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# An Adaptive ALE Formulation to Solve Fluid-Structure Interaction with Large Deformations and Added Mass Efects

*** Facundo Del Pin**

Livermore Software Technology Corporation
Livermore, 94551, CA, USA
fdelpin@lstc.com

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## ABSTRACT

Numerical simulation has recently faced a large demand in the field of multi-physics applications. The need in this area is not new but the growth of computational resources and the development of new numerical techniques have driven the industry to a more aggressive and demanding approach regarding numerical simulation software.

This work describes a Fluid-Structure interaction algorithm that was developed in the context of a commercial non-linear solid mechanics solver. To simplify the coupling with the pre-existing code and the maintenance of the module a strongly coupled staggered approach has been used. In this approach successive Newton iterations between the fluid and the structure take place at each time step. A similar iterative technique has been proposed in [1]. This kind of semi-implicit approach is improved by a Newton loop between the fluid and the structure as in [2]. Boundary terms added on the interface of the fluid incompressibility equation help stabilize the method and improve the convergence rate. To simplify the model elastic structures will be considered although this is not a limitation. The Navier Stokes equations for incompressible Newtonian flow will govern the fluid dynamics problem. They will be approximated using an ALE framework. The time integration will be based on a projection scheme where pressure and velocity are segregated [3]. For the ALE approach multiple moving mesh algorithms have been tested. In the case of large deformations or rotations the solver is provided with a re-meshing strategy. When error control is necessary the re-meshing technique could be coupled to an error estimator. The re-meshing strategy is a key component of the overall algorithm. The basic idea has been taken from the Particle Finite Element Method [4,5] and adapted to an ALE framework. In the present work hemodynamics applications will be emphasized. This kind of problems have shown to be extremely challenging for staggered algorithms due to the added mass effect. Fig. 1 depicts a $3D$ test case of a valve that open and closes for three complete cycles due to a flow rate that changes in time. The physical properties and inflow conditions were chosen so that to approximate a real hemodynamics case.

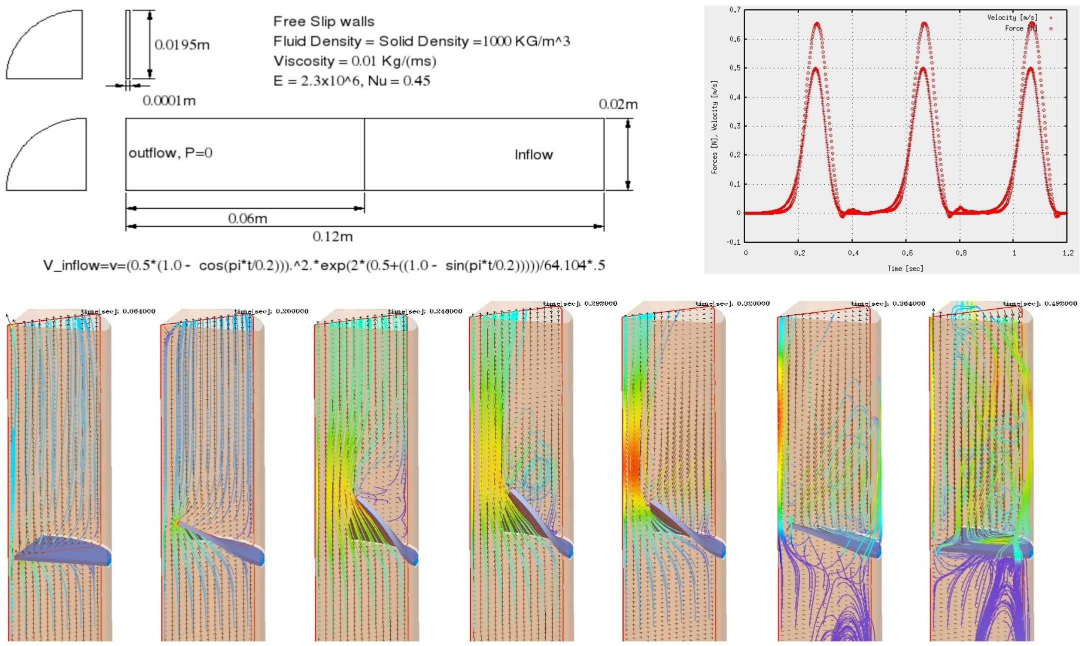


Figure 1: FSI simulation of a flexible valve. On top: sketch of the problem and graphic of total force and inflow velocity vs time. On bottom: seven different states showing the valve aperture, velocity vectors and streamlines on a vertical cut plane.

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