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ABSTRACT

Fundamentals of Melt-Water Interfacial Transport Phenomena: Improved Understanding for Innovative Safety Technologies in ALWRs

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The interaction and mixing of high-temperature melt and water is the important technical issue in the safety assessment of water-cooled reactors to achieve ultimate core coolability (conventional as well as advanced LWRs). For specific advanced light water reactor (ALWR) designs, deliberate mixing of the core-melt and water is being considered as a mitigative measure, to assure core coolability. The development and evaluation of such an innovative safety concept are hampered by the lack of fundamental understanding of the interfacial transport phenomena involved in melt-water mixing during the transient quenching process. The goal of this work is then to enhance the fundamental understanding of melt-water interfacial transport phenomena, thus enabling the development of innovative safety technologies for advanced LWRs. To achieve the goal of improved understanding of melt-water mixing and associated interfacial transport phenomena, the objectives of this research will be:

1) Adapt the existing experimental facilities at the University of Wisconsin-Madison (UW) and Argonne National Laboratory (ANL) for the characterization of transient cool down of melt mixed with water.

2) Measure the cool down behavior of the melt-water mixing zone by thermal mapping of this multiphase, multi-component system (ANL).

3) Measure the flow regime and interfacial area behavior of the melt-water multiphase, multi-component mixture by the use of innovative real-time X-ray imaging (UW).

4) Develop and integrate analytical models of interfacial transport phenomena in the framework of a computer model, including separate-effects experimental studies (Korean researchers at the Korea Maritime University).

5) Demonstrate the applicability of fundamental knowledge to the development of a novel safety concept of ex-vessel core debris coolability by (all participants): developing the scaling logic for this large scale application, analyzing past and current experiments that involve quenching of a simulant oxidic melt by water injection, assess needs for larger scale melt-water mixing tests in future R&D work.

The intent of these research objectives is to provide better understanding of the process of melt-water mixing and interactions specifically in representative reactor geometries and with simulant materials to demonstrate the capability to provide core coolability to achieve a safe stable state.