Magneto-convective analyses of the EU-DCLL outboard equatorial module using Q2D methods

†Fernando R. Urgorri[1], Ivan Fernández-Berceruelo, David Rapisarda, Iole Palermo, Angel Ibarra

[1]National Fusion Laboratory, CIEMAT, Madrid, Spain

†Corresponding and presenting author: fernando.roca@ciemat.es

Abstract

Due to the location of the Breeding Blankets (BB) in future fusion reactors, they will be subjected to large neutronic and thermal loads. Moreover, the plasma generates a directional heat source in the BB materials creating steep temperature gradients. The Dual Coolant Lithium Lead (DCLL) blanket, one of the concepts under consideration in EU, is designed to use liquid lead-lithium (PbLi) as main coolant flowing at relatively high velocities (~2cm/s).

Most of the PbLi channels of the EU-DCLL are oriented along the poloidal direction, parallel to gravity field. As a consequence, buoyancy effects can become dominant in the PbLi dynamics with Grashof numbers that take values of the order of 10^{10} and 10^{11}. Besides, the superconductor coils needed to confine the plasma originates a very large magnetic field (~3-4 T) in which the BB is unavoidably immerse. The main component of the magnetic field lies transversally to the PbLi flow (toroidal direction) which creates important magnetohydrodynamics (MHD) forces in the bulk of the fluid. Hartmann numbers in the DCLL channels take values of the order of 10^3 and 10^4 which represent the importance of the MHD interactions in the blanket.

Magneto-convective calculations of the EU-DCLL outboard equatorial module have been performed. These multiphysics analyses describe the coupling between the thermal, velocity and induced magnetic fields in the bulk of the fluid. Quasi 2 dimensional (Q2D) methods have been used for describing the Lorentz forces in a radial-poloidal section of the module. With the results of the computations, phenomena affecting the blanket functionality have been studied. These include the vortex suppression caused by the magnetic field, the homogenization of the temperature field along the PbLi flow path and the presence of reverse flow regions originated by the buoyancy interactions.

Keywords: MHD, buoyancy, Q2D, DCLL