Contribution ID: **23155** Type: **Paper**

Large Eddy Simulation of a Simplified Pressurized Thermal Shock Scenario

Tuesday, 14 November 2023 16:10 (5 minutes)

The Reactor Pressure Vessel (RPV) is a crucial component in nuclear systems. One of the mechanisms that can jeopardize the integrity of RPV is a transient condition called Pressurized Thermal Shock (PTS). During accidents such as Loss of Coolant Accidents (LOCA), emergency systems are initiated to mitigate the accident. The cold water injected by the Emergency Core Cooling System (ECCS) causes a quick cooling of the downcomer and internal surface of the RPV. As a result of this rapid cooling, large temperature gradients and thermal stresses occur, representing the PTS phenomenon. A proper understanding of this scenario is essential for the long-term safe operation of a nuclear power plant. In this regard, we have obvious limitations of experimental means. Similarly, one-dimensional thermal-hydraulic system codes don't add value in understanding this complex three-dimensional phenomenon. In that respect, advanced numerical methods such as Computational Fluid Dynamics (CFD) could play an important role in better understanding the thermal hydraulics of a PTS-type scenario. In the framework of CFD, direct numerical simulation (DNS) is considered as the most accurate method, which comes at the cost of large computational resources. This, in turn, limits the application of DNS to relatively low-Reynolds number flow cases. Whereas the large eddy simulation (LES), which is also considered as the high-fidelity method in CFD, once validated, could be beneficial in simulating high-Reynolds number flows. Therefore, in this present study, LES has been used to study the simplified PTS scenario. The obtained results are compared with the available DNS database. The obtained results indicate that, if performed correctly, LES can be used as a reference to validate low-order turbulence modelling approaches, such as RANS-based models

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Session Classification: Day 2- Research Pitch Competition - III

Track Classification: Student competition