A Unified Finite Volume Approach for Numerical Simulations of Fluid Piezoelectric Structure Coupled Systems

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Abstract

Piezoelectric structures have been widely used in many controlling devices, sensors for flow control and energy harvesters [1]. Among many challenges in designing piezoelectric based devices, understanding and characterization of such prototypes and designs are essential in scaling up and optimization process. Direct conversion between mechanical to electrical energy renders higher efficiency for coupled piezoelectric system, yet creating formidable challenges for modelling and simulations. A computational model for piezoelectric structure and fluid coupled system was proposed in this present work. Responses of piezoelectric structures were first calculated using electro-mechanical coupling model taking into account anisotropic properties of piezoelectric materials. The electro-mechanical model was then coupled with Navier-Stokes flow solver for simulations of piezoelectric structures responses in various flow conditions. The whole coupled system was discretized using second order finite volume approach thus enabling efficient coupling mechanism for fluid structure interaction simulations. The proposed approach is applied for a benchmark problem of piezoelectric cantilever beam oscillation in cross flows where numerical results are validated against experimental data [2]. It is possible to extend the current approach for simulations of piezoelectric energy harvester as future potential applications

Keywords: Piezoelectric structures, actuators, fluid structure interactions, energy havesting

References

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