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PRESSURE AND TEMPERATURE-DRIVEN FLOWS THROUGH A SINGLE RECTANGULAR MICRO-CHANNEL

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ABSTRACT

The realistic description of the gas-surface interaction is a challenge for the modeling of the gas micro flows [1]. Several models are available for more or less complete description of this phenomenon. However the further investigations are needed to improve the existing models and to suggest the new ones [2].

The main objective of the present work is the systematic measurements of the pressure and temperature driven flows through a same single micro channel. The experimental results will be then analyzed to test the capacities of the available gas-surface models to provide the correct description of the gas molecules-solid surface interaction.

The measurements of pressure and temperature-driven flows through a single rectangular micro-channel are carried out. The rectangular micro-channel, used in this work, is similar to that implemented in Ref. [3] and have the following dimensions: height H=220µm, width W=1mm and length L=73mm. This channel was grooved on a PEEK (polyether ether ketone) plate and covered by a flat plate of same material. Two stainless steel blocks with gas reservoirs inside were placed vertically at each end of the micro-channel to achieve the temperature gradient. The experimental apparatus used in the present work is the same as in Ref. [3].

The typical behaviors of the pressure difference between the tanks in a pressure-driven-flow are evidenced in Fig.1(a). The exponential fit of this pressure difference is used for the mass flow rate extraction, and it is shown in Eq.(1). The dimensionless mass flow rate (G), defined in Eq.(2), obtained for nitrogen using two different pressure transducers (10torr and 1000torr) is shown in Fig.1(b). The dimensionless mass flow rate was obtained also for argon and helium, using the 10torr pressure transducers, see Fig.1(c).

$$\Delta p(t) = (p_h - p_c)e^{-t/\tau} \tag{1}$$

$$G = \frac{\mathrm{L}\sqrt{2RT}}{H^2 w \Delta p} \tag{2}$$

A series of the temperature driven flow measurements using the same principle of the pressure relaxation as it was proposed in [3] will complete the experimental data base. The measured thermal molecular pressure difference as function of δ is show in Fig.1(d).

The obtained data base with the carefully estimations of the experimental errors can then be used to test the availability of different scattering kernels implemented in the Boltzmann equation (or in kinetic models) to reproduce the measured parameters as pressure variations with time and the mass flow rate.

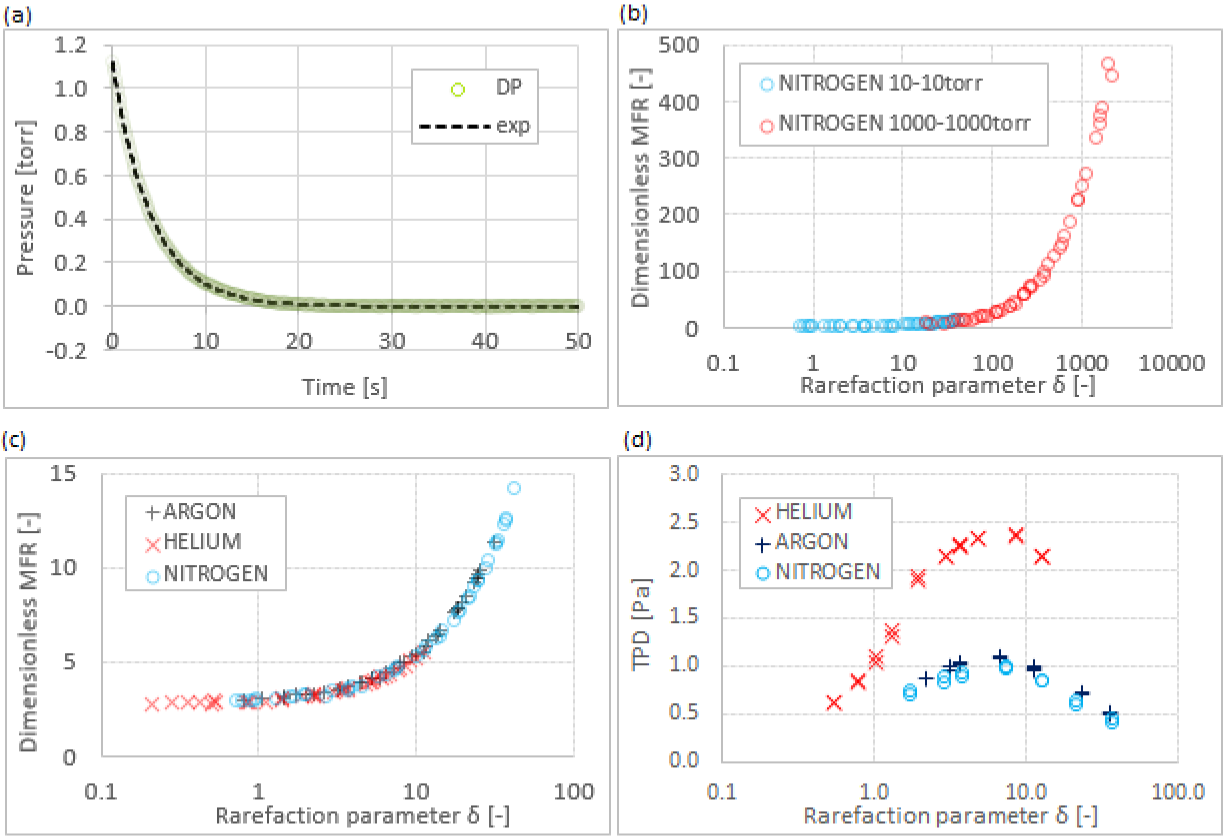

Figure 1: (a) Typical behavior of pressure difference between the tanks in pressure-driven-flow. Dimensionless mass flow rate as a function of rarefaction parameter for (b) nitrogen for a large range of δ and (c) argon, helium and nitrogen for a moderate range of δ. (d) Thermal molecular pressure difference for argon, helium and nitrogen.

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