MPCMIV

Kick-off Meeting

16-17 May 2018 – Lucca, Italy
in conjunction with
the Best-Estimate Plus Uncertainty (BEPU) – 2018 Conference

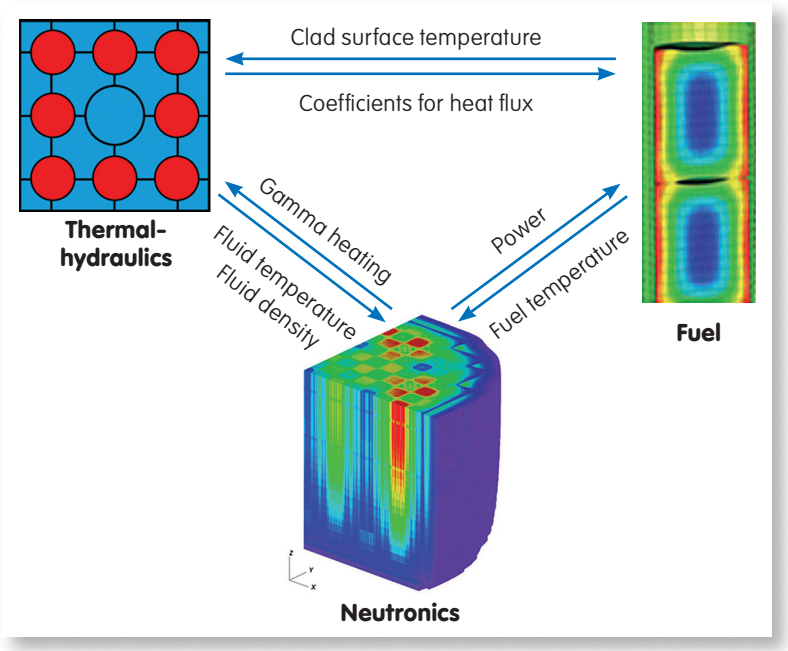
Multi-physics Pellet Cladding Mechanical Interaction Validation (MPCMIV) Benchmark

The challenges constituted by the accurate and realistic simulation of some multi-physics phenomena are of great concern in the industrial environment, and the demand for an advanced reactor modelling tool of multiple physics phenomena has thus increased significantly in recent years. Pellet cladding interaction (PCI) has been identified as one of the more interesting multi-physics, multiscale problems since possible PCI fuel failures reduce reactor performance related to power uprates, higher burn-up and fuel rod manufacturing quality.

Under the guidance of the NEA Expert Group on Multi-physics Experimental Data, Benchmarks and Validation (EGMPEBV), the Multi-physics Pellet Cladding Mechanical Interaction Validation (MPCMIV) benchmark was proposed by Nuclear and Industrial Engineering (N.IN.E.), in co-ordination with Studsvik, to:

- create methodologies for validation of single and coupled physics phenomena;
- derive validation requirements;
- derive an accuracy metric; and
- determine uncertainty methodologies to extrapolate beyond the validation domain.

The MPCMIV benchmark initiative is based on experiments that require coupling between reactor physics, thermal-hydraulics and fuel performance tools to achieve a high-fidelity simulation.

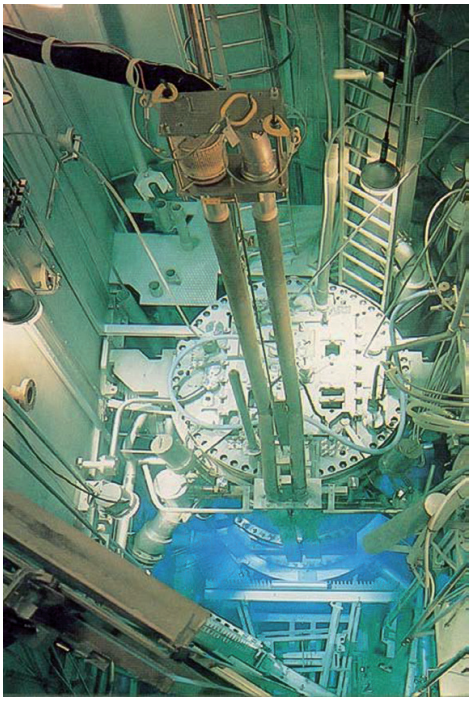


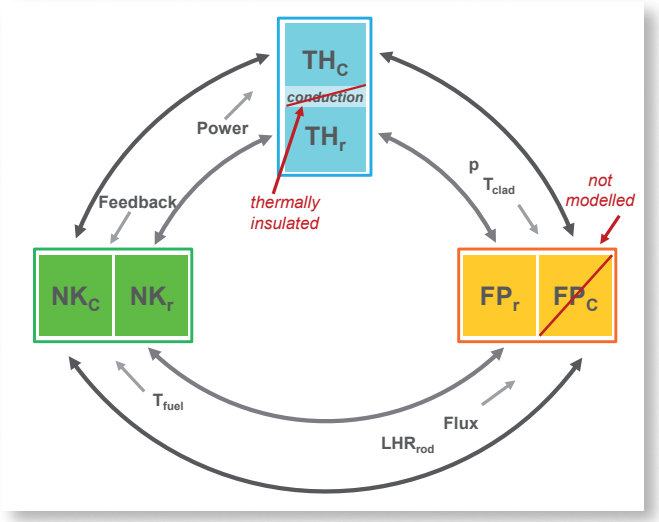
Selected cases involve cold ramp tests assessed in the Studsvik R2 tank-in-pool testing reactor (the R2 core domain) that has an in-pile U-Tube system loop where the fuel rodlet is positioned (the fuel rodlet domain). The fuel response was investigated at cold criticality conditions (below 100°C) since the cladding mechanical properties and the potential failure mechanisms could differ from those at normal operation.

The test was performed with an ad hoc procedure that first places the rod in cold conditions and then exposes it to a relatively fast transient, in which the maximum power generation in the rod increases from practically zero to 45 kW/m or more in about five seconds. The heat flux and fuel temperature reach their maximum values 10 to 15 seconds after the end of the power ramp, and the experiment ceases with a manual reactor shutdown.

A three-tiered structure of fidelity has been proposed so as to accommodate as many participants and computational tools as possible:

- **Tier 1 (for novel tools):** A 3D heterogeneous model of the R2 reactor and fuel rodlet (3D deterministic core physics simulator of both R2 core domain and fuel rodlet domain).
- **Tier 2 (for novel tools – simplified):** The benchmark team will generate a cross-section data set for the R2 reactor and then perform a core physics calculation (e.g. with a nodal diffusion code) in order to obtain the boundary conditions (i.e. neutron and gamma fluxes) for the fuel rodlet domain. These boundary conditions will then be used by the participants to develop a high-fidelity model of the fuel rodlet domain.
- **Tier 3 (for traditional tools):** The procedure is similar to tier 2 but the modelling is conducted with traditional tools. In this case, the cross-section generation step is needed.

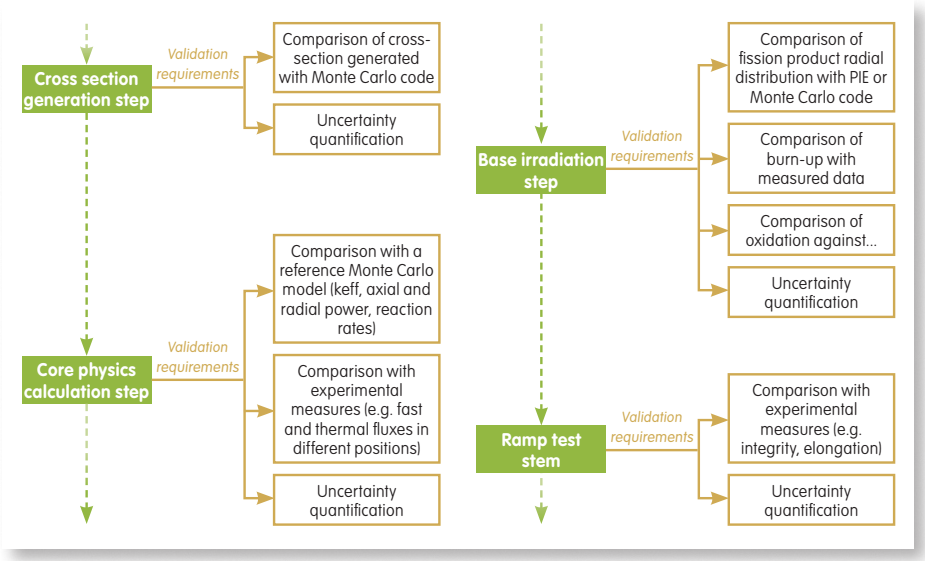




For each tier, the MPCMIV benchmark will be structured into four main phases:

- the development phase;
- the pre-qualification phase (data based on calibration ramp – empty rodlet – and initial ramp with the boiling water reactor [BWR] rodlet);
- the blind simulation phase (data based on a repeated ramp with the BWR rodlet), including uncertainty analysis (the results will not be attributed to any particular organisation in NEA reports – individual participants are free to publish their results openly);
- the open or post-test phase, including sensitivity analysis.

Validation requirements will be set in all of the aforementioned steps.



The MPCMIV kick-off meeting will be held in conjunction with the American Nuclear Society (ANS) Best-Estimate Plus Uncertainty (BEPU) conference (www.nineeng.com/bepu) on 16-17 May 2018 in Lucca, Italy. The benchmark team will provide the benchmark specifications for each tier at the kick-off meeting, and the participants will be free to choose the tier that best fits their modelling tools.

Additional information will be available soon on the NEA web page:
www.oecd-nea.org/science/egmpebv/mpcmiv/ and at **www.nineeng.org/mpcmiv/**