SADE
Safety Analyses for Dynamical events

Elina Syrjälahti, Ville Hovi, Anitta Hämäläinen, Hanna Räty, Ville Sahlberg, Veikko Taivassalo

VTT Technical Research Centre of Finland Ltd

Introduction

SADE was a four-year project focused on reactor dynamics and thermal hydraulics. Aim of the project was to model transients and accidents in such a way that we can give more reliable answers to the safety requirements. The goal is to have at VTT a fully self-developed, independent calculation system which can be used for the whole calculation sequence from basic nuclear data to coupled 3D transient analyses. We have developed our simulation codes with the aim of a tool, which is more accurate than before and still fast and robust enough for practical safety analyses. Own codes and in-depth understanding of them enables the best possible expertise on safety analyses.

Tools for safety analyses

During the project we have developed internal coupling between VTT's reactor dynamics code HEXTRAN and system code SMABRE. The new version of the coupled code that includes both internal and traditional parallel coupling modes, enables use of more versatile nodalization in the reactor cores improving modelling of the open core geometry of VVER-1000 and AES-2006 reactors. Both coupling modes can now be used in practical safety analyses. Internal coupling has also been the basis for CFD coupled analysis tool.

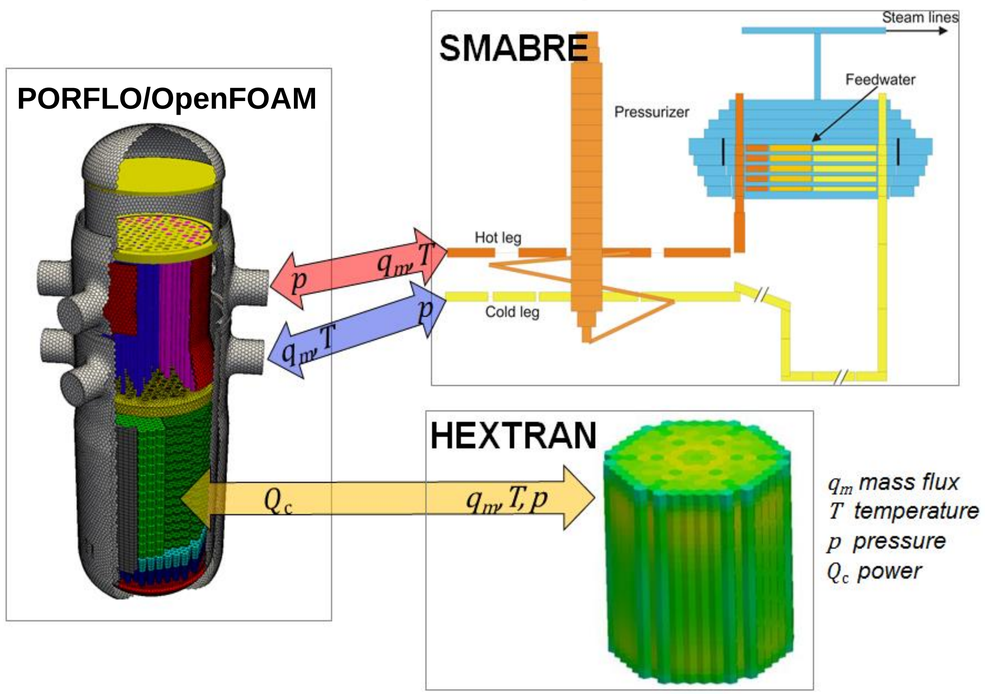

Figure 1. *Coupling between the neutronics code HEXTRAN, system code SMABRE and CFD code (PORFLO or OpenFOAM) in a VVER-1000 simulation.*

Neutronics and Reactor core

During the project Serpent 2 was adopted as a tool for group constant generation for TRAB3D and HEXTRAN as well as an analysis tool. This enabled further refinements in neutronics solution of HEXTRAN and TRAB3D: e.g. modelling of axially heterogeneous fuel and pin-wise power distributions were enhanced. Coupling between reactor dynamics codes and fuel behaviour code FINIX was also renewed.

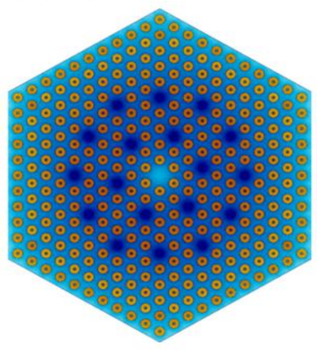

Figure 2. *Serpent-generated plot of a 2D assembly geometries used for group constant generation for the V-1000 calculation case.*

CFD + Neutronics + Plant modelling

We have developed a true two-way coupling between CFD codes, transient neutronics code HEXTRAN and system code SMABRE. With this novel code system we have simulated several transients and accidents :

- The start-up of an inoperable cold loop of VVER-440 both using CFD in downcomer+lower plenum only, and a CFD grid for the whole reactor pressure vessel
- Several VVER-1000 main steam line break (MSLB) scenarios, using PORFLO or OpenFOAM as a CFD code
- Real VVER-1000 plant test concerning switching off main main coolant pump (MCP) of working four MCPs

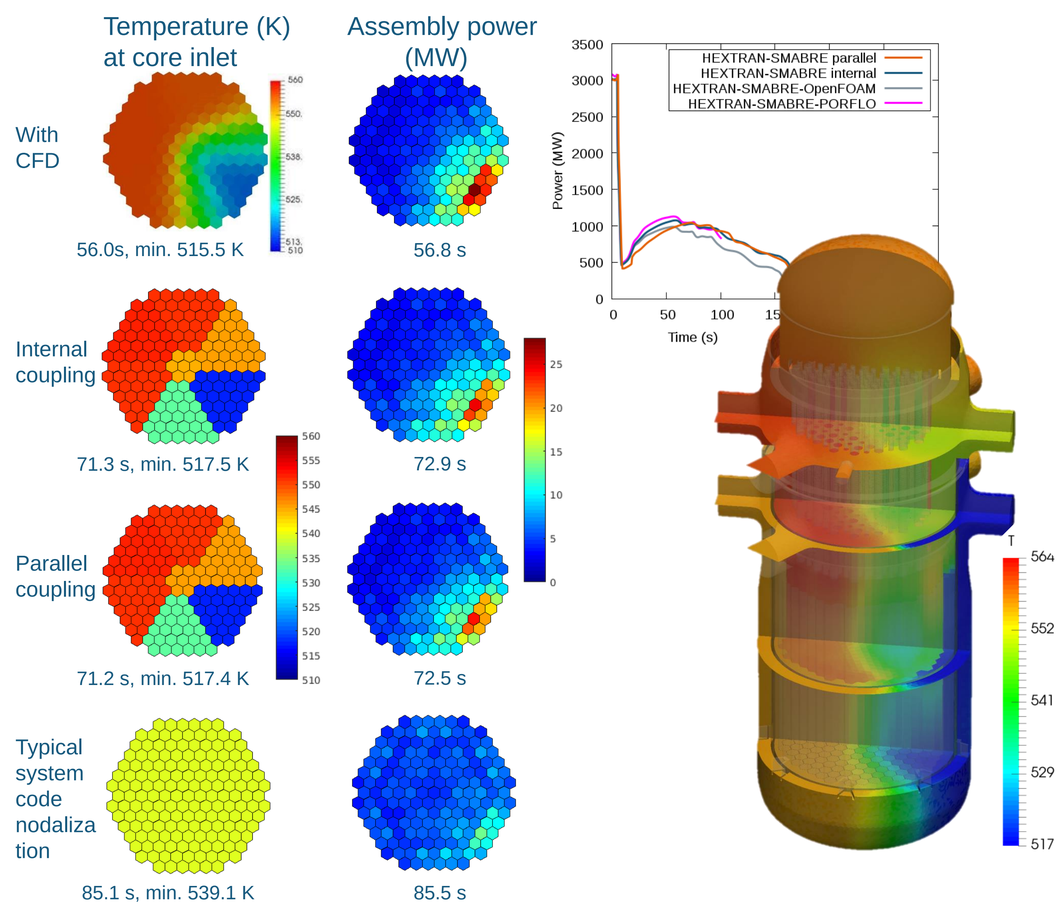

Figure 3. *Coolant temperature and fission power during return-to-power in VVER-1000 MSLB simulation with different coupling methods between HEXTRAN, SMABRE and OpenFOAM.*

Summary

- **We have developed the new version of the HEXTRAN-SMABRE code with internal coupling between the codes.**
- **Safety analyses can now be done for VVERs using in transient and accident modelling either internal or parallel coupling between the neutronics code and system code.**
- **We have developed a true two-way coupling between neutronics, plant model and CFD codes.**
- **We have simulated several transient and accident scenarios with this novel coupling using in RPVs detailed 3D thermal-hydraulics.**
- **We have further developed neutronics modelling of the reactor dynamics codes to get full benefit on the improved accuracy of the thermal-hydraulics modelling.**

Contact
Elina Syrjälahti
Tel. +358 20 722 5017
Elina.Syrjalahti@vtt.fi