DEVELOPMENT OF NUMERICAL SIMULATION CODE OF MEMBRANE REACTOR FOR DETRITIATION

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The plasma exhaust gas from a fusion machine needs to be processed with very high tritium removal efficiency. Such a high decontamination factor is achieved by multistage processes. The last stage of the three-step CAPER process developed at the Tritium Laboratory Karlsruhe is based on a so-called permeator catalyst (PERMCAT) reactor, a direct combination of a Pd/Ag permeation membrane and a catalyst bed. The PERMCAT principle is based on isotopic swamping in a counter current mode. Previous tritium experiments employing laboratory scale PERMCAT reactors have demonstrated decontamination factors higher than 10^5 even for gas mixtures beyond specifications. In support to experiments, dynamic process simulation is indispensable for process design, analysis, and operation, which can reduce costly experiments for process optimization and reactor scale-up.

A first numerical calculation code has been developed for the process simulation of PERMCAT [1]. The numerical model developed was based on counter current one-dimensional plug flows partitioned with a membrane. The mass balance equations in the reactor have been developed by considering catalytic reactions, isotope exchange reactions and permeation of hydrogen isotopes through the Pd/Ag permeation membrane. The basic equations are based on unsteady material balances, and thus transient responses after changing the operational condition can be calculated as well.

In this study, the axial dispersion was newly taken into consideration to the numerical simulation code and its effect was examined. The results reveal that the axial dispersion considerably affects the result of calculation, and tend to better reflect the experimental results at high decontamination factors. Improvement of the numerical simulation code considering a 2-dimensional model was developed and test calculations were carried out. This new tool will enable the optimization of the PERMCAT reactor geometry and design.

[1] K. Munakata, B. Bornschein, D. Corneli and M. Glugla, “Numerical Simulation of Membrane Reactor for Detritiation of Plasma Exhaust Gas”, Fusion Science and Technology, Vol. 48 (1), pp 17-22, 2005.