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CFD Simulation of Corium / Materials Interaction for Severe Accidents

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In case of a severe accident inside a sodium-cooled fast reactor, corium interacts with many materials along its way towards the core catcher. Once deposited, corium can also interact with protective and / or sacrificial material. Among those materials, refractory ceramics like zirconia are credible candidates due to their high fusion temperature. Through CFD methodology, calculations have been made in order to reproduce the fusion mechanism and kinetics of the UO2-ZrO2 system, in order to reproduce ablation phenomena of ZrO2 by UO2. This process is not only thermal but also chemical, as eutectic material formation is expected, around 2500°C. That is why the eutectic diagram of the UO2-ZrO2 system has been linearized and put directly inside the CFD software in order to take into account the formation of this eutectic material. Comparisons have been made with experimental data: a layer of UO2 is deposited inside a cooled zirconia crucible. Results show good correspondence between calculated and experimental data: the onset and effective melting of the zirconia is modelled, but also chemical saturation processes are identified, explaining the inhibition of the melting after a certain time.

A practical application of this development has been made in the frame of the AREVA research program on sodium reactor, demonstrating that in the case of a jet of corium flowing down on an internal core catcher, the shape of the molten sacrificial material enables the apparition of a so-called “pool effect”being very favorable with respect to the local ablation of the core catcher.

Finally, another application of this methodology could be in the frame of In-Vessel Retention study. A CFD simulation is made modelling the progression of the melting front inside the thickness of the bottom of a steel vessel due to the presence of molten UO2 emitting residual thermal power. Results show the formation of a floating steel layer at the surface of the UO2 molten pool, and the consecutive focusing effect occurring on the solid remaining parts of the steel vessel.

All these calculations show that some of the complex thermo-chemical phenomena occurring during a severe accident can be modelled and used in order to give better understanding of the main phenomena.

Country/Int. Organization

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