A 3D MULTIPHYSICS PREDICTIVE MODEL FOR TRITIUM TRANSPORT FROM

PBLI

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A key aspect of tritium transport prediction from PbLi concerns modeling of permeation. Permeation is the primary tritium removal mechanism for vacuum permeator based extraction system. Tritium permeation occurring inside the blanket requires knowledge of MHD for accurate estimation.

In this paper, progress toward the development of a comprehensive 3D predictive capability is discussed and presented. Concerning the tritium permeator, the major issue is the estimation of mass transfer in PbLi flow, where the tritium mass transport coefficient has a large impact on tritium extraction efficiency. In a previous TMAP analysis¹, a mass transport coefficient was obtained by correlation from Harriott and Hamilton². In the present simulation, a diffusion-driven process is simulated in the dialysis process by taking into account the turbulent mixing effects for pipe flow geometry. Calculated tritium permeation flux and mass transport coefficient for the reference design of the DCLL(dual-cooled lead-lithium) tritium permeator are in agreement with TMAP results. Concerning tritium transport inside the blanket, the proposed model includes several individual physics phenomena, adequately coupled, such as convection-diffusion in PbLi, permeation through the walls, MHD, and temperature effects. For the PbLi-wall interface, appropriate boundary conditions using the stiff-spring method have been applied to define continuous flux conditions, at the same time, ensure the discontinuities of the concentrations. In this work, MHD velocity profiles were obtained using Stream³ by solving flow equation and electrical potential equation. Preliminary results (Fig. 1) shows that for the same flow rate the MHD velocity profile has a significant benefit in preventing tritium permeation due to the higher convection effects near the wall, especially in the side layer.



Fig. 1 Tritium permeation flux through the containing wall shows MHD velocity profile significantly reducing tritium permeation

B. Merrill, C. Wong, Issues of tritium migration and control in PbLi blankets, June, 2007
Harriott and Hamilton, Chem. Engin. Sci. 20 (1965) 1073
Stream, Software Credia Co., Ltd. Japan

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