Modeling the behavior of hydrogen isotopes in the elements of the fusion reactor DEMO TIN fuel system

Anan’ev S.S., Spitsyn A.V., and Kuteev B.V.

National Research Centre Kurchatov Institute, Moscow, Russia, [Ananyev\_Ss@nrcki.ru](mailto:Ananyev_Ss@nrcki.ru)

To assess the distribution of tritium in thermonuclear reactor and “tritium plant” systems, it is necessary to carry out a dynamic simulation of the deuterium and tritium fuel mix behavior in all system elements, taking into account tokamak operation modes. Nowadays, such calculations are performed based on FC-FNS code. The code allows the calculation of hydrogen isotope flows and stocks in tokamak fusion systems. FC-FNS calculation code allows calculating flow rate calculations for various hydrogen isotopes in the fuel mixture of thermonuclear reactor as they pass through various elements of the fuel cycle, and assessing the isotope accumulation in various elements. Particle loss mechanisms due to thermonuclear burnup and β-decay of tritium in all the systems are taken into consideration for the calculations. Calculations are based on the assumption that in the steady-state facility operation mode the fuel flow through the vacuum chamber is determined only by the plasma demands in the thermonuclear fuel, not considering the tritium accumulation in the materials of the first wall. Balance equations are formed for all the FC systems, considering the fuel input-output and the operation mode of the system. At the same time all the gas mixture flows and DT fuel mixture mass are calculated.

Model of tritium recovery dynamics in the hybrid blanket is built to quantitatively assess hydrogen isotope distribution in the fuel cycle system elements.

An algorithm for giving the recommended capacity value for the fuel mixture protium removal system is integrated in the code, proposing several mechanisms to increase protium quantity in the FC.

Moreover, the code allows modeling the tritium reproduction processes in the hybrid blanket. Two alternative scenarios for feeding gas to neutral injectors are studied as an example of the code implementation: one with deuterium and tritium in equal shares, and another with deuterium only, as a closed loop deuterium cycle (without tritium).

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References

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