FUEL SYSTEMS of FUSION NEUTRON SOURCE DEMO-FNS DEVELOPMENT, AND HYDROGEN ISOTOPES distribution MODELING by "FC-FNS" CODE

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Tokamak-based fusion neutron source (FNS) [1] is the centerpiece of the fusion-fission hybrid reactor (combining nuclear and thermonuclear technologies). The main difference between FNS and the demonstration fusion reactor DEMO is that FNS can produce nuclear fusion power comparable with the power of plasma auxiliary heating without the need to reach ignition conditions, i.e. to have fusion energy multiplication factor (ratio of fusion power to imposed power of additional heating) Q about 1. The existence of a fissile material in the system allows one to reduce by a factor of 100 the fusion power. This leads to a significant reduction of requirements to plasma parameters, structural and functional materials of the tokamak.

Fusion neutron source is promising for research, testing of structural materials of future fusion and fusion-fission hybrid reactors, utilization of nuclear waste, fuel breeding and control of subcritical nuclear systems. Tokamak seems to be a most promising device for the building fusion neutron sources with the DT-fusion power exceeding 10 MW. Currently, several countries are developing FNS and FNSF projects, aimed at support of further development of the ITER project towards DEMO. In Russia, for the demonstration of stationary and hybrid technologies, the DEMO-FNS project has been developed, which should operate at least 5000 hours per year.

Fueling systems (FS) are an extremely important part of FNS. The plasma operation in a tokamak requires the continuous injection of the fuel mixture containing hydrogen isotopes (deuterium and tritium) into the vacuum chamber, as well as its subsequent pumping out and processing. Calculation of the distribution of tritium (as well as deuterium and protium) in fuel systems is important for assessing safety features of the facility and for designing these systems. Calculations of the tritium accumulation in fuel systems allows us to estimate the "starting" amount of fuel necessary for the facility start-up and operation, and also to evaluate the amount of fuel in each system of the FNS, which is necessary to justify the safety of operation of these systems. To simulate hydrogen isotope flows and inventories in the fuel systems of FNS, computer code FC-FNS has been created that continues to be developed. This paper describes capabilities of the code (including, [1]).

The report presents the possibilities of FC-FNS code. The results of calculations are presented for the conceptual design of DEMO-FNS developed at the National Research Center "Kurchatov Institute". The balance of three hydrogen isotopes is taken into account, the performance of deprotiation systems is calculated to maintain the required level of protium in the plasma tokamak and detritiation (for the variant of the neutral injection system - NBI). Three alternative scenarios for supplying gas to NBI system are simulated. It is shown that the proposed approach to NBI fueling allows reducing the total amount of tritium in FS up to 1.5 times, that leads to the initial loading for DEMO-FNS of 460 g. The time for tritium breeding up to the amount sufficient for starting a new similar device will be 2.5 - 4 years (for different scenarios for FS NBI).

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References

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