Numerical and Experimental Study of Piezoelectric Valveless Micropump

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ABSTRACT

The present paper aims to present the design, fabrication, and test of a novel valveless piezoelectrically actuated micropump. The proposed micropump mainly comprises a stainless-steel structured chamber with a piezoelectric (PZT) diaphragm as a driving source to propel liquid stream under actuation. An integrated diffuser/ nozzle bulge piece was devised to produce a flow resistance difference across the fluid inlet and the outlet for delivering a net liquid flowrate. During tests, the micropump, operating at the frequency of 250 Hz and the voltage of 160 Vpp, engendered a mean water flowrate up to 0.779 ml/min. In the analysis, the computational fluid dynamics (CFD) software ESI-CFD ACE+? was used to examine the time-varying flow phenomenon inside a full-scale PZT micropump throughout an actuation cycle. The computational approach adopted the transient three-dimensional conservation equations of mass and momentum with the moving boundary specified to represent the movement of the diaphragm. To validate the computer package, the predictions were compared with measured water flowrates generated by the micropump. The simulations revealed that the number of vortices and their rotating direction were determined by the driving amplitude and frequency of the diaphragm. At the frequency ranging from 100 to 250 Hz, the vortex pairs were clearly formed and thereby caused a relatively high pressure drop near the diffuser outlet inside the micropump chamber. In effect, the presence of vortex pairs could develop distinct resistance characteristics in the advancing and retreating phases of the PZT diaphragm to generate a net pumping flowrate from the inlet to the outlet over a full actuation cycle. Numerical experiments were also carried out by varying the opening angle of the diffuser/nozzle module within the range of 8 ° －12 ° , the angle setting of 8 ° can provide the best performance in term of the maximum pumping flowrate achieved.

Keywords : Valveless micropump、Piezoelectric actuator、CFD simulation、MEMS

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