

Status of FCI modeling and reactor applications: Achievements during the SARNET project

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Energetic fuel-coolant interactions (steam explosions) have to be considered as a potential hazard in the course of a severe reactor accident with core melting. The question, whether ex-vessel events can jeopardize the containment integrity is of high importance for evaluating and designing risk management strategies. In order to predict steam explosion induced loads, multi-dimensional computer codes like MC3D or IKEMIX/IDEMO have been developed in the EU and are continuously being improved. The work on FCI within SARNET was closely linked to Phase 1 of the OECD/SERENA programme, which had the objective of evaluating the capabilities of the current generation of FCI computer codes and reaching consensus on the understanding of important FCI phenomena relevant to the reactor situations.

The work in SERENA Phase 1 has shown that the computer codes are in general mature enough to be applied for reactor cases. However, larger discrepancies between the codes were obtained concerning the predicted loads in reactor cases. These originated mainly from differences, how the codes capture and treat major mechanisms limiting the strength of explosions. Such limitations were identified and elaborated in the past, recently in the OECD-SERENA Phase 1 project and in continued and extended analyses in the frame of SARNET. Concerning formation of an explosive premixture, they are given by the limited rate of melt entry into water, limited coarse breakup (jet fragmentation), possible strong void buildup during mixing (water depletion) and partial solidification of melt droplets inhibiting subsequent fine fragmentation. In the explosion event, equilibration processes in the detonation wave, which limit fast heat transfer from melt to coolant, as well as venting due to multi-dimensional propagation and interaction with free surfaces reduce the loads on structures.

In the present paper, the importance of the above effects limiting the strength of steam explosions are analyzed and elaborated by means of calculations with the codes MC3D and IKEMIX/IDEMO for representative ex-vessel conditions. The importance of main parameters as well as the influence of different model assumptions is discussed. Conclusions are drawn on the current status of modeling and steps for further resolution of remaining uncertainties are discussed, that are the subject of the recently started Phase 2 of the OECD/SERENA project.