GEN IV International Forum
Expertise | Collaboration | Excellence

Security Study of Sodium-Gas Heat Exchangers in Frame of Sodium-cooled Fast Reactors

Summary / Objectives:

This webinar provides an overview of a Sodium Fast Reactor system and presents an accident scenario in Compact plates Sodium-Gas heat Exchangers (ECSG) of SFR. The overpressure (180 bar in the nitrogen loop while 5 bar in the sodium loop) could result in nitrogen leaking into the liquid sodium. The present work focuses on the analysis of the predominant physical phenomena in the jet (the viscous diffusion, the momentum exchange between the two fluids) and supersonic gas jet, the development of the compressible multiphase flow model (Baer-Nunziato model) and its numerical schemes. In addition, the model is implemented using the numerical tool CANOP that enables researchers to generate the Adaptive Mesh Refinement and to calculate in parallel.

Meet the Presenter:

Dr. Fang Chen recently earned her PhD titled: “Numerical study of the under-expanded nitrogen jets submerged into liquid sodium in the frame of sodium-cooled fast reactor (SFRs)” from the university of Aix Marseille, France. She pursued her research at the CEA Cadarache, Service de Technologie des Composants et des Procédés (STCP), Laboratoire de Technologie, Procédés et Risques Sodium (LTPS). In 2016, she double majored as an Engineer in Energetics, Mechanics and received a Master in Physics of Multiphase Flow from the University of Aix-Marseille, France.

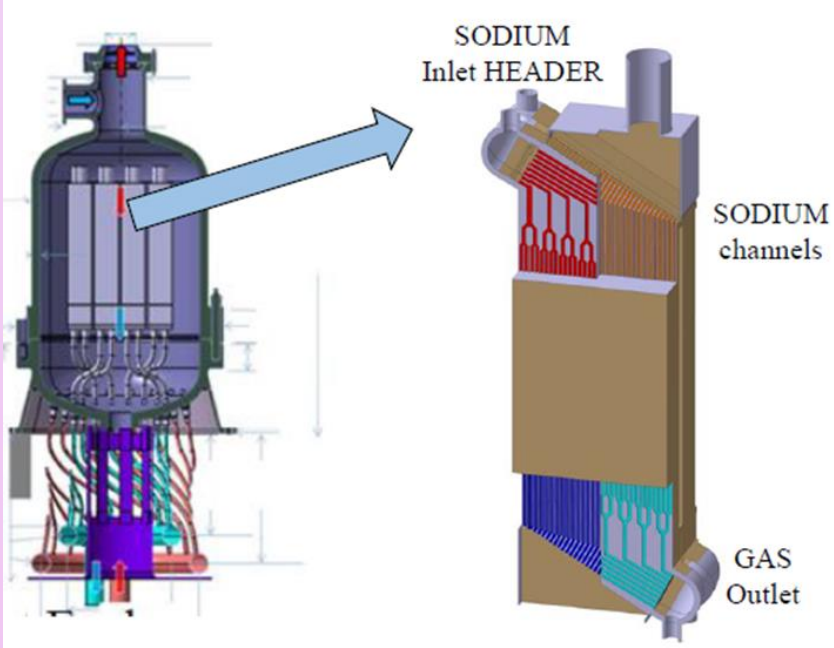
1. SGHE (Sodium Gas Heat Exchangers) design of French SFR ASTRID :

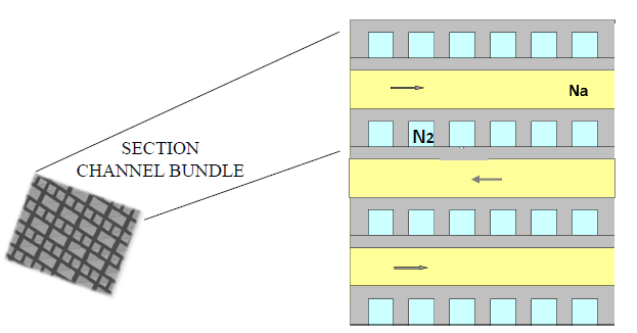
Pressure difference between the secondary & tertiary loop:

–180 bar in gas loop, 5 bar in sodium loop.

Accident scenario (wall crack): gas leak into sodium, under-expanded gas jet.

Safety analysis : acoustic detection of gas leak

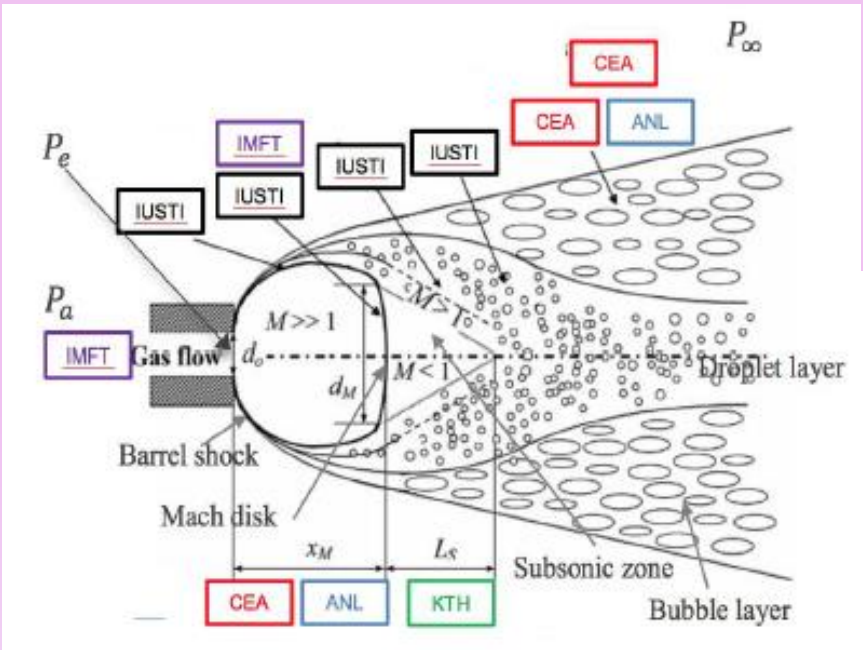


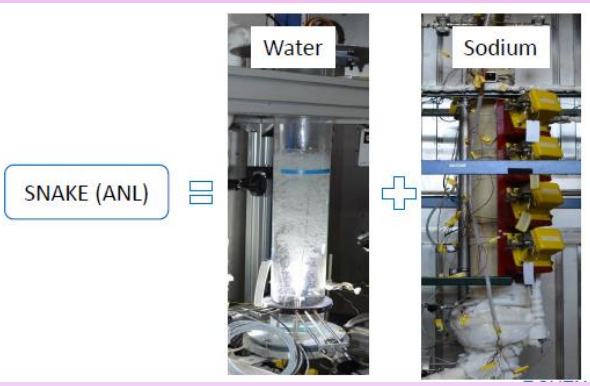


2. Objective of present work :

Provide a numerical tool to find the structure of under-expanded gas jet as a function of the flowrate of the gas leak

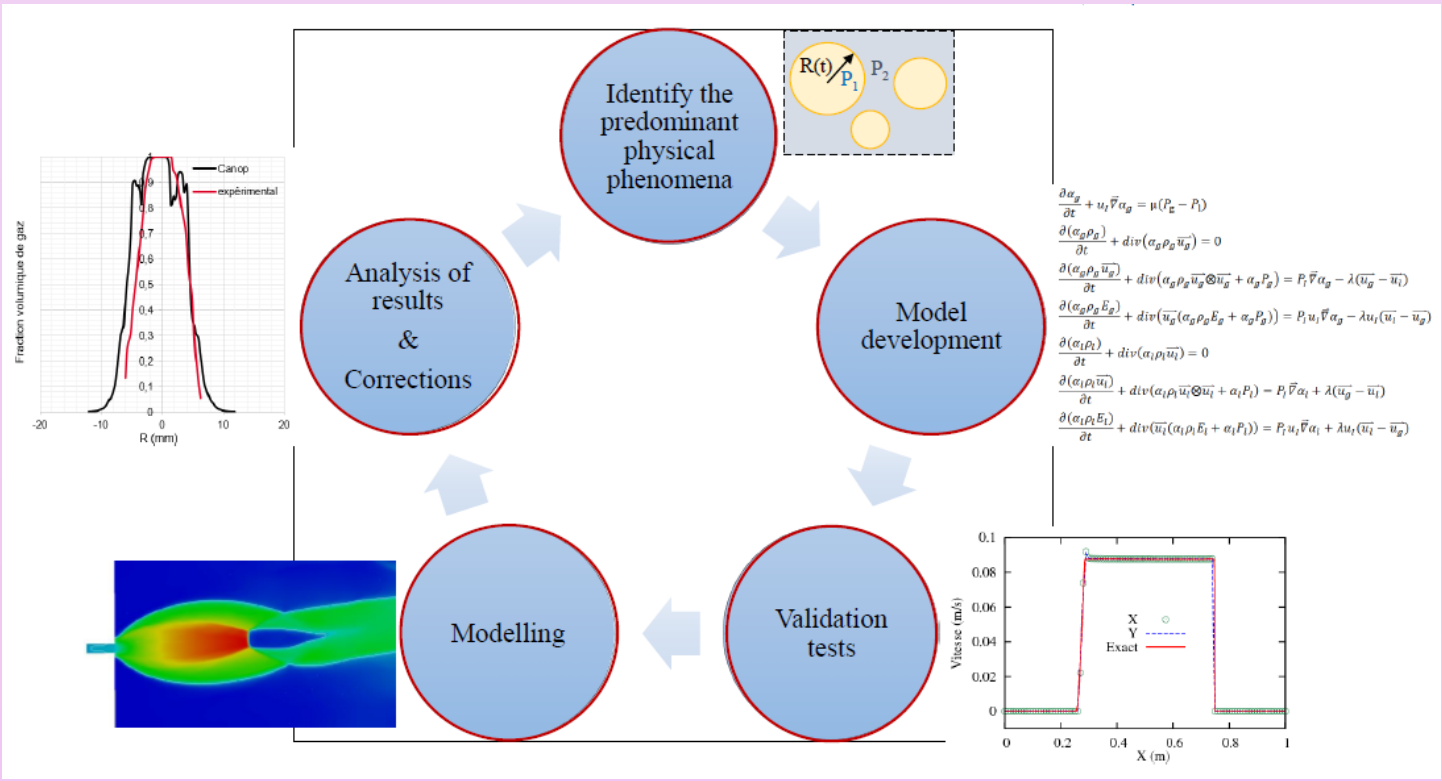
Many organizations including IMFT, CEA, ANL, IUSTI, KTH are in cooperation.





3. Development process :

Model development, Validation tests, Modelling , Analysis of results & Corrections, Identify the predominant physical phenomena

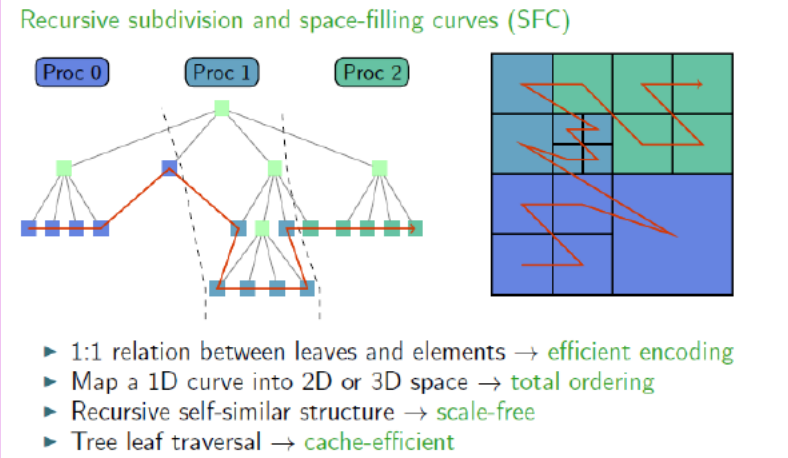


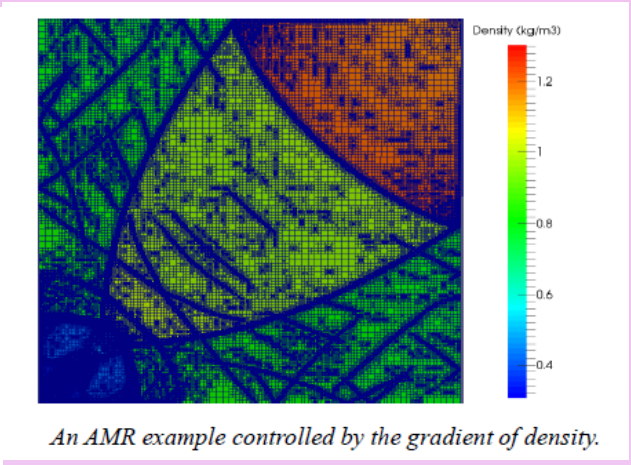
4. Numerical tool –CANOP (Two layers in CANOP) **:**

- Low-level layer:

  Cell-based Adaptive Mesh Refinement (P4estlibrary),

  Efficient parallel computation





An AMR example controlled by the gradient of density.

- High-level layer, for implementing numerical schemes:

  Finite volume method,

  PDF problems in Fluid Dynamics (for astrophysics, multiphase flows, *etc*)

5. Model Validation:

Validation of convective part :

– Two-phase shock tube tests: analytical cases of the literature

Viscous diffusion :

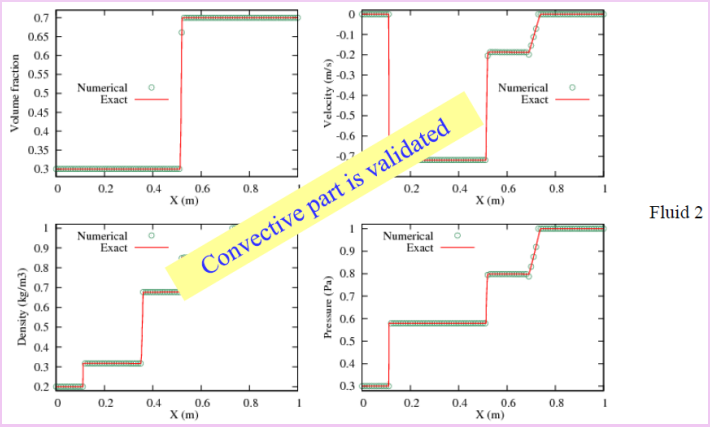
– Viscous diffusion: Poiseuille flow

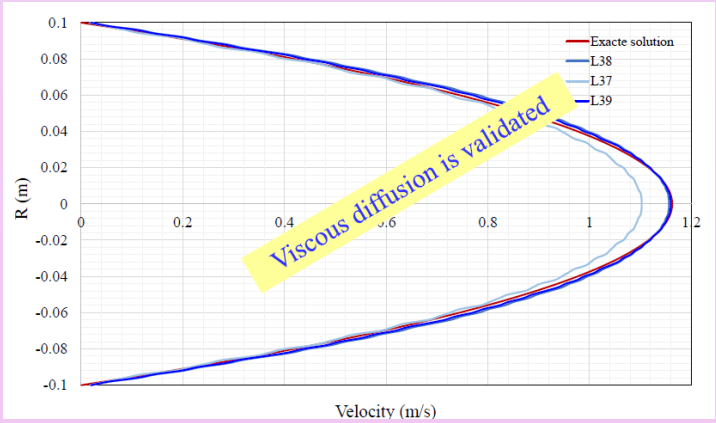
– Momentum exchange: mixing layer between two fluids

Modelling of under-expanded gas jets

– Comparison between the numerical results & experiments

– Under-expanded gas jets in SGHE channel

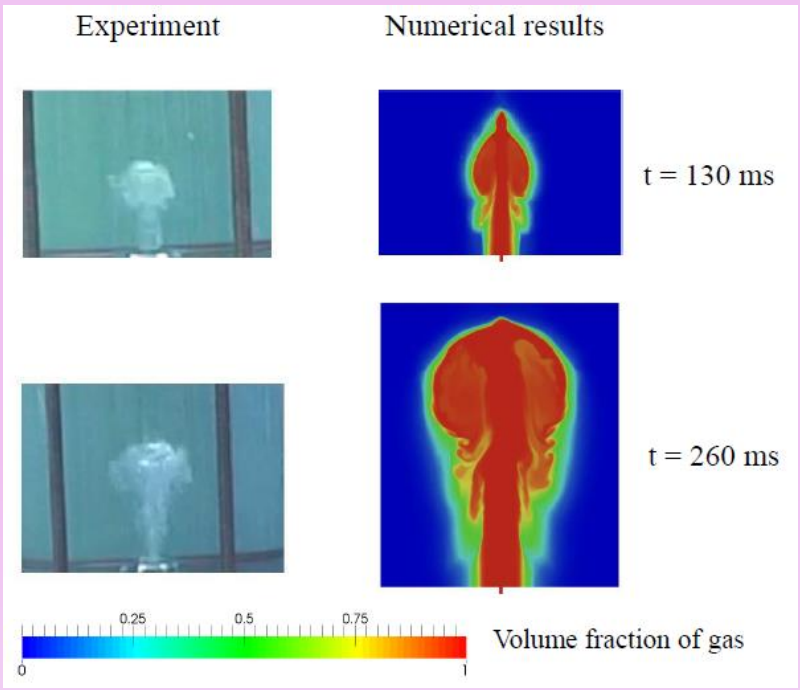




6. Under-expanded gas jets :

Left : Comparison with experiments (Colleoc1990)

Right : Gas jets submerged into sodium liquid in SGHE



Further experimental validation on IKHAR 2 facility in CEA Cadarache