He bubbles nucleation in lead-lithium and implications on tritium transport for HCLL breeding blanket design

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Compulsory requirements of high tritium (T) self-sufficiency in future D–T fusion reactors are linked to high helium (He) production rates in liquid metal (LM) breeding blankets. The existence of a large number of long residence time nano- or micro- bubbles in the LM might act as an effective T sink. The issue of He bubbles formation is, hence, highly relevant to tritium inventory control and recovery. Fundamental studies on tritium behavior and confinement are mandatory for safety evaluation, being the T confinement in the fuel cycle systems one of the most important safety objectives. In our previous works Batet et al. [1] and Fradera et al. [2] models for tritium and helium transport phenomena involving He nucleation, bubble growth, T absorption into He bubbles, T adsorption onto structural material and desorption to cooling system channels (CSC) were implemented into OpenFOAM® CFD code (BelFoam solver). The code has been upgraded with a conjugated scalar transfer algorithm in order to take into account LM-structural material interface and to couple solid and liquid domains, both for heat and mass transfer.

In the present work models for tritium and helium transport and BelFoam solver results for a HCLL breeding unit are shown. Heterogeneous nucleation at solid walls has also been implemented and its impact on tritium permeation is discussed. Furthermore, an analysis of the results and their implications for the design of LM breeding blankets are exposed.

[1] L. Batet, J. Fradera, E. Mas de les Valls and L. Sedano, 2009, Numeric Implementation of a Nucleation, Growth and Transport Model for Helium Bubbles in Lead-Lithium HCLL Breeding Blanket Channels, Fus. Eng & Des. Publishing pending.

[2] J. Fradera. L. Batet, E. Mas de les Valls and L. Sedano, 2010, Numeric implementation of a transport model for tritium in lithium-lead HCLL breeding blanket channels: Theory and code implementation, submitted to Fus. Eng & Des.