Two-dimensional (2D) Topology Optimization of IPMC integrated Fluidic Diodes (Sim-AM 2019)

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ABSTRACT

Uncontrolled CO_2 and CH_4 emissions can have a great influence on the climate impacts. The emission occurs in a variety of ways; such as leakage from mechanical seals on compressors, turbines, and also from pneumatic devices, which are designed to vent gas as part of the operation. The Studies show that the major emission sources are related to pneumatic devices/pumps and equipment leaks, accounting for approximately 60% of emissions. In the quest to reduce the climate effects caused by CO_2 and CH_4 emissions, the improvement of the Fluidic Diodes in multi-stage pumps, and compressors becomes a necessity. This paper discusses the Topology Optimization of Ionic Polymer Metal Composite (IPMC) integrated Fluidic Diodes. Main advantages of IPMCs compared to conventional smart materials consist large deformation, low voltage actuation, and low weight. Due to these characteristics, IPMCs are a promising candidate for manipulation of the fluid. The interaction of the IPMC with flow inside the Fluidic Diodes absorb their energy and release at appropriate phase. A model is developed by coupling equations of governing IPMC deformation (chemo-electro-mechanical) and Navier-Stokes equation to describe IPMC-fluid interaction. This model implementation is based on comcoupling a wide range of physics including the fluid-structure interaction (FSI) and the Topology Optimization. Then, a Topology Optimization Method consists of density method, fluid domain introduced by Borvall, Solid Isotropic Material with Penalization and solver by using Sparse nonlinear OPTimizer (SNOPT) solver is coupled with chemo-electro-mechanical model and Navier-Stokes equations to simulate the behavior of the IPMC integrated Fluidic Diodes and to optimize the performance of the Fluidic Diodes leakage. Extending the topology optimization method to these physical domains generally involves some rethinking of the design problem to determine suitable design objectives. Post processed results e.g. Topology optimization design, fluid flow and pressure contour, etc. will be produced to employ in IPMC integrated labyrinth seal design. The results show the optimum design of Fluidic Diodes with minimum leakage.