MSc project proposal:
Passive residual heat removal system

When the fission chain reaction is stopped in a nuclear reactor, there is still some heat stored and released, the residual heat. The decay heat is initially of the order of percent of the thermal power but decreases exponentially over time. This heat must be removed to limit the temperature increase, because that could damage the reactor systems and lead to release of radioactive matter. In most existing commercial nuclear reactors, there are active cooling systems to remove this heat. Passive functions are however preferred before active. For both safety and economy, effort is made to use passive residual heat removal in newer reactor generations. A passive function is also somewhat easier to accomplish in smaller reactors and is hence also more common in SMRs.

Though yet uncommon in commercial reactors, passive Decay Heat Removal Systems - DHRS has been designed and used in various ways in research and concept reactors, see for example Liesowski_2021 or NiemandPhD_2021. These systems employ different fluids, finally air or water, and remove the heat from different locations, for example directly from the reactor or from the cavity it resides in. They do however have in common that they all rely on natural convection. One of the principal solutions is called Reactor Cavity Cooling System (RCCS). In such, the heat is removed from the reactor by a natural convection system which is not in structural contact with the vessel.

The proposal entails investigations of a boiling water RCCS for residual heat removal from a 250 MWth fluoride molten salt reactor vessel. It should start with a literature review, summarizing the existing solutions. The review should include availability of measurements for validation of calculations. Then one configuration, possibly with variations, can be analyzed by calculations. The calculations start with stationary lumped parameters (dimensionless heat transfer numbers) using textbook formulas and can then be extended as appropriate to hour scale transients and further dimensions with appropriate software.

Having studied heat transfer (e.g. MMVF05 heat transfer) is advantageous

Contact: Jens Klingmann