Modelling hydrogen transport in breeding blankets: influence of trapping effects

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The replenishment of tritium fuel in a breeding blanket is fundamental for the functioning of commercial nuclear fusion reactors. Accurate modelling of hydrogen transport and inventories, accounting for trapping mechanisms, within the breeding blanket will be essential for safety issues and economic sustainability.

The hydrogen transport code FESTIM [1] is used to perform multi-material, multi-dimensional and multi-physics simulations of the Water-Cooled Lithium Lead (WCLL) design [2]. Fluid dynamics models were implemented to simulate the flow of LiPb in the blanket. The associated velocity field was coupled with FESTIM to accurately simulate hydrogen transport in both the liquid and structural parts of the model. Existing research concerning hydrogen solubility and diffusivity in LiPb provided a variety of temperature dependent values from experimentation and, therefore, parametric testing was conducted to investigate the impact of such a variation.

The inclusion of trapping mechanisms increased tritium inventory values by 15% and delayed permeation to cooling channels. Varying hydrogen solubility in lithium lead over the range found in the literature varied EUROFER tritium inventories by a factor of 25. Permeation fluxes to the coolant channels were found to vary over a factor of 3.

[1] R. Delaporte-Mathurin, E. Hodille, J. Mougenot, G. De Temmerman, Y. Charles, and C. Grisolia, "Parametric study of hydrogenic inventory in the ITER divertor based on machine learning," *Sci. Rep.*, vol. 10, no. 1, pp. 1–12, 2020, doi: 10.1038/s41598-020-74844-w.

[2] A. Del Nevo *et al.*, "WCLL breeding blanket design and integration for DEMO 2015: status and perspectives," *Fusion Eng. Des.*, vol. 124, pp. 682–686, 2017, doi: 10.1016/j.fusengdes.2017.03.020.