Identifying the main parameters affecting fuel rod failures in an EPR LB-LOCA accident scenario by using sensitivity analysis

SAFIR 2018 Interim Seminar

Espoo, 24th March 2017

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Background

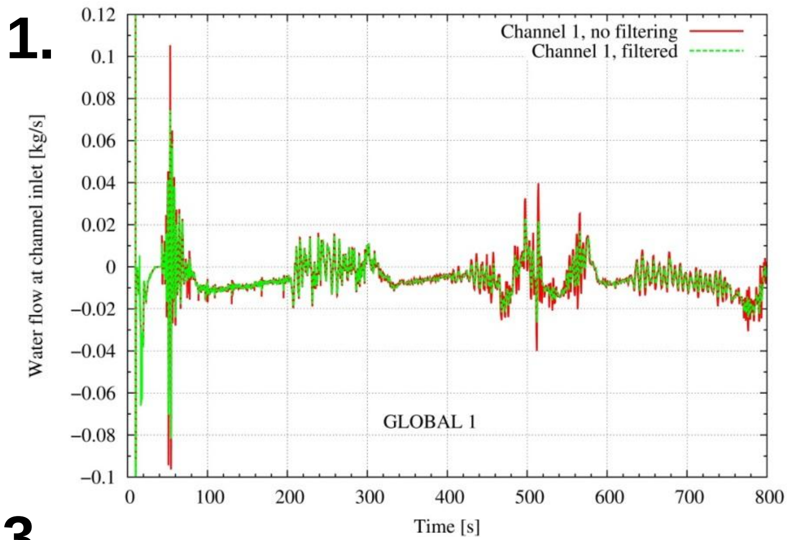
- Previously, a methodology for statistically assessing the number of failing rods in loss-of-coolant accident was developed and applied to an EPR large break LOCA scenario[1].
- This methodology utilizes a calculation chain using APROS and FRAPCON to provide initial conditions and boundary conditions and FRAPTRAN/GENFLO to simulate the effects of the LOCA in detail on fuel rod level.
- Due to the complexity of the calculation chain, identifying the underlying causes of simulated fuel rod failures is challenging.
- A three step sensitivity analysis methodology was developed for this identification task utilizing partly novel methods.

[1] Arkoma, A., et al. "Statistical analysis of fuel failures in large break loss-of-coolant accident (LB-LOCA) in EPR type nuclear power plant", Nuclear Engineering and Design Vol. 285, pp. 1–14, 2015

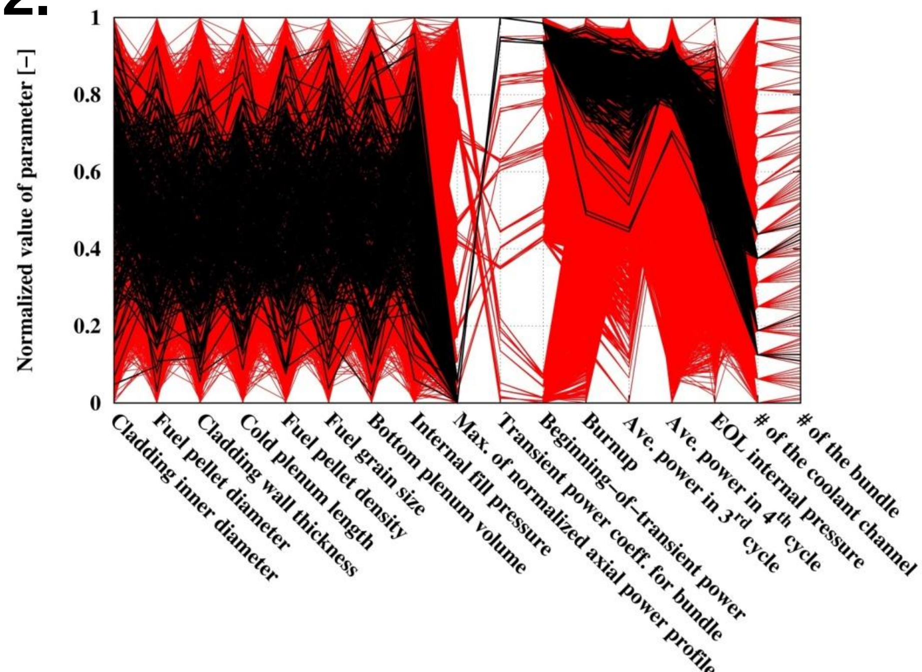
Sensitivity analysis methodology

1. Pre-processing of data into scalar format in order to apply the visualization and sensitivity calculation methods.
2. Qualitative analysis based on data visualization.
3. Quantitative analysis using three different sensitivity calculation methods.

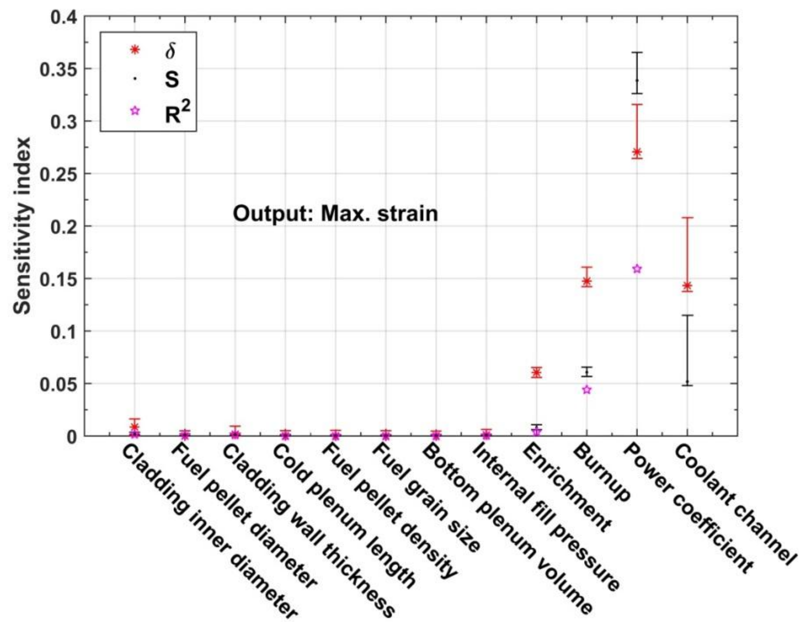
1.



2.



3.



Findings

Findings from the qualitative analysis:

- Tolerances in fuel manufacturing parameters do not significantly affect the transient cladding strain.
- High cladding strains are associated with distinct coolant channels and bundles.

Findings from the quantitative analysis:

- Sensitivity indices confirm that the most relevant parameters are:
  - Decay heat power during the transient represented by the bundle power coefficient
  - Steady-state irradiation history of the rod represented by the rod burnup
  - Thermal hydraulic boundary conditions plus the coolant channel power in the rod's location as represented by the coolant channel number
    - Further analysis revealed that the thermal hydraulic effects dominate over the effect of the coolant channel power

[2] Arkoma, A., Ikonen, T. "Sensitivity analysis of local uncertainties in large break loss-of-coolant accident (LBLOCA) thermo-mechanical simulations", Nuclear Engineering and Design Vol. 305, pp. 293-302, 2016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