Analysis of a water LOCA in the EU DEMO Vacuum Vessel

Introduction

The Loss-Of-Coolant Accident (LOCA) inside the Vacuum Vessel (VV) of the EU DEMO fusion reactor is of interest for the design of the tokamak, since the peak pressure induced by the accident in the VV should stay below a prescribed threshold. In order to quantify the pressure peaks on the VV walls during the accident, a detailed analysis is needed. In particular, a 3D Computational Fluid Dynamics (CFD) transient analysis of the hypersonic flow developed during the accident is needed. This analysis is currently carried out on the Helium Cooled Pebble Bed (HCPB) [1] blanket design, simulating a loss of gaseous helium at high pressure inside the VV, see Figure 1. One of the other possible designs is based on the Water-Cooled Lithium-Lead (WCLL) [2] concept. Therefore, in case of a rupture in the WCLL blanket, water would flow inside the VV.

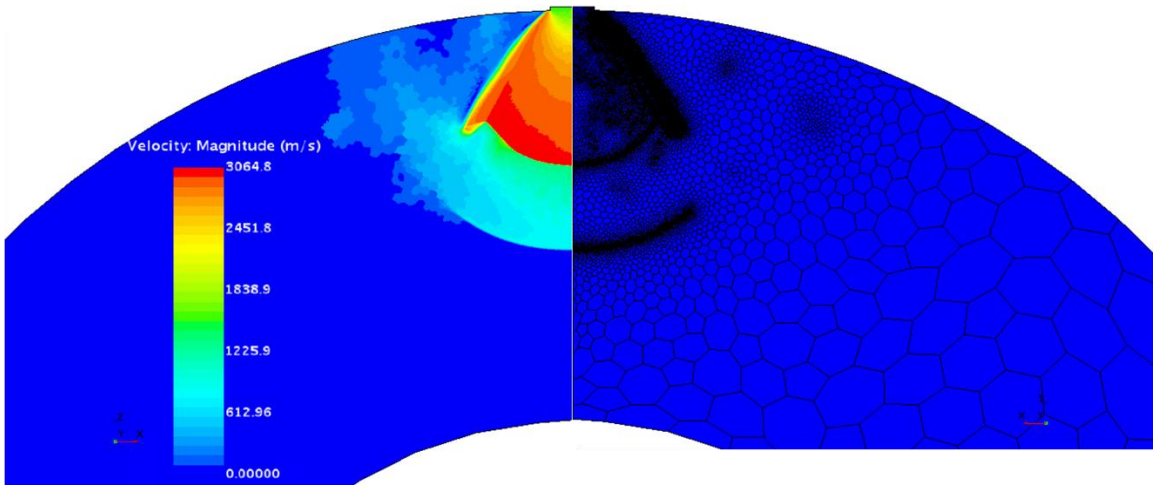

Figure 1: (left) Preliminary computation of the velocity field during a Helium LOCA in the vacuum vessel and (right) the adaptive mesh adopted to follow the fronts of the Helium jet.

Aim of the work

Due to the very different thermophysical properties and the state of the coolant in the case of the WCLL with respect to the HCPB, a 3D CFD analysis of a water LOCA in the VV requires careful tuning of the simulation set-up and parameters. Detailed preliminary studies are needed to select the most reliable models, mesh and time step adaptivity strategy. In particular, 2D models should be employed in order to investigate the best models to be adopted in the full 3D analysis. Note also that, due to the water thermophysical properties, it is foreseen to have multiphase flow, e.g. from liquid to vapor due to the sudden flashing. Once the models and the solution strategies have been developed, the full 3D transient analysis will be carried out exploiting High-Performance Computing (HPC) facilities.

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References

[1] F. A. Hernández, et al., "Overview of the HCPB Research Activities in EUROfusion," IEEE Transactions on Plasma Science 46(6):2247-2261, 2018.

[2] A. Del Nevo, et al., "Recent progress in developing a feasible and integrated conceptual design of the WCLL BB in EUROfusion project," Fusion Engineering and Design 146(B):1805-1809, 2019.