Global thermal-hydraulic model of the EU DCLL breeding blanket

† Iván Fernández-Berceruelo, Iole Palermo, Fernando R. Urgorri, David Rapisarda, Belit Garcinuño, Ángel Ibarra

Fusion National Laboratory, CIEMAT, Avda. Complutense, 40, 28040 Madrid, Spain

† Corresponding author: ivan.fernandez@ciemat.es

Abstract

The limitations in the performance of the primary heat transfer system of a fusion power plant have important consequences on its power balance and, therefore, on the cost of fusion energy. In the case of the breeding blanket, it is mandatory to maintain the equilibrium between requirements like: 1) the maximization of the outlet temperature and thermal gain of the primary coolants, 2) the achievement of the most suitable integration with the rest of thermal sources in the power conversion cycle, 3) the minimization of the recirculating power (i.e. pumping/recompression) and 4) the reduction of thermal stresses in materials which are severely subjected to cyclic loads. Furthermore, the operation of the blanket primary heat transfer system directly affects the functioning of ancillary systems devoted to tritium extraction and purification of fluid circuits, among others. For all these reasons, finding an effective way to comprehensively evaluate the main thermal-hydraulic parameters of the blanket becomes essential.

This work presents a methodology to generate a global thermal-hydraulic model of the Dual Coolant Lithium Lead (DCLL) breeding blanket design which is under development within the EUROfusion Power Plant Physics and Technology Programme. This methodology is aimed to reduce the requirements of computational resources by limiting the use of computational fluid dynamics (CFD) and by resorting to a number of approximations. These characteristics provide enough flexibility to assess the implications of different design choices, facilitating the identification of possible issues in less time. It also accelerates the process of obtaining the necessary input data for subsequent detailed analyses.

Together with the description of the methodology, the results of the model (coolants temperatures, flow distribution, pressure drop, hot spots in solids, etc.) and their impact on the breeding blanket design are discussed.

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