tokamak-nuclear-fusion-world-record-1014
2) Breakthrough in Nuclear Fusion: https://www.youtube.com/watch?v=KkpqA8yG9T4