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Tag der Forschung 2020
-Part 3-

Monday 18th January 2021, 14:00-16:00, Microsoft Teams

Swissnuclear supports since several years research projects in nuclear science at the Nuclear Energy and Safety (NES) division from the Paul Scherrer Institute, Villigen, CH. These projects contribute to the further specialization of highly educated young professionals and to maintaining a high level of competence in strategic research areas such as nuclear material science, modelling or thermo-hydraulic.

The “Tag der Forschung” 2020 aimed at presenting the 2018-2019 research projects to a wider group of collaborators from the Swiss nuclear powerplants, representative of the Swiss federal offices, and interested public. Originally planned as a physical meeting, the “Tag der Forschung” was reorganized as a virtual event in three parts because of the Covid-19 pandemic.

Agenda of the third part

18.01.2021, Microsoft Teams

14:00-14:05	Opening	swissnuclear
14:05-14:30	Energy Systems Analysis (LEA) - Energy and Risk Research	V. Dang, PSI
14:30-14:55	Laboratory of Radiochemistry in Nuclear Research	R. Eichler, PSI
14:55-15:20	Scientific Computing and Modelling - more than Bits and Bytes	A. Adelmann, PSI
15:20-15:30	LRC-02 “Waste and Isotope Reclamation”	I. Kajan, PSI
15:30-15:40	LSM-01 “CARSAN : Computational thermodynamic aspects of reactor chemistry and severe accident analysis”	S. Nichenko, PSI
15:40-15:50	LSM-02 “Numerical prediction of boiling crisis considering surface characteristics”	Y. Sato, PSI
15:50-15:55	Closing remarks	swissnuclear

Laboratory for Energy System Analysis (LEA)

Laboratory Head: Vinh N. Dang

Presentation: "Energy Systems Analysis (LEA) - Energy and Risk Research"
Time: 14:05-14:30

Laboratory for Radiochemistry (LRC)

Laboratory Head: Robert Eichler

Presentation: "Laboratory of Radiochemistry in Nuclear Research"
Time: 14:30-14:55

Project: LRC-02 "Waste and Isotope Reclamation"

Laboratory for Scientific Computing and Modelling (LSM)

Laboratory Head: Andreas Adelmann

Presentation: "Scientific Computing and Modelling - more than Bits and Bytes"
Time: 14:55-15:20

Projects: LSM-01 "CARSAN : Computational thermodynamic aspects of reactor chemistry and severe accident analysis"

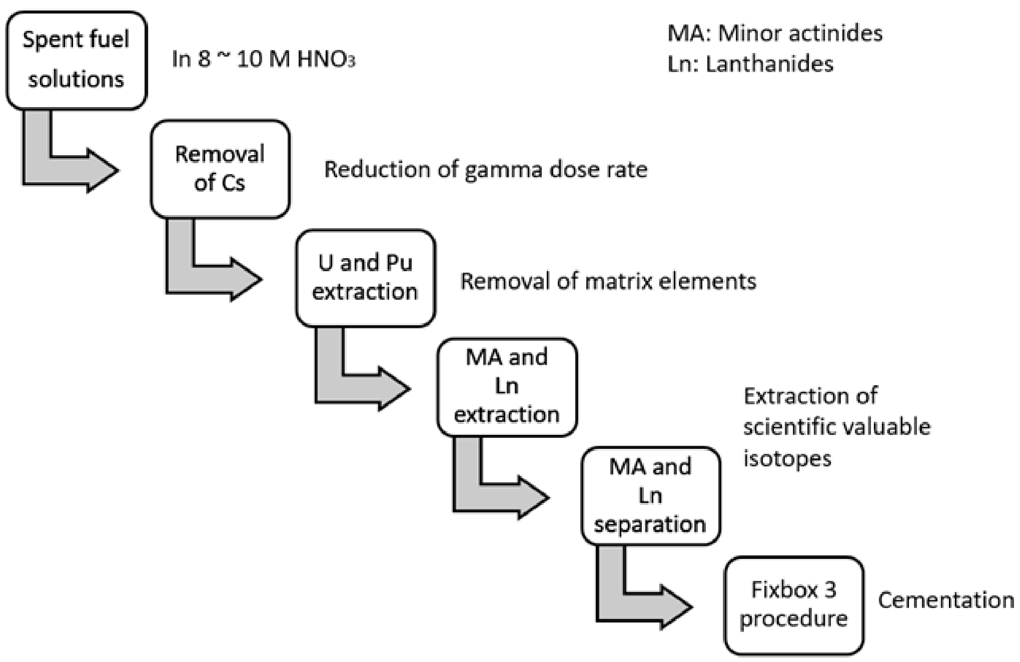
LSM-02 "Numerical prediction of boiling crisis considering surface characteristics"

Waste and Isotope Reclamation

I. Kajan[a], M. Lin[a], D. Schumann[a],
[a]Laboratory of Radiochemistry
Paul Scherrer Institute, CH-5232 Villigen, Switzerland

The proper disposal of the liquid waste solutions stemming from analysis of spent nuclear fuel over the past 30 years, currently stored in the Hotlab, is a task of which urgency is continuously increasing every further year. However, such burned nuclear fuel solutions don't present only waste but are also source of scientifically valuable isotopes for further research. The spent nuclear fuel solutions contain several rare and urgently needed radionuclides, which are of high interest for nuclear energy related research, in particular for neutron capture and fission cross section measurements
In the Waste and Isotope Reclamation project, we developed a suitable chemical separation system for the liquid nuclear waste treatment. The prospectives of the developed system are twofold. First, the extraction of the isotopes of cesium contributing most significantly to the dose rate emitted by the waste solutions. This procedure is expected to decrease the dose rate by a factor of 10 and will thus allow the solution treatment within the Fixbox-3 cementation facility. In the following stage, the scientifically interesting neutron rich isotopes of the lanthanide and actinide series are extracted and separated for fundamental research.
As the result the Waste and Isotope Reclamation project shows the important conjunction between the waste conditioning for the repository purposes with the benefit of collecting scientifically interesting isotopes for the future nuclear research.

Fig. 1: The flow sheet for the conditioning of nuclear fuel solutions



CARSAN : Computational thermodynamic aspects of reactor chemistry and severe accident analysis

S. Nichenko[a], D. Kulik[b], T. Lind[c], L. Fernandez-Moguel[c], J. Kalilainen[c]
[a]Laboratory for Scientific Computing and Modelling (LSM)
[b]Laboratory for Waste Management (LES)
[c]Laboratory for Reactor Physics and Thermal-Hydraulics (LRT)
Paul Scherrer Institute, CH-5232 Villigen, Switzerland

The main goal of the project was to improve the thermodynamic description of the fission products and core materials behaviour during the severe accident modelling using the integral analysis code MELCOR. The project's goal was achieved by developing the cGEMS (coupled GEMS) code that serves as an interface between the integral analysis code MELCOR and chemical thermodynamic modelling package GEMS and controls the exchange of the information between two codes (Fig. 1). The developed cGEMS code was applied for the modelling of the FP release behaviour from the spent nuclear fuel under accident conditions during the VERDON tests. In particular, VERDON-1 was selected as a representative experiment helpful for understanding the FP release under the severe accident conditions in a conventional LWR reactor (Fig. 2) and serve as an experimental reference for the simulations. The developed cGEMS code allowed for a significantly improved description of the FP release under severe conditions using the MELCOR modelling tool.
A part of the project was dedicated to the analysis of the accident sequence in unit 3 of 1F for up to 500 hours with the goal to reproduce the main accident signatures. The focus was on the transport of fission products (Fig. 3) and thermodynamic properties of the relevant species. Significant time was spent on checking the thermodynamic data found in the literature by validating the data against the known experimental data.

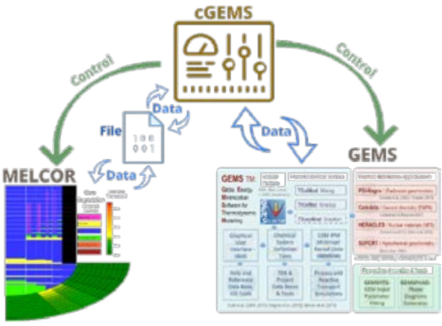


Fig. 1: Schematics of the cGEMS code

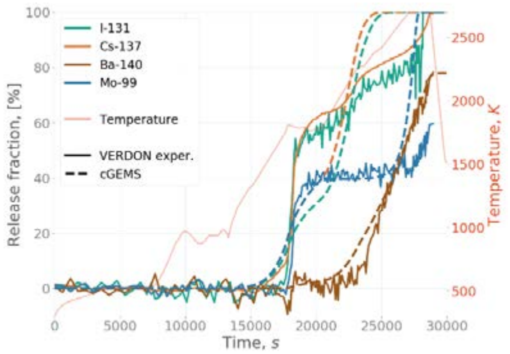


Fig. 2: cGEMS modelling of the VERDON experiment

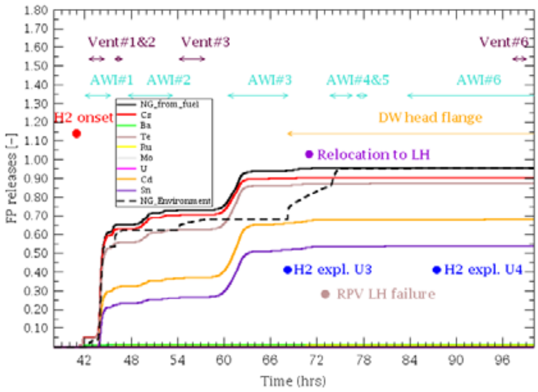


Fig. 3: Fission product release from the fuel and noble gas release to the environment in the reference sequence

Numerical prediction of boiling crisis considering surface characteristics

B. Niceno[a], K. Karalis[c], N. Prasianakis[b], R. Patel[b], S. Churakov[bc], Y. Sato[a]
[a]Laboratory for Scientific Computing and Modelling
[b]Laboratory for Waste Management
Paul Scherrer Institute, CH-5232 Villigen, Switzerland
[c]University of Bern, CH-3012 Bern, Switzerland

The goal of the project is to predict the boiling crisis, i.e. Critical Heat Flux (CHF), based on purely numerical simulation, in which surface condition/roughness of heat-transfer surface is fully taken into account. The flow around fuel rod(s) will be calculated, emulating the conditions commonly found in PWR/BWR reactors at the pressure of 150/70 bar. Via detailed simulations, a deeper understanding of the boiling phenomena at CHF will be obtained. Special attention will be paid to the microscopic properties (roughness, wettability, etc.) of the fluid-solid interface. Four types of numerical approaches will be included as outlined in Fig. 1: (i) Molecular Dynamics (MD) (ii) Lattice Boltzmann (LB) (iii) Computational Fluid Dynamics (CFD) on structured grids and (iv) CFD on unstructured grids. In (i), MD for boiling of water from ZrO_2 will be developed, and the fundamental physics on the vaporization on hydrophilic/hydrophobic surface will be studied as an in-kind contribution. In (ii), LB will be developed to simulate the effect of surface roughness on boiling. In (iii), CFD for boiling flow at high pressure will be developed, in which the surface roughness effect will be introduced through the upscaling of the LB results. In (iv), the phase change (boiling) models which are established in (ii), will be implemented in in-house CFD code, which can handle complex geometry such as fuel assemblies. Finally, CHF will be predicted using the CFD codes without employing any empirical correlations.

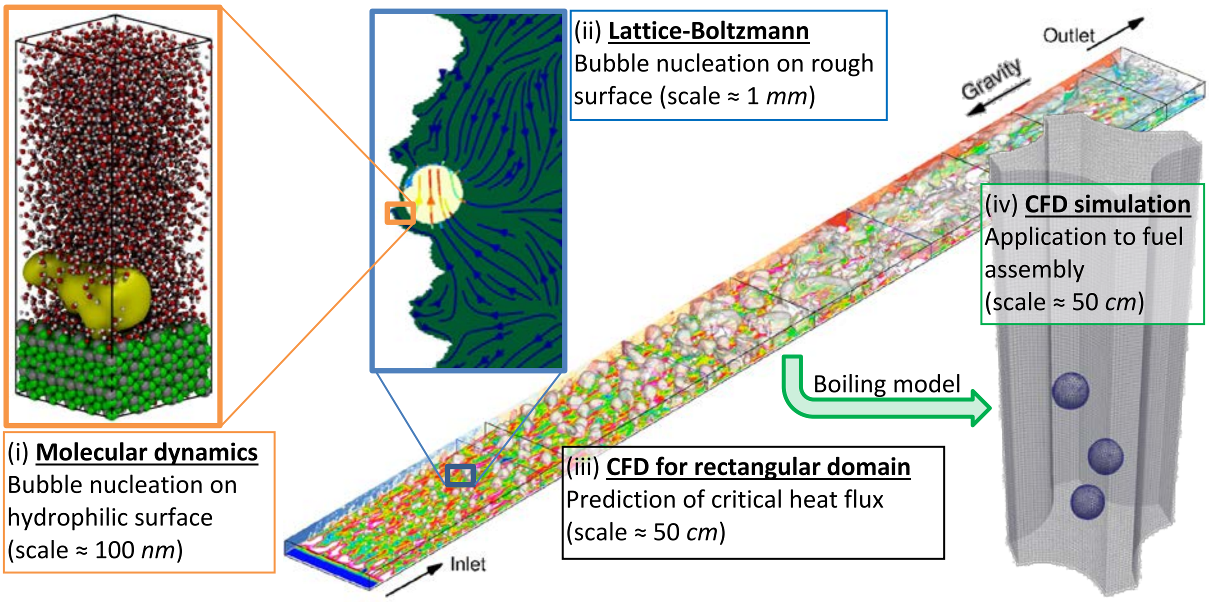


Fig. 1: Simulation system for the prediction of Critical Heat Flux (CHF) in a fuel assembly.