

Progress in design of DEMO-FNS hybrid facility

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Further development of a fusion-fission hybrid facility based on superconducting tokamak DEMO-FNS continues in Russia for integrated commissioning of steady-state and nuclear fusion technologies at the power level up to 40 MW fusion and 400 MW fission reactions. This facility is considered as the main source of technological and nuclear science information in National program for development of controlled fusion and plasma technologies till 2035 that is being currently developed and submitted to the authorities for approval. The facility DEMO-FNS exploits a conventional tokamak (CT) with major radius $R=3.2$ m, minor radius $a=1.0$ m, elongation 2.7, triangularity 0.5. The design is aimed at reaching steady state operation of the plant with the neutron wall loading of ~ 0.2 MW/m², the lifetime neutron fluence of ~ 2 MWa/m², with the surface area of the active cores and tritium breeding blanket ~ 100 m². This report summarizes works performed in 2017-2018. The design goals of 2017 were concentrated on development of new simulation tools and plasma scenario, improving characteristics of enabling systems, implementing upgraded and new systems like first wall, divertor, active core, tritium breeding blanket, NBI, fueling and pumping, heat transfer, remote handling in the integrated device design. NBI system with 6 injectors, 5 of which operate in 2 hour-cycle with sequential recuperation and one can be used for repair and maintenance procedures. Total power of 500 keV deuterium beams is 36 MW. Optimization of beam transport ducts allowed reduction of their cross section to 0.4×0.8 m². Core plasma modeling showed that neutron yield is maximal if the tritium/deuterium density ratio is 1.5-2.3. For active core with $k_{eff} = 0.95$ (hybrid plant case) the neutron damage of FW-materials in dpa is comparable for fusion and fission neutron sources. Advantages of supercritical CO₂ as a coolant for active cores, TBB, FW and divertor were evaluated. This coolant is attractive due to acceptable pressure (~ 75 bars) and temperature (up to ~ 500 C) ranges, low activation level in neutron environment, saving the hard neutron spectra, and compatibility with lithium technologies better than water coolant. Selection of prospective concepts is being made for hybrid fuel cycle and blankets capable to support development of Nuclear Power in RF with thermal and fast nuclear reactors.

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