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Development and Validation of Multi-scale Thermal-Hydraulics Calculation Schemes for SFR Applications at CEA

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In the framework of the ASTRID Gen4 SFR project, extensive R&D efforts are under way to improve and better validate the SFR thermal-hydraulics codes available at CEA. These efforts include :

- The development and validation of SFR-specific models in CATHARE. Developed at CEA, CATHARE is the reference STH code for French LWR safety studies : SFR developments are being integrated and validated into the lastest version of the code, CATHARE3.
- The development and validation of TrioMC, a subchannel code specific to SFR core TH. Initially created for design studies (with the aim of computing the maximum cladding temperature of a given core flowrate), TrioMC has been upgraded in order to compute the local behavior of the core during accidental transients.
- The application and validation of TrioCFD, a 3D CFD code developed at CEA, to SFR studies. TrioCFD is being used to compute flow behavior in the large plena of pool-type SFRs (hot and cold pools), as well as in the IHX primary side and in the in-core inter-wrapper gap regions.

In most cases, these codes are used independently. However, in some cases, local phenomena may have a strong feedback effect on the global behavior of the reactor : for instance, during passive decay-heat removal by natural convection, inter-wrapper flows may contribute to up to 30% of the overall DHR if the heat sink is provided by DHXs in the hot pool. The strength of this contribution leads to a feed-back effect from a local (subchannel/CFD) phenomenon) to the global (system) scale.
In order to model such effects, a coupling between CATHARE, TrioMC and TrioCFD has been developed at CEA and integrated into a new code : MATHYS (Multiscale ASTRID Thermal-HYdraulics Simulation). Within MATHYS, TrioMC and TrioCFD are coupled at their boundaries (core outlet and hex-can sides), using a domain-decomposition approach : then, the two codes are coupled with a CATHARE simulation of the complete system using a domain-overlapping method. The resulting multi-scale simulation is able to account for feedback effects between all three scales.
This paper first outlines the development and validation efforts related to CATHARE, TrioMC and TrioCFD; then, the coupling algorithm underlying MATHYS is described. The final section discusses the validation of MATHYS : overall approach, validation of coupled effects on existing experiments (TALL-3D for STH/CFD, PLANDTL-DHX for subchannel/CFD, PHENIX at the integral scale).

Country/Int. Organization

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