Main Results of the Bundle Test QUENCH-08 (In Comparison with QUENCH-07)

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Abstract

The ninth bundle experiment QUENCH-08 was performed at FZK on 24 July 2003. It differed from the experiment QUENCH-07 only in that the bundle was equipped with a standard unheated fuel rod simulator as a central rod and not with a B_4C control rod simulator. Major objective of the test was to investigate, whether and to which extent the phenomena observed in QUENCH-07 test can be attributed to the impact of B_4C.

Conduct of the quench-08 experiment

In common with the previous QUENCH experiments, the bundle was heated by a series of stepwise increases of electrical power up to about 4 kW from room temperature to ~600°C. The atmosphere consisted of 3 g/s flowing argon and 3.4 g/s preheated steam. During this time, the operation of the various systems was checked. At the end of the stabilisation period the power was ramped smoothly to 13.2 kW, corresponding to a maximum temperature of 1040°C, and then kept constant until the temperature of 1430°C was reached at 2277 s. At that time, the power was decreased to 8 kW and then controlled to maintain the temperature at that level for a period of ~15 minutes. Similarly to QUENCH-07, at the end of the temperature plateau one of the corner rods was removed to check the extent of oxidation, before going into the second transient, which started at 3240 s, by ramping the power at 6 W/s. This was continued until the pre-defined cooldown criteria as in QUENCH-07 were reached to be as close as possible to that test. Towards the end of this phase there were indications of shroud failure. The cooldown was initiated at 3776 s by switching the injection to cold steam at a rate of 15 g/s. Just at the same time krypton was detected in the off-gas pipe, indicating failure at least of one of the fuel rod simulators. The power ramp was continued for ~40 s and then power was reduced from 17.8 to ~4 kW in 15 s and kept constant for ~190 s. The electrical power was then shut off, but the steam injection continued until cooldown to ~200 °C had been achieved.

Within the heated zone all the observations indicated immediate cooling (however, it is noted that several thermocouples failed). Several locations toward the top of and above the heated zone experienced a strong escalation which clearly began immediately after increase of the steam flow. Associated with this escalation an increased release of hydrogen was observed during the cooldown phase for a period of about 2 minutes.

First evaluation of the mass spectrometer data gives ~46 g of total hydrogen generation up to the beginning of the cooldown phase and ~38 g of hydrogen release during the cooldown phase, hence about 84 g in total.

Summary

- Test QUENCH-08 (bundle without B_4C absorber rod) was performed as a reference test to QUENCH-07 (bundle with B_4C absorber rod): 1) preoxidation in

steam (3 g/s) with similar electrical power regulation and similar transient conditions, 2) cooldown in steam with the rate 15 g/s

- The growth of temperatures during preoxidation in QUENCH-08 was delayed in comparison to QUENCH-07, therefore the duration of the preoxidation period in QUENCH-08 was longer as the one in QUENCH-07
- The axial bundle temperature profiles on the start of the transient phase coincide well for both tests. The axial oxide layer profiles on the surface of the corner rod (removed before the transient begin) also coincide well for both tests
- Temperature escalation at elevations above 850 mm during the transient phase is more intensive in QUENCH-07. After the cooldown initiation there is a comparable temperature escalation in the upper part of the bundle for both tests
- The rate of the hydrogen generation during the preoxidation phase (including the period after the B_4C rod failure) is well comparable for both tests. The integral hydrogen release in QUENCH-07 is at least 25 % higher than in QUENCH-08
- The QUENCH-08 shroud is melted above the zirconia fiber insulation (1024 mm) in the angular range between 270° and 0°. The whole shroud of QUENCH-07 is melted above 1024 mm. There is an intensive interaction between the shroud and the fiber insulation in the region between 900 mm and 1024 mm for both tests