# Liquid immersion blanket simulations using VERTEX-CFD

K. Borowiec[1], A. Sircar[1], M-O. Delchini[1]

[1] *Oak Ridge National Laboratory, Oak Ridge, USA*

Fusion Power Plant design is a challenging task that will rely on high-fidelity modelling and simulation due to lack of experimental data. This is true both for the exploration of the plasma configuration as well as engineering design. Computationally efficient, accurate, and high-fidelity codes are required to capture complex and coupled physics encountered in fusion simulations. To tackle the challenge of fusion modelling, a new multiphysics software is being developed at Oak Ridge National Laboratory, called VERTEX. VERTEX is developed to solve problems of gas dynamics, rarefied flow, plasma-surface interaction, electromagnetics, magneto-hydrodynamics (MHD), and thermal hydraulics [1].

This talk will focus on one package of the VERTEX framework: VERTEX-CFD. VERTEX-CFD is developed specifically to model fusion blanket, implementing the incompressible Navier-Stokes with heat transfer and magneto-hydro-dynamics (MHD) equations. The software was used to model ARC class device molten salt liquid immersion blanket (LIB), a design proposed by Commonwealth Fusion Systems (CFS). The working fluids are typically electrically conducting, and the flow is strongly influenced by magnetic field. The MHD effects make the modeling and simulation challenging. Significant effects are observed for important performance metrics including maximum temperature and pressure drop in the system [2]. We performed MHD analysis for the LIB using VERTEX-CFD with recently developed modifications to the k-$\epsilon$ turbulence model with MHD source terms [3]. Code-to-code verification was performed using OpenFOAM software. VERTEX software was also used to assess the cooling system of the ARC class device. In the future, this workflow will be connected to the optimization algorithm and multiphysics software to allow iteration on the cooling system design.

## References

[1] Marc-Olivier Delchini, Kellis C. Kincaid, Doug Stefanski, Ryan Glasby, Franklin Curtis. “VERTEX-CFD: A Multiphysics Solver” in proceedings of American Nuclear Society (2024)

[2] Badalassi, V., et al. "FERMI: fusion energy reactor models integrator." Fusion Science and Technology 79.3 (2023): 345-379.

[3] Sircar, Arpan, Katarzyna Borowiec, and Vittorio Badalassi. "Data-driven modeling of MHD turbulence for fusion device blankets." Bulletin of the American Physical Society (2023).