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Micro-Channel Flows Simulation Based on Nonlinear Coupled Constitutive Model

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Abstract : MicroElectrical-Mechanical System (MEMS) is one of the most rapidly developing frontier research field both in theory study and applied technology. Micro-channel is a very important link component of MEMS. With the research and development of MEMS, the size of the micro-devices and the micro-channels becomes further smaller. Compared with the macroscale flow, the flow characteristics of gas in the micro-channel have changed, and the rarefaction effect appears obviously. However, for the rarefied gas and microscale flow, Navier-Stokes-Fourier (NSF) equations are no longer appropriate due to the breakup of the continuum hypothesis. A Nonlinear Coupled Constitutive Model (NCCM) has been derived from the Boltzmann equation to describe the characteristics of both continuum and rarefied gas flows. We apply the present scheme to simulate continuum and rarefied gas flows in a micro-channel structure. And for comparison, we apply other widely used methods which based on particle simulation or direct solution of distribution function, such as Direct simulation of Monte Carlo (DSMC), Unified Gas-Kinetic Scheme (UGKS) and Lattice Boltzmann Method (LBM), to simulate the flows. The results show that the present solution is in better agreement with the experimental data and the DSMC, UGKS and LBM results than the NSF results in rarefied cases but is in good agreement with the NSF results in continuum cases. And some characteristics of both continuum and rarefied gas flows are observed and analyzed.

Keywords : continuum and rarefied gas flows, discontinuous Galerkin method, generalized hydrodynamic equations, numerical simulation
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