Multiphysics modelling of the ARC Breeding Blanket – Part II: thermal-hydraulics

Introduction

The ARC reactor is a proposed concept of high-field fusion reactor under investigation at MIT [1]. Its Breeding Blanket (BB) will be based on a non-conventional approach, as it will have a liquid immersion BB made of molten salt (FLiBe with 90 % ^{6}Li enrichment), containing the Vacuum Vessel (VV), see Figure 1. The same salt will also be used as coolant for the other components, such as the VV and the divertor. Inside the Blanket tank, the neutrons coming from the fusion reactions taking place in the plasma will interact with the lithium in the salt to produce tritium.

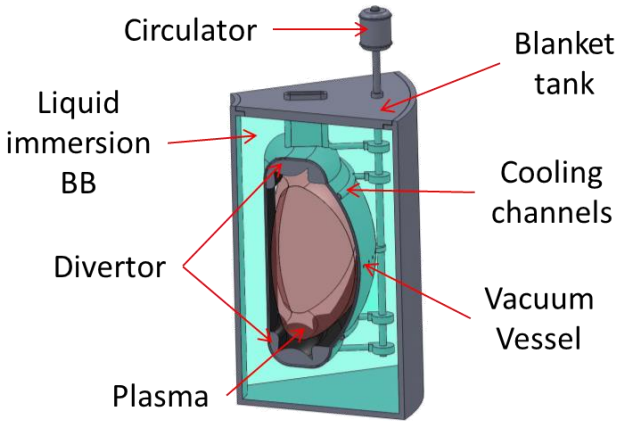

Figure 1: Conceptual scheme of the ARC blanket tank containing the liquid BB, the VV and the divertor.

The modelling of such a complex system requires the analysis of different physical phenomena, such as the effect of the magnetic field on the fluid flow (MHD), the propagation of neutrons in the salt and the natural convection due to the power generation inside the salt caused by nuclear reactions.

Aim of the work

The aim of the present proposal is to develop a thermal-hydraulic model of the ARC molten salt BB and to couple it to a neutronic model. The TH model should include a 3D CFD/MHD model developed with the OpenFOAM code [2], and a 1D system-level MHD model developed with the Modelica language [3]. The two models should be coupled in order to solve transient simulations together. The 3D model should take into account both the MHD effects and the natural convection in the tank, whereas the 1D model should consider MHD pressure drop and heat transfer for the cooling channels.

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References

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[2] H. G. Weller, G. Tabor, C. Fureby, and H. Jasak, “A tensorial approach to computational continuum mechanics using object-oriented techniques,” Computers in Physics 12(6):620–631, 1998.
[3] Modelica Association, “Modelica® - A Unified Object-Oriented Language for Systems Modeling - Language Specification Version 3.4,” 2017.