

Stabilised Finite Element Methods vs LES modelling for fluid-structure interaction with anisotropic adaptive meshing

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Résumé — This paper presents a stabilised finite element method for the solution of incompressible multiphase flow problems in three dimensions using an immersed volume method with anisotropic adaptive meshing. The proposed method is developed in the context of the monolithic formulation for solving general fluid-structure interactions. We assess the behaviour and accuracy of the proposed formulation coupled to the levelset method approximation in the simulation of 2D and 3D time-dependent numerical examples.

Mots clés — SFEM, Fluid-Structure Interaction, Adaptive mesh, high Reynolds number.

1 Introduction

Fluid-Structure Interaction (FSI) describes a wide variety of industrial problems arise in engineering, technology, bioengineering... Due to the high complexity of these problems, FSI simulations are nowadays the focus of numerous investigations and various approaches are proposed to treat them. A recently developed method which draws upon features of both multiscale and stabilized finite element methods is generalised to deal with fluid-structure interactions at low or high Reynolds number.

2 Variational MultiScale approach

We present in this paper a new stabilized finite element method for the solution of incompressible multiphase flow problems in three dimensions using an immersed volume method with anisotropic adaptive meshing [1]. This finite element solver is used for solving general fluid-structure interactions. The proposed method is developed in the context of the monolithic formulation. Such strategy gives rise to an extra stress tensor in the Navier-Stokes equations coming from the presence of the structure (e.g. rigid or elastic) in the fluid. The distinctive feature of the Variational MultiScale approach is not only the decomposition for both the velocity and the pressure fields into coarse/resolved scales and fine/unresolved scales but also the possible efficient enrichment of the extra constraint [2]. This choice of decomposition is shown to be favorable for simulating multiphase flows at high Reynolds number [3].

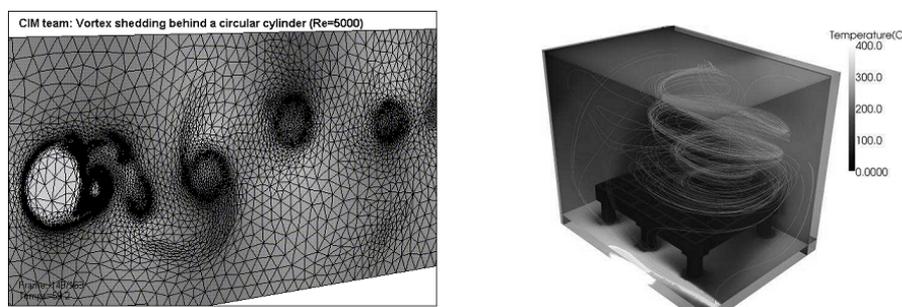


FIGURE 1 – Dynamic anisotropic mesh adaptation for vortex shedding behind a rigid obstacle (left). Turbulent heat transfer inside an industrial furnace (right)

3 LevelSet method

The interface between the phases is resolved using a convected level set approach developed in [4]. This approach enables first to restrict convection resolution to the neighbourhood of the interface and second to replace the reinitialisation steps by an advective reinitialisation. This enables an efficient resolution and accurate computations of flows even with large density and viscosity differences. The level set function is discretized using a stabilized upwind Petrov-Galerkin method and can be coupled to a direct anisotropic mesh adaptation process enhancing the interface representation.

4 Results and discussion

We assess the behaviour and accuracy of the proposed formulation coupled to the levelset method approximation in the simulation of 2D and 3D time-dependent numerical examples such as : the water waves propagations, vortex shedding behind a rigid obstacle, conjugate heat transfer inside industrial furnaces and the rigid bodies motion in incompressible flows (see Figure 1). Results are compared with the literature and show that the present implementation is able to exhibit good stability and accuracy properties.

5 References

Références

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