Effect of surface roughness: comparison between continuum and kinetic approaches

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Abstract

In the present work a numerical analysis of the flow field in rough microchannels is carried out using two approaches: Navier-Stokes equations provided with first order slip- boundary condition and kinetic S-model equation with Maxwell diffuse reflecting boundary condition. An implicit scheme is used for the solution of S-model equation and an algorithm allowing massive parallelization in both physical and velocity spaces has been developed. The roughness geometry is modelled as a series of triangular obstructions with relative roughness ε equals to 1.25%, 2.5% and 5%. A wide range of Mach numbers is considered, from nearly incompressible to chocked flow conditions and a Reynolds number up to 170. To estimate rarefaction effect the flow at Knudsen number ranging from 0.01 to 0.08 and fixed pressure ratio has been considered. Accuracy and discrepancies between full Navier - Stokes and S- model solutions are discussed, assessing the range of applicability of first order slip condition in rough geometries. The effect of the roughness is discussed via Poiseuille number as a function of local Knudsen and Mach numbers.