Numerical analysis of thermal creep flow in curved channels for designing a prototype of Knudsen micropump

V Leontidis[1], J J Brandner[2], L Baldas[1] and S Colin[1]

[1]Université de Toulouse; INSA, UPS, Mines Albi, ISAE; ICA (Institut Clément Ader) 135 avenue de Rangueil, F-31077 Toulouse, France
[2]Karlsruhe Institute of Technology, Institute of Micro Process Engineering, Campus North, Hermann-von-Helmholtz-Platz 1, D-76344 Eggenstein-Leopoldshafen, Germany

E-mail: stephane.colin@insa-toulouse.fr

Abstract
The possibility to generate a gas flow inside a channel just by imposing a tangential temperature gradient along the walls without the existence of an initial pressure difference is well known. The gas must be under rarefied conditions, meaning that the system must operate between the slip and the free molecular flow regimes, either at low pressure or/and at micro/nano-scale dimensions. This phenomenon is at the basis of the operation principle of Knudsen pumps, which are actually compressors without any moving parts. Nowadays, gas flows in the slip flow regime through microchannels can be modeled using commercial Computational Fluid Dynamics softwares, because in this regime the compressible Navier- Stokes equations with appropriate boundary conditions are still valid. A simulation procedure has been developed for the modeling of thermal creep flow using ANSYS Fluent®. The implementation of the boundary conditions is achieved by developing User Defined Functions (UDFs) by means of C++ routines. The complete first order velocity slip boundary condition, including the thermal creep effects due to the axial temperature gradient and the effect of the wall curvature, and the temperature jump boundary condition are applied. The developed simulation tool is used for the preliminary design of Knudsen micropumps consisting of a sequence of curved and straight channels.