Study of the Dynamics of Fuel Assemblies Under Flow and External Mechanical Excitation

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Fluid-structure interaction (FSI) phenomena are widely present in various industrial fields. In the nuclear sector, they occur in multiple locations within a nuclear power plant. To ensure nuclear safety, it is essential to study these phenomena. In this work we focus on studying an FSI phenomenon within the reactor core, specifically on understanding the vibratory response of a fuel assembly subjected to flow and external mechanical excitation, particularly in the event of an earthquake.

Several experimental studies have been conducted to better understand this phenomenon. Additionally, macroscopic models have been developed, enabling simulations at the core scale. The goal is to perform best-estimate calculations of a fuel assembly (of ruduced size) to extend the experimental results beyond the measurements taken and improve the understanding of fluid-structure interaction mechanisms.

To achieve this goal, we adopt the partitioned coupling technique, which consists of using a different solver for each of the considered media. In this approach, the equations are considered as subsystems and are solved at each time step, successively or iteratively, with variables exchanged at the fluid-structure interface. This type of coupling has been implemented between two solvers [2] : TrioCFD [3] and Europlexus [1]. TrioCFD, in this case, is used to solve the equations modeling an incompressible unsteady flow, while Europlexus is employed to address the nonlinear dynamics equations of structures. To track the fluid-structure interface, the Arbitrary Lagrangian-Eulerian method is employed. Additionally, a temporal coupling algorithm is used to ensure the stability and accuracy of the solution and to manage the multiple time scales between the fluid and the structure for improved computational efficiency.

To assess the stability of the coupling, we adopted the Mok test case, known for its significant added mass effect. This study has allowed us to analyze the impact of added mass on the stability of the coupling algorithm between TrioCFD and Europlexus. Additionally, for the numerical validation of the coupling, a comparison of the TrioCFD-Europlexus results with those from the literature was conducted using this test case.

[1] Europlexus. A computer program for the finite element simulation of fluid-structure systems under transient dynamic loading. https ://www-epx.cea.fr.

[2] Antonin Leprevost. *Couplage partitionné fluide-structure à l'échelle locale avec grille mobile pour des transitoires non-linéaires.* Thèse de doctorat, Université Paris-Saclay, 2024.

[3] TrioCFD. Logiciel de simulation numérique en mécanique des fluides (cfd). https ://triocfd.cea.fr/.

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