KIT Numerical and Experimental Investigations for LWR Reactor Safety

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Abstract

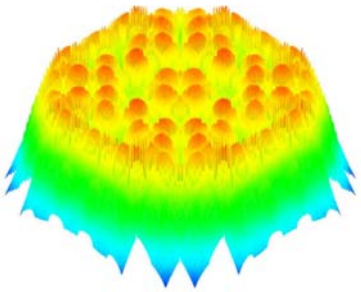
Nuclear power plants are complex systems where different phenomena is taking place e.g. neutron-matter interaction within the core, single and two phase flow and heat transfer within the primary and secondary circuits.

The safety evaluation of nuclear power plants requires both validated numerical simulation tools -called safety analysis codes- and experiments dedicated to key-safety relevant phenomena. The NUSAFE Research Program of the Karlsruhe Institute of Technology (KIT) is engaged since many decades in both experimental and numerical investigations for both design basis accidents and severe accidents of LWR. As part of the research strategy, the analytical word is devoted to the development of computer codes (TWOPORFLOW, SUBCHANFLOW), its verification, validation, and uncertainty quantification. In parallel key-experiments are performed for example in the WENKA or COSMOS facilities. The numerical investigations for the assessment of design basis accidents is following the multi-scale and multi-physics approach. In this context, the coupling of different codes/solvers (neutronic, thermal hydraulic and thermo-mechanics) outside and within the European Reactor Simulation Platform (NURESIM), which is based on the open source software SALOME, is being extended and improved within European or national research initiatives.

For example, the in-house code SUBCHANFLOW was implemented in the NURESIM-Platform and coupled with core simulators such as DYN3D and COBAYA3. In addition, SUBCHANFLOW is coupled with the simplified transport DYN3D-SP3 solver for high fidelity core simulations at pin-level taking into account local feedbacks. Since data at pin level is very scarce, the development of high-fidelity coupled simulations based on Monte Carlo methods and subchannel codes are pursued for code validation. At KIT, MC-codes MCNP5 and SERPENT were coupled with SUBCHANFLOW code. These methods make possible the simulation of whole PWR cores at pin level, e.g. the PWR UOX/MOX. Finally, Fukushima accident underlined the needs for the further development and improvement of severe accident simulations tools. At KIT a set of key experiments to address in- and ex-vessel phenomena in LWR (QUENCH, LIVE, DISCO, MOCKA) were built and the data generated is used for code validation e.g. of ASTEC, ATHLET-CD, MELCOR, etc. This presentation will present and discuss the KIT approach followed to improve the prediction accuracy of safety analysis tools. Selected examples will be given for the validation of codes and the new capabilities under development of advanced simulation tools.



KIT QUENCH Facility



DYNSUB5: 3D Power Density (Pin-Level)

Recent publications:

1. K. L. Zhang, V. Sanchez; Multi-scale coupling of TRACE and SUBCHANFLOW based on ECI-Interface. ANS Best Estimate Plus Uncertainty International Conference (BEPU 2018) Abstract ID: 000 Real Collegio, Lucca, Italy, May 13-19, 2018
2. Jose Angel Gonzalez-Vargas, V. H. Sanchez-Espinoza, R. Stieglitz, R. Macian-Juan; Development and Validation of the new Couple Code System TRADYN. Annals of Nuclear Energy 112 (2018) 685–692.
3. Ignacio Gómez-García-Toraño; Victor Hugo Sanchez Espinoza, Robert Stieglitz; Cesar Queral, María-José Rebollo; Assessment of primary and secondary bleed and feed strategies during a Station Blackout in a German Konvoi PWR using ASTECV2.0. Annals of Nuclear Energy 113 (2018) 476-492.
4. V. Sanchez, A. Miassoedov, M. Steinbrück and W. Tromm; KIT Multi-physics tools for the analysis of design and beyond design basis accidents of light water reactors. Kerntechnik 81 (2016)2 (KT110687-2.3.16)
5. Miriam Daeubler, Nico Trost, Javier Jimenez, Victor Sanchez, Robert Stieglitz, Rafael Macian-Juan; Static and transient pin-by-pin simulations of a full PWR core with the extended coupled code system DYNSUB. Annals of Nuclear Energy 84 (2015) 31–44
6. Ivanov, V. Sanchez, R. Stieglitz, K. Ivanov; Large-scale Monte Carlo neutron transport calculations with thermal hydraulic feedback. Annals of Nuclear Energy 84 (2015) 204–219



Biography

Victor Hugo Sanchez-Espinoza is nuclear engineer with long experience in safety-related investigations for Gen-II, III Light Water Reactors including SMR. He is head of the Group "Reactor Physic and Dynamics" at KIT CN and lecturer at the KIT Campus South on Reactor Safety Fundamentals and Safety Assessment of NPPs. More than 20 years of experience on core neutronics, thermal hydraulics and safety analysis methodologies for research reactors and nuclear power plants of Gen-II, III and IV. Main areas of interest are validation of multi-scale and multi-physics codes, reactor dynamics, coupled Neutronic/Thermal hydraulics and uncertainty quantifications. Dr. V. Sanchez is WP Leader of the EU CESAM Project and of the German WASA-BOSS Subproject F, both devoted to the improvement of SAMG for LWR using the codes such as ASTEC and ATHLET-CD. He is acting as IAEA expert and he took part in different IAEA missions devoted to severe accident assessment of BWR.

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Notes/Comments: