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FTP/P7-07: Conceptual Design Requirements and Solutions for MW-Range Fusion Neutron Source FNS-ST

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Development of the demonstration fusion neutron source FNS-ST for the nuclear fuel production and the nuclear waste transmutation on the basis of a spherical tokamak with the MW power of deuterium and tritium fusion has reached the stage of technical requirements for conceptual design.
The concept of a FNS-ST has been proposed and developed in details (plasma current 1.5 MA, magnetic field 1.5 T, major radius 0.5 m, aspect ratio 1.67 and auxiliary heating power up to 15 MW). A comparison of physical plasma parameters and the economics for an FNS-ST and a conventional tokamak will be presented. It suggests the feasibility to reach 1-10 MW of the Fusion power for a conventional or low aspect ratio. It will be shown that the ST economics is better. Zero and one-dimensional plasma models have been developed and used in this analysis. The necessary operation characteristics of the plasma confinement, stability and current drive have been determined. Scenarios to reach and maintain the steady state operation are considered and optimized.
Perspective technical solutions for technology systems have been validated, and choices of enabling technologies and materials of the basic FNS have been made. The best characteristics both for the neutronics and the power consumption for the toroidal magnet system suggest Be-made toroidal coils, cooled to the liquid nitrogen temperature. A conceptual design of a thin-wall water cooled vacuum chamber for the heat load up to 6 MW/m2 will be presented. The chamber consists of 2 mm Be tiles, pre-shaped CuCrZr 1 mm shell and a 1 mm stainless steel shell as a structural material. A concept of the double-null divertor for the FNS-ST will be suggested that is capable to withstand heat fluxes up to 6 MW/m2. Lithium dust injection technology is proposed to use for control of the border plasma radiation and plasma-surface interaction in the scrape-off layer.
Concepts of the FNS-ST blankets for the pure thermal neutron production and for the development of a thorium fuel cycle for fission reactors will be considered. It is shown that thermal neutron fluxes as large as 1015n/cm2s are feasible in the FNS with Be coils. The radial structure, neutronics and thermal hydraulic characteristics as well as the U233-production rate and opportunities to self-breed tritium will be discussed.

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