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Modeling of a zero-net mass flux actuator for aqueous media[1]
BRADLEY AYERS, California State University, Northridge, CHARLES HENOCH, Naval Undersea Warfare Center, HAMID JOHARI, California State University, Northridge — A zero-net mass flux actuator was designed to maximize the jet thrust with a 3-in size constraint. The actuator was driven by a solenoid moving a piston in a cavity and when the solenoid circuit was opened, a return spring pulled the piston until the de-energized position was reached. Using the solenoid characteristics, a model was developed to assist in determining the optimal design parameters such as the piston diameter and stroke length, orifice diameter, and the spring constant. The model consisted of three separate elements: the solenoid and return spring forces; the fluid inertia within the cavity as well as the mass of moving parts; and the pressure loss associated with the orifice. The actuator model was used to determine the piston motion through one cycle. A piston stroke length of 4 mm and a cylinder bore of 45 mm was chosen resulting in a slug stroke ratio of 3.9. For the shortest possible waveform and the chosen actuator parameters, the model predicted the piston reaching its maximum stroke of 4 mm in 10 ms, and then returning to its resting position in 31 ms. Thus, a maximum frequency of 32 Hz was found for the shortest waveform in an ideal setup. The model predictions were compared with PIV measurements.

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