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Level Set-Based Topology Optimization Using the Lattice Boltzmann Method Considering Two-Phase Fluid Flows

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Abstract

This paper presents a topology optimization method using the lattice Boltzmann method for the design of a flow channel considering two-phase fluid flows. This approach enables the design of fluidic devices such as two-phase microchannels that achieve a desired flow with maximal performances such as mixing and reaction, and extraction efficiencies. The optimization problems are formulated using the continuous Boltzmann equation, and the design sensitivities are derived based on the adjoint lattice Boltzmann method. In the adjoint lattice Boltzmann method, based on a novel discretization strategy similar to that of the lattice Boltzmann method, the adjoint equations can be implemented as simple time evolution equations. Based on the above formulations, we construct a topology optimization method incorporating level set boundary expressions for the design of a two-phase microchannel that aims to maximize extraction efficiency while minimizing the pressure drop. A numerical example is provided to confirm the utility of the proposed method.

Keywords: topology optimization; lattice boltzmann method; two-phase flow; level set method.