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NUMERICAL INVESTIGATION OF THE FLUID-STRUCTURE INTERACTION PHENOMENON COUPLING 2-PHASE FLOW AND STRUCTURES IN A NUCLEAR REACTOR CORE
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ABSTRACT

In the framework of the Generation IV International Forum [1] gathering countries engaged in the development of future nuclear reactor designs, safety assessements have to be performed in order to demonstrate their reliability.

Regarding that purpose, numerical tools are intensively used by industry and research institutes to simulate transient phenomena, some of them being difficult to reproduce within an experimental mockup. They can help therefore to provide major safety features in case of any reactor failure.

The work presented during the minisymposium will deal with the numerical study of a 2-phase flow interacting with structures placed in an hexagonal lattice of a Sodium-cooled Fast Reactor [1]. This hexagonal lattice consists in several rings of closed hexagons separated by a constant geometrical step. Since the space between these structures is quite small (about 2% of each assembly's characteristic diameter), the movement of the assemblies caused by an external source of excitation could lead to a complex Fluid-Structure Interaction (FSI) phenomenon. In the case where this excitation is high enough in term of amplitude and/or frequency, it will be shown that the induced pressure decrease could involve vaporization of the fluid (cavitation phenomenon) and may then lead to a different FSI behaviour.

A presentation of an analytical model predicting the pressure field of a 1-phase incompressible fluid in a duct with moving boundaries had been performed at ECCM-ECFD 2018 [2]. This model has provided initial setup parameters in order to reach the vapour pressure within the reactor core.

Using this preliminary study, we will then present the results in the fluid domain at a reactor scale in 2D in case of forcing movement of the boundaries. These results have been obtained using the software Code_Saturne and its Arbitrary Lagrange-Euler (ALE) module. In these results the fluid is, without cavitation, modeled by the classical incompressible Navier-Stokes equations and the Merkle 3-equations

model [3] is used when cavitation is assumed. In order to afford calculations at a large scale, a 1D-homogeneization procedure of the fluid domain will be presented as well.

Finally we will deal with the case of FSI calculations which have been considered by means of an internal coupling procedure using a spring-mass model for the structures. Numerical coupling between Hydraulics and Mechanics is performed using a Newmark algorithm. Nevertheless the high ratio value between the fluid added mass and mass of each structure renders such a calculation unstable without any relaxation procedure. In order to overcome this limitation, a sub-cycling process with relaxed fluid forces terms has been implemented will be shown. The extension to 3D of the FSI study using the beam theory for the structures will be introduced.

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