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Development of DEMO-FNS fueling systems and modeling hydrogen isotopes distribution via «FC-FNS» simulation code

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In the NRC "Kurchatov Institute"fueling systems (FS) concept for the DEMO-FNS facility incorporating components maintaining plasma parameters, tritium processing and breeding, is being developed. The FS computer model provides calculation functions using the computer code «FC-FNS». It allows to calculate gas flows, tritium inventories and losses in FS for steady-state operation mode.

Within the DEMO-FNS design development the device parameters were better specified and «FC-FNS» code was upgraded accordingly. In 2016-2018, the structural diagram of fuel cycle was expanded to include systems for fuel mixture deprotiation, cooling the divertor and first wall, tritium extraction from lithium circulating in the vacuum vessel. The code functionality was expanded to take into account the new systems and operating modes. The updated version simulates the balance of all three hydrogen isotopes (H, D, T). The values of tritium inventory in main systems (blanket, storage, processing and separation) calculated on the basis of the particle balance can be compared with those obtained using solution of differential equations describing the dynamics of tritium inventories.

Due to the fact that the neutral beam injection (NBI) system is included in the FS, its gas supply configuration and integration in the facility FS are being considered. Calculations showed that in a neutral injection system it is inappropriate to use D:T = 1:1 gas mixture. The scenario is optimal in which a tritium-containing gas mixture is pumped out to the facility's FS when a specified tritium fraction (5%) is reached. The total tritium inventory in FS can be reduced to 1.5-2 times compared with 1:1 case.

Previously, the particles balance was set on the assumption that injection systems must compensate the particles loss from plasma due to burnout and removal of hydrogen isotopes from the plasma. The new code version includes the possibility to simulate the gas inlet to the vacuum chamber associated with control of the edge plasma parameters, ELMs control, etc. Tritium losses in the FS reach 30-50 g due to its decay and about 20 g due to diffusion through the structural materials in addition to the burnout of 1.7 kg per year in plasma. Tritium inventories in structural materials reach up to 90 g per year. In this case, the total amount of tritium in the FS will be up to 1000 g.

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