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# RANS and LES simulations of flow-induced vibrations in rod bundles with mixing grids

Antoine Michel<sup>1</sup>, Maria Adela Puscas<sup>1</sup>, André Bergeron<sup>1</sup>

<sup>1</sup> Université Paris-Saclay, CEA, Service de Thermo-hydraulique et de Mécanique des Fluides (STMF), 91191 Gif-sur-Yvette, France

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## Abstract

Flow-induced vibrations (FIV) are an important phenomenon to maintain operational conditions in existing nuclear power plants and for future designs. Vibrations arise due to the load induced by the fluid flow on long and slender rods in the core, steam generator and heat exchangers. Their effect can range from fretting to fatigue and may induce early wear or even failure of the mechanical components. As part of the research effort conducted by the CEA on FIV, an Arbitrary Lagrange-Euler (ALE) method has been implemented in TrioCFD [1] to study fluid-structure interaction. This tool has been successfully employed to reproduce analytical results in state-of-the-art configurations [2], but its capability to predict the vibrations in a realistic setup has yet to be determined. In the present study, as part of the European GO-Viking project, numerical simulations are undertaken to assess the ability of TrioCFD to reproduce the FIV measurements performed on ALAIN experiment [3]. The investigated setup is made of a 5x5 rod bundle with a split-type mixing grid encased in a square duct in which water flows axially at  $Re=90\,000$ , mimicking the core of a pressurized water reactor. The ALE method is employed to account for the influence of the fuel-rod assembly moving boundaries on the turbulent flow. Comparison between the numerically predicted FIV and the experimental measurements is conducted for two classes of flow modeling approaches. One, in which the mean flow is determined by solving Reynolds Averaged Navier-Stokes equations (RANS), is commonly employed in industry. The second involves solving filtered Navier-Stokes equations to capture the largest eddies of the turbulent flow (LES) and includes a higher level of detail of the flow features. Analysis of the results provides insight into the capacity of the ALE module of TrioCFD to reproduce experimental FIV measurements, and allows to propose guidelines for FIV simulations in an industrial context.

[1] P. E. Angeli, U. Bieder, G. Fauchet, Overview of the TrioCFD code: Main features, V&V procedures and typical applications to nuclear engineering, in: Proceedings of 16th International Topical Meeting on Nuclear Reactor Thermal

Hydraulics (NURETH-16), Chicago, USA., 2015, p. 252.

[2] D. Panunzio, M.-A. Puscas, R. Lagrange. FSI—vibrations of immersed cylinders. Simulations with the engineering open-source code TrioCFD. Test cases and experimental comparisons. *Comptes Rendus. Mécanique*, Tome 350 (2022), pp. 451-476.

[3] [https://go-viking.eu/wp-content/uploads/2023/10/G0\\_VIKING\\_D2\\_3\\_Alain\\_5x5\\_pwr\\_rod\\_bundle\\_experiment\\_and\\_benchmark\\_setup\\_v2\\_submitted\\_on\\_15\\_12\\_2022\\_UNDER\\_REVISION.pdf](https://go-viking.eu/wp-content/uploads/2023/10/G0_VIKING_D2_3_Alain_5x5_pwr_rod_bundle_experiment_and_benchmark_setup_v2_submitted_on_15_12_2022_UNDER_REVISION.pdf)