Numerical simulation of the strong staggered aerodynamic coupling of an electrostatic micropump

M. Drosson*, D.Vigneron and J.-A. Essers

Mechanical and Aerospace Department, University of Liège

Chemin des Chevreuils 1, 4000 Liège, Belgium

e-mails: *M.Drosson@ulg.ac.be*, *Didier.Vigneron@ulg.ac.be*, *JA.Essers@ulg.ac.be*

Since several years, the modeling of fluid-structure interaction (FSI) is no longer restricted to traditional applications such as divergence or flutter prediction encountered in aeroelasticity. New application fields namely micro-electro-mechanical systems (MEMS) and bioengineering have become more and more important.

In the present work, an electrostatic micropump has been studied. The device comprises a cuboid pump chamber equipped with two ideal check valves. Fluid motion is generated by applying an electrostatic force that deforms a flexible membrane. Fluid-structure interaction effects are considered in the evaluation of the pump performance. For this purpose, a coupling technique proposed by J. Vierendeels [1] that allows a strong coupling of partitioned solvers has been used. The idea of this technique consists in reducing the calculation time by replacing the exact fluid model by a reduced order model much easier to solve. Furthermore, an amelioration of the stability properties of the coupling procedure is expected.

The fluid model is based on a finite volume approach for compressible viscous flows on unstructured grids. An arbitrary Lagrangian-Euler strategy is used to describe the motion of the fluid domain [2]. The structure model rests upon a finite element formulation using two-dimensional shell elements.

The effect of fluid-structure interaction on the pump performance is evaluated by comparing membrane deflection and fluid flow to the results obtained by a weak coupling method. Comparisons to a "traditional" strong staggered coupling method, which consists in iterative solving of the fluid and the structure model, are presented to demonstrate the capability of the algorithm.

References

[1] J. Vierendeels. Implicit coupling of partitioned fluid-structure interaction solvers using a reduced order model. In American Institute of Aeronautics and Inc. Astronautics, editors, *35th AIAA Fluid Dynamics Conference and Exhibit*, Toronto, Ontario Canada, 6-9 June 2005.

[2] I. Lepot, D. Vigneron, J.-A. Essers, and O. Léonard. Implicit high-order geometrically conservative scheme for the solution of flow problems on moving unstructured grids. In Elsevier Science Ltd, editor, *Second MIT Conference on Computational Fluid and Solid Mechanics*, pages 992–996, MA,USA, June 2003.

*Aspirant F.R.S. - FNRS