MEMBRANES AND CATALYTIC MEMBRANE REACTORS IN BREEDER BLANKET

FOR IMPROVED TRITIUM MANAGENMENT AND FACILITATED ACCOUNTANCY

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In addition to the inner fuel cycle to be validated in ITER, tritium self-sufficiency using a breeder blanket shall be demonstrated for DEMO. Each system should act as a separated material balance area, thus a precise and accurate tritium accountancy stage as interface between both systems is mandatory. Both the concentration and chemical form of tritium (either molecular of oxide, noted Q_2 and Q_2O , respectively, with Q = H, D or T) to be accounted and routed to the inner-fuel cycle fundamentally depend on the process options retained for the Tritium Extraction System (TES) and the Coolant Purification System (CPS).

Up to now, most of the TES & CPS concepts rely on dedicated traps for Q_2 and Q_2O to remove and recover tritium from helium using adsorption/regeneration cycles. This implies frequent temperature and/or pressure cycles producing transients that are not in favor of tritium accountancy, not mentioning possible tritium dilution and potential chemistry so as to end up with tritium in only one molecular form. Improvement of tritium management with synergy between processes and accountancy is important for DEMO operation.

The PERMCAT process using a catalytic Pd-based membrane reactor has been developed at the Tritium Laboratory Karlsruhe. It is particularly adapted for breeder blanket since it allows removing and recovering tritium (as Q_2O and Q_2) in one step while producing a continuous and pure Q_2 stream. This is of advantage for on-line and real-time accountancy using ionization chambers or spectroscopic methods. However, the huge flow rates and small tritium concentrations to be processed in TES & CPS ask for a pre-separation and pre-concentration stage in combination with PERMCAT. The potential use of zeolite membranes for selective permeation of He / Q_2 / Q_2O mixtures has been investigated at the conceptual level. Promising candidate materials have been identified, and first evaluation of the process appears competitive.

This paper discusses such a combination of selective permeation and catalytic membrane reactor that could simplify and improve the tritium processes in the breeder blanket with additional benefits for tritium accountancy.