INTERNSHIP PROPOSAL

Title

Contribution to the development of a calculation scheme into the APOLLO3® code dedicated to the modeling of a REA (Rod Ejection Accident) in a PWR: implementation of an adaptive meshing for tracking the rod displacement.

Internship context

The nuclear energy division of the Commissariat a l’Energie Atomique (CEA) has launched an ambitious program for the renovation of its codes system for the reactor physics simulation. One of the key issues is the development of the APOLLO3® code dedicated to deterministic neutronic calculations.

APOLLO3® code can simulate accidental configurations (Rod Ejection Accident, steam Line Break Accident …) with a fine 3D core description. The kinetic model is generic for some APOLLO3® solvers, in particular: MINOS [1], performs diffusion and simplified transport, MINARET [2][3] performs full transport. A recent internship allowed validating the use of these different solvers for the simulation of a control rod Ejection accident [4][5]. Presently, the current geometric model applied for the core description involves some simplifications that can lead to some deviations from the exact solution.

One of these simplifications is due to the fact that the kinetic solvers currently implemented in APOLLO3® assume a constant spatial discretization during all the transient calculation. This constraint leads to an approximation of the exact position of the control rods. Thus if we assume a given discretization in time, during the transient at each time step the position of the control rods does not necessarily coincide with the fixed axial meshing associated to the initial operating configuration, the mesh containing a control rod is so heterogeneous (no rod medium in the lower zone and rod medium in the upper zone). To traduce this heterogeneous aspect, a dilution method is used which consist in replacing the heterogeneous environment by a mixture (fuel medium) + (fuel/rod medium). This dilution process leads to physical deviations by the fact that the average medium smooths the rod absorption.

Internship Proposal

It is proposed during this internship to develop an algorithm that take into account the exact position of the control rods during a transient simulation. By this fact, the calculation spatial mesh is variable in time and thus, it’s necessary for each time step to generate a mesh that considers the real position of the rod. This meshing update (assumed to be constant over the time step), will require the projection of neutronic flux and precursors concentrations from the current time step to the following one. Note that the development of such functionality will also allow implementing a method for mesh adaptation giving a better estimation of local flux variations over the time step. It will be the occasion to improve the calculation precision and the computation time, two main challenges for the development of an industrial modelling.

On the other hand, another functionality available in the previous solvers is to locally modify the degree of approximation, as example, near the rod/fuel interface, this functionality could be used concurrently to the local mesh refining method to improve the flux precision.

Local meshing refinement/approximation order adaptation will require finding a criterion that measures the quality of the solution. Taking into account that the flux in MINOS and MINARET are discontinuous through the mesh interfaces, a possible criterion to be validated might be the estimation of the discontinuity, a too high jump being sign of a too low precision due to a too coarse mesh or a too low approximation order.

Student Profil

Master 2 – knowledge in reactor physics and scientific computing (C++ language)
Internship localization

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