Contribution ID: **640** Type: **Regular Poster**

Concept development and candidate technologies selection for the main DEMO-FNS fuel cycle systems

Thursday, May 13, 2021 12:10 PM (20 minutes)

As part of the work on the creation of a pilot industrial hybrid reactor (PHP) in Russia, a demo fusion neutron source DEMO-FNS is being designed. Progress in the facilities development and tokamak fuel cycle (FC) modeling allowed for a number of systems to move from the conceptual design stage to the engineering stage. The report discusses technical proposals for key fuel cycle systems and their integration into DEMO-FNS.
Design of a tokamak-based fusion neutron source (DEMO-FNS) with parameters R/a = 3.2m/1m, B = 5T, Ipl = 4-5 MA, PNBI = 30 MWт and PECR = 6MW and power of DT synthesis Pf = 40 MW involves the use of TC technologies previously developed as part of the ITER project, as well as those used in JET and TFTR and other tritium systems..
The fuel cycle model/computer code FC-FNS (Fuel Cycle for Fusion Neutron Source) , which describes the processes in the DEMO-FNS fuel cycle, has been significantly upgraded in the last 2 years . For the first time, a comprehensive simulation of fuel flows in fuel cycle systems was performed for DEMO-FNS, depending on the main and divertor plasma parameters upon injection of an impurity for power re-emission (seeding gas) in divertors. Modeling shows that when using Ne impurity (2%) in the fuel mixture, a change in the plasma parameters (a decrease in the plasma density due to the balance of currents, including the beam) leads to a decrease in fuel flows in the pumping and injection systems (˜2 times) by increasing the impurities re-emission efficiency in comparison with hydrogen isotopes.
Fuel cycle optimization is carried out to minimize the tritium amount in all systems when meeting safety requirements. The specific technologies selection was carried out on the basis of fuel cycle systems main parameters calculations taking into account the characteristics of the physical and chemical processes occurring in them.
As a result of optimization, it was assumed that 3 circuits will be allocated in the fuel cycle: (i) for the fast processing of tokamak "exhaust" gases, (ii) for the separation of tritium from the reactor blanket and (iii) for the processing of tritium-containing wastes, trapping of tritium from process streams (in including from the air of working rooms in emergency situations) and the process gases release. It is also shown that for the successful functioning of DEMO-FNS, 2 kg of tritium is sufficient, taking into account the burnup and decay of T in a long-term storage.

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Session Classification: P5 Posters 5

Track Classification: Fusion Energy Technology