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Development of methodology to evaluate mechanical consequences of vapor expansion in SFR severe accident transients: lessons learned from previous France-Japan collaboration and future objectives and milestones

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In the frame of France-Japan collaboration, one of the objectives is to define and assess the calculation methodologies, and to investigate the phenomenology and the consequences of severe accident scenarios in sodium fast reactors (SFRs). A methodology whose purpose is to assess the loadings of the structures induced by a Fuel Coolant Interaction (FCI) taking place in the sodium plenum of SFR has been defined in the frame of the collaboration between France and Japan during 2014-2019. The work progress will be spread over the period 2020-2024 and the main objectives and milestones will be introduced in this paper. The objective of studies is to comprehensively address the margin between the limit of integrity of the main vessel structures and the loadings resulting from severe accidents.

For this purpose, the SIMMER mechanistic calculation code simulates core disruptive accident sequences in SFRs. However, SIMMER cannot be used for main vessel loading assessment while it does not take into account fluid structure interactions. That is the reason why, associated with SIMMER code, a fluidstructure dynamics tool evaluates this interaction i.e. EUROPLEXUS is used in CEA studies and AUTODYN tool is used in JAEA studies. In this paper, a benchmark study is described in order to illustrate the evaluation of vapour expansion phase in the hot plenum. To do that, joint input data are used on the basis of an ASTRID 1500 MWth core degraded state after the power excursion which leads to vapour expansion. The most penalizing case was evidenced in this study by suppressing the action of transfer tube in-core mitigation devices in SIMMER input deck and thus privileging the upward molten core ejection. Since the risk of main vessel failure by cumulative stresses is an issue often discussed in the SFR concepts, the calculation methodology presented in this paper based on chaining of SIMMER code with another Fluid/structure evaluation tool is very promising. The future perspectives are highlighted.

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Authors: BACHRATA, Andrea (CEA); Mr GENTET, David (CEA); BERTRAND, Frédéric (CEA Cadarache); Mrs NATHALIE, Marie (CEA); Mr KUBOTA, Ryuzaburo (JAEA); Mr SOGABE, Joji (JAEA); Mr SASAKI, Keisuke (JAEA); KAMIYAMA, Kenji (Japan Atomic Energy Agency); YAMANO, Hidemasa (Japan Atomic Energy Agency); KUBO, Shigenobu (Deputy Director Advanced Fast Reactor Cycle System R&D Center, JAEA)

Presenter: BACHRATA, Andrea (CEA)

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