HEAT TRANSFER IN A POROUS MICROCHANNELS WITH SECOND ORDER SLIPPING BOUNDARY CONDITIONS

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In recent years a wide range of microdevices has emerged partially or completely filled with a porous medium, and the results of studying physical processes in them find their application in many industries. The purpose of this work is the study of hydrodynamics and heat transfer under forced convection in a flat and circular microchannels incorporating porous medium under slip boundary conditions of the first and second order.

Effects of porosity and slip velocity on velocity and temperature profiles were investigated. Behavior of the normalized Nusselt number as a function of the Knudsen and Prandtl numbers, as well as the parameter M characterizing porosity of the medium in the microchannel was also elucidated. The problem was solved analytically and compared with a numerical solution based on the Boltzmann lattice method.

Computations indicated that a decrease in porosity (an increase in the parameter M) causes decrease in the velocity and temperature jumps on the wall, which contributes to the increase in the Nusselt number. Considering the effect of the second-order slip boundary conditions leads to the decrease in the velocity jump on the wall, when the coefficient A_2 (this coefficient considers the second-order slip boundary conditions) changes from negative to positive values.The heat transfer rate at high Prandtl numbers increases with the increasing Knudsen number, because of the improved thermal interaction of the flow with the channel wall. Given the second-order boundary conditions, the effect of parameter A_2 was not observed at small Prandtl numbers (Pr≤1). For $A_2 < 0$, the second-order boundary conditions cause an increase in the normalized Nusselt number, whereas for $A_2 > 0$ the normalized Nusselt number decreases in comparison with the case of $A_2 = 0$ (the first-order boundary conditions).The results by the analytical solution and the lattice Boltzmann method are in a good agreement with each other for $A_2 \geq 0$, with the differences ≤ 1%. For $A_2<0$, the differences between two models are more noticeable. For $A_2 \geq 0$, predictions by the analytical model lie higher than the numerical results, whereas for $A_2 < 0$, numerical simulations exceed the analytical solution