AN ISOTHERMAL COMPRESSIBLE SLIP GAS FLOW THROUGH MICROTUBE

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Abstract

In this paper the authors considered compressible isothermal steady subsonic slip gas flow through microtube at low Reynolds numbers. The dimensions of the components in microelectromechanical systems (MEMS) are very small (the order of magnitude is 1 μm), and because of that the effect of gas rarefaction cannot be neglected, so it should be taken into account. In the analyzed problem gas flow occurs due to the pressure difference at the inlet and outlet section of the circular microtube, with the variable cross-section (convergent case, divergent case, case with constant radius).

The solving approach in the paper is macroscopic, so the fluid flow is defined by the continuity and Navier-Stokes equations. The rarefaction effect is taken into account by the velocity slip boundary condition at the walls. The solution process is based on a perturbation analysis where the order of the terms in the governing equations and boundary conditions is determined by using the exact relation between Mach, Reynolds and Knudsen numbers. Therefore, with this problem-solving procedure, two approximations for the pressure and velocity fields are obtained. The first approximation of the characteristic variables corresponds to the conditions of continuum flow, while the second approximation shows the effects of rarefied gas flow.

Keywords: microelectromechanical systems, Navier-Stokes equations