

Materials and technology challenges for nuclear fusion reactor

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Our current energy landscape is heavily dependent on the fast-depleting fossil fuels, changing this dependence is critical to cut down on the greenhouse gas emissions. One of the future solution for energy source problems is a nuclear fusion process. Nuclear fusion is the same process that powers stars and our Sun. The technological challenges of bringing fusion power to the electricity grid will be addressed by a DEMO-type reactor. The design for the demonstration fusion power plant (DEMO) utilizes the tokamak concept, in which a burning plasma is contained in a torus-shaped vacuum vessel. The fuel – a mixture of Deuterium and Tritium – is heated to temperatures in excess of 150 million °C, forming hot plasma. Strong magnetic fields keep the plasma away from the walls.

Fusion reactors experience many commonalities with advanced fission reactors and high power accelerator spallation targets. The operational requirements of the structural materials in fusion power plants are beyond today's experience. This includes elevated operating temperature, cyclic operation with long hold time, prolonged periods of operation, steep temperature and stress gradients, high neutron irradiation damage and a very high production rates of helium and hydrogen as well as corrosion. Databases supporting mathematical models and designs of future fusion power plant are mainly derived from relatively few tests facilities. Individual countries are exploring ways to facilitate a faster research and technology development and share information in large collaborative programs. For example studies of H isotopes retention (also referred to as “fuel retention”) in Plasma Facing Components (PFC) are carried at the currently world's largest nuclear fusion experimental reactor JET (Joint European Torus) as a part of the international effort under EUROfusion consortium agreement.

The main goal of this talk is to present the tokamak fusion device concept, illustrated by an overview of JET, and to discuss selected challenges of nuclear fusion technology, such as PFC fuel retention and magnetic-field assisted corrosion.

** See the author list of “Overview of the JET results in support to ITER” by X. Litaudon et al., 2017 Nuclear Fusion 57 102001