A numerical study for a steady-state, two-dimensional, laminar convective heat transfer of a rarefied gas in a micro-tube is conducted using first-order slip velocity and temperature jump boundary conditions and taking into account the viscous dissipation and the axial conduction. The numerical model based on the finite volume method was validated using the available data for fully developed slip flow and developing continuum flow. The study reveals significant impact of slip velocity and temperature jump conditions and viscous dissipation on the velocity and temperature profiles at different sections of the micro-tube. The friction coefficient and the Nusselt number are substantially affected by rarefaction and viscous dissipation. The influence of the viscous dissipation depends on whether the fluid is heated or cooled. For the heating case, the Nusselt number distribution exhibits a special behavior characterized by the existence of a singular point where Nusselt number goes to the infinity. The thermal field development continues after the location of this singular point until reaching the fully developed regime. Furthermore, including viscous dissipation for continuum flow results in a significant increase in the Nusselt number regardless the value of the Brinkman number. Applying the temperature jump boundary condition reduces drastically the heat transfer rates along the micro-tube. The axial conduction improves the heat transfer process in the entrance region of the tube for low Peclet numbers and with no temperature jump condition.

Keywords: Micro-tubes; Slip flow; Jump temperature; Viscous dissipation; Heat conduction