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Lesson learned from numerical activities in support to the development of SCWRs at the University of Pisa

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Supercritical Water-Cooled Reactors are among the selected proposed designs for the upcoming GEN IV of nuclear power plants. They represent the natural evolution of presently available LWRs: borrowing the experiences and competences developed during the last decades for both PWRs and BWRs, it indeed aims at increasing the efficiency of the thermodynamic cycle while reducing the construction capital costs. During the last decades the European Union and IAEA launched projects in support of the development of such a technology: the University of Pisa joined the common efforts providing numerical analyses addressing the thermal-hydraulics aspects of SCWRs.
Among the most challenging issues related to the development of SCWRs, the prediction of heat transfer to supercritical fluids probably represents one of the toughest ones. In fact, the interesting phenomenon of heat transfer deterioration can hardly be predicted by both CFD approaches and heat transfer correlations. Being the consequence of dramatic thermophysical properties changes, buoyancy phenomena or flow acceleration, generally available approaches cannot provide suitable predictions of this complex phenomenon: the development of advanced modelling techniques is thus required.
At the University of Pisa, during the last years, a modified k-ε model adopting the algebraic heat flux model (AHFM) for the prediction of the turbulent heat fluxes and buoyancy production terms was implemented in the commercial code STAR-CCM+ reporting promising capabilities in the prediction of several supercritical fluids operating conditions. A fluid-to-fluid similarity theory for heat transfer to supercritical fluids was proposed as well achieving a preliminary validation on the basis of DNS, LES and RANS calculations. Limitations and capabilities of available heat transfer correlations were investigated as well.
The present paper reports on the recent numerical activities performed at the University of Pisa also providing information about the foreseen next steps and possible developments in modelling.

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