VALIDATION OF THE ASTEC INTEGRAL CODE USING THE QUENCH-06 AND QUENCH-08 EXPERIMENTS

F. Gabrielli[1], V.H. Sánchez-Espinoza[1], J. Stuckert[1], and I. Gómez-García-Toraño[2]
[1]: Karlsruhe Institute of Technology (KIT), Hermann-von-Helmholtz-Platz 1, D-76344 Eggenstein-Leopoldshafen, Germany
[2]: Institut de Radioprotection et de Sûreté Nucléaire (IRSN), PSN-RES, Cadarache, 13115 Saint-Paul-lez-Durance, France
Fabrizio.gabrielli@kit.edu, victor.sanchez@kit.edu, juri.stuckert@kit.edu, ignacio.gomezgarciatorano@irsn.fr

Abstract

The assessment of the Severe Accident Management Guidelines (SAMGs) is a key-component of the Defence-in-Depth concept applied in nuclear reactors to ensure that accidental consequences do not violate safety criteria. The Fukushima events showed that further improvements of SAMGs are necessary. Efforts are therefore worldwide underway to improve the performance of the current integral codes for severe accident (SA) analyses of Light Water Reactors (LWRs). In this frame, the Accident Source Term Evaluation Code (ASTEC), developed by IRSN, is being developed to analyze the complete SA scenario from the initiating event until radioactive release from the containment in Gen. II and Gen. III water-cooled reactors.
At the Karlsruhe Institute of Technology (KIT), both experimental and analytical investigations on severe accidents have been carried out for many decades, including QUENCH tests.
In this paper, the results of recent KIT activities devoted to the validation of the current ASTEC V2.1 version using selected QUENCH tests are presented and discussed. The main goal of such investigations is analyzing the physical phenomena occurring during water injection into a partially degraded core, which is one of the prime SAM measures to prevent the failure of the safety barriers i.e. Reactor Pressure Vessel. In fact, under particular conditions, steam generated during reflooding may significantly enhance the Zircaloy cladding oxidation accompanying by temperature escalation and then trigger a spiky hydrogen generation.
In the current work, QUENCH-06 and QUENCH-08 experiments have been selected for code validation. The two experiments aim at evaluating the effect of the injection of 40 g/s of water and 15 g/s of saturated steam, respectively, on the hydrogen production and the bundle degradation. In both tests, the melting point of Zircaloy was reached without significant final bundle damage. The analysis of the results shows that ASTEC is able to reproduce the experimental data of hydrogen production and cladding oxide thickness in instrumented bundle positions. The hydrogen production computed by ASTEC V2.1 in QUENCH-06 (34 g) and QUENCH-08 (84.1 g) shows a very small deviation from the experimental results, 35.7 g and 83.6 g, respectively. Such analyses are of relevance for the ASTEC V2.1 validation since they integrate all the key phenomena governing the effects of reflooding in the early in-vessel phase of a severe accident in PWRs.

Keywords: ASTEC, Code Validation, Reflooding, QUENCH, Severe Accident