Implementation of a Q2D turbulence model and detection of flow instabilities in liquid metal MHD flows

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The understanding of magneto-convective liquid metal flows are of most interest in the breeding blanket designs for the nuclear fusion reactors. Under the projected magnetic fields, heat deposition and flow velocities, the liquid metal may flow showing curly streamlines enhancing the transport of heat and tritium in the blanket channels. Although this flow regime is most probable, many studies are still using fully-developed MHD flow profiles to assess the transport of heat and tritium in the blanket. The magnetohydrodynamic (MHD) effect under this curly-buoyant phenomenon tends to align the vortexes in the direction of the magnetic field (the so called toroidal direction in Tokamak). The very narrow boundary layers in the walls perpendicular to the magnetic field suggests a very small influence of such boundary layer in the overall flow behavior. The development of a quasi-2D (Q2D) MHD flow model by Sommeria and Moreau (SM82) eased the analysis of such vortexes. In terms of computational fluid dynamics (CFD), the use of the Q2D model instead of full 3D models can save time and resources by several orders of magnitude, although reducing the accuracy of the results. In order to deepen in the understanding of the flow regimes in magneto-convective conditions, the use of the Q2D model for a wide range of flow conditions (Reynolds, Hartmann and Grashof numbers) is proposed. To post-process the large amount of data generated in such simulations the Fast Fourier Transform (FFT) method is going to be used. It will allow to relate the flow conditions with the stability or not of the flow. The work presented here is the first step of this large analysis. In this work the implemetation and validation of the Q2D model in OpenFOAM is described as well as the FFT model to post-process the results. A future work will make use of the tools presented here to describe the pursued magneto-convective regimes map.