6th European Conference on Computational Mechanics (ECCM 6)
7th European Conference on Computational Fluid Dynamics (ECFD 7)
11-15 June 2018, Glasgow, UK

Design of a Diaphragm Pump under Uncertainties using the Continuous Adjoint to the Cut-Cell Method

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Keywords: *Diaphragm pumps, Uncertainty Quantification, Polynomial Chaos Expansion, Cut-Cell Method, Continuous Adjoint Method*

This paper is on the development of the unsteady continuous adjoint method associated with a flow solver based on the cut-cell method to be used for the optimization of a diaphragm pump. A key feature of this pump is the oscillating diaphragm which can properly be handled by the cut-cell method on a stationary Cartesian grid, dynamically adapted to the moving diaphragm. In both the flow and adjoint solvers, emphasis is laid on the proper treatment of cells that appear in or disappear from the fluid domain, due to the motion of the diaphragm. The continuous adjoint method is implemented to compute the derivatives of an integral measuring the backflow along the outlet with respect to parameters controlling the shape of the stationary part of the pump.

In the second part of this paper, the developed adjoint method is used for the shape optimization of the same pump under uncertainties. For the quantification of uncertainties, the non-intrusive Polynomial Chaos Expansion (PCE) method is used. The new objective function includes the mean value and the standard deviation of the quantity of interest used as objective function in the previous optimization without uncertainties. The adjoint solver for the case without uncertainties is also used for the gradient computation at the Gauss quadrature nodes, in the presence of uncertainties.

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