

Tritium well depth, tritium well time and sponge mechanism for reducing tritium retention

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Abstract

New simulation results are predicted in a fusion reactor operation process. They are somewhat similar to, but quite different from, the xenon poisoning effects resulting from fission-produced iodine during the restart-up process of a fission reactor. We obtained completely new results of tritium well depth and tritium well time in magnetic confinement fusion energy research area. This study is carried out to investigate the following: what will be the least amount of tritium storage required to start up a fusion reactor and how long the fusion reactor needs to be operated for achieving the tritium break-even during the initial start-up phase due to the finite tritium-breeding time, which is dependent on the tritium breeder, specific structure of the breeding zone, layout of the coolant flow pipes, tritium recovery scheme and applied extraction process, the tritium retention of plasma facing component (PFC) and other reactor components, unrecoverable tritium fraction in the breeder, leakage to the inertial gas container and the natural radioactive decay time constant. We describe these new issues and answer these problems by setting up and solving a set of equations, which are described by a dynamic subsystem model of tritium inventory evolution in a fusion experimental breeder (FEB). Reasonable results are obtained using our simulation model. It is found that the tritium well depth is about 0.319 kg and the tritium well time is approximately 235 full power operation days for the reference case of the designed FEB configuration, and it is also found that after one-year operation the tritium storage reaches 0.767 kg, which is more than the least amount of tritium storage required to start up another FEB-like fusion reactor. The results show that the tritium retention in the PFC is equivalent to 11.9% of tritium well depth that is fairly consistent with the result of 10–20% deduced from the integrated particle balance of European tokamaks. Based on our experimental and theoretical studies, some new mechanisms are proposed for reducing the tritium retention in PFC and structure materials of tritium-breeding blanket. In this paper, a qualitative analysis of the 'sponge effect' is carried out. The 'sponge effect' may help us to reduce tritium retention by ~20% in the PFC.