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Self-Propagating High-Temperature Synthesis of a Nuclear Reactor Core Melt for Safety Experiments

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ABSTRACT

Under nuclear accident and severe accident conditions for the water-cooled reactors, the materials of the nuclear reactor (nuclear fuel, cladding, metallic alloys, structural materials, concrete, etc…) could melt to form complex mixtures called *corium*.
This paper presents for the SHS (Self Propagating High temperature Synthesis) process applied to the prototypic corium synthesis by thermitic reaction, an example of the selection of the promising raw powders mixtures and the calculation of some characteristics temperatures (i.e. Adiabatic, liquidus and solidus temperatures) of the charge.
The thermodynamic predictions and computations have been performed using the GEMINI2 code and the relevant European Nuclear Thermodynamic Data-bases NUCLEA version05. The GEMINI2 code with NUCLEA is successfully applied on a regular basis to the corium melting experiments carried out on the PLINIUS platform of CEA.
An accurate analysis of the ANL (Argone National Laboratory) corium thermitic experiments (ACE-MACE programs) using the GEMINI2 code with NUCLEA 05 method has permitted to obtain two important results:
(i) the adiabatic temperature $T_{adiabatic}$ is always lower than the liquidus temperature $T_{liquidus}$ for the ANL tests. This result means the initial corium load would be partially melted (below liquidus temperature).
(ii) Gemini2 calculates successfully the equilibrium phases for specific temperatures ($T_{adiabatic}$, $T_{liquidus}$ or $T_{solidus}$) regarding thermitic process as well as the composition.
Special investigations concerning the SiO_2 effect on the thermitic reactions have been conducted for Cr_based and for Fe_based corium prototypic load.
Experiences are presently conducted at small scale in VITI facilities (on the CEA PLINIUS platform) in order to verify the thermodynamic prediction for the most promising raw powders mixtures selected on the basis of this preliminary work.

Keywords: Corium prototipic synthesis, thermitic reaction, SHS process, nuclear thermodynamic calculation code, nuclear severe accidents