Secondary Hydriding during LOCA – Results from the QUENCH-L0 Test

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Introduction

In the framework of the KIT QUENCH program design basis loss of coolant accidents (LOCA) and severe accidents (accidents beyond LOCA) are simulated experimentally on fuel rod bundle scale in large scale tests.

Processes occurring during LOCA

Processes occurring during LOCA include:
- Burst
- Ballooning
- Oxidation
- Sekundy hydriding
- Thermo-shock - Quenching
- Fragmentation and fuel relocation

The diagram shows the time dependence of the cladding temperature during a loss of coolant accident.
Sekundary hydriding

Influence on mechanical properties?

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QUENCH-L0 (commissioning test)
Neutron radiography

X-ray radiography

Experiments

- ICON facility (SINQ, PSI Villigen, CH)
- 13.-16.08.2010 (radiography)
- 09.-17.09.2010 (tomography)
- Illumination time per image: 300 s (radiography)
  625 x 90 s (tomography)
- Spatial resolution: ~23 µm (radiography)
  ~46 µm (tomography)
Results Radiography rod 15 ($p_i = 3$ bar)

$Z = 700 \text{mm}$

$Z = 1120 \text{mm}$

$\Sigma = 0.215,$

Is in the range measured for not-oxidized Zry-4

($\Sigma = 0.197 \ldots 0.216$)

Results Radiography rod 03 ($p_i = 55$ bar, $\Delta t = 104$ s)

$\Sigma = 0.197$
Results Radiography rod 17 ($p_i = 40$ bar, $\Delta t = 71$ s)

Results Tomography rod 01 ($p_i = 50$ bar, $\Delta t = 112$ s)

$x_H = 1330$ wppm
Summary and Conclusions

- Secondary hydriding was investigated by means of neutron radiography and tomography.
- The hydrogen distribution is not symmetric.
- The extension of the hydrided zone seems to depend on the time between bursting and quenching.
- Maximal hydrogen concentrations of ~1300 ppm was determined.
- No influence of inner pressure or crack length is obliviously.
- Strong influence of the hydrogen bands on the crack positions in the tensile tests (not shown in this presentation)

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Thanks for your attention, questions?