MIGRATEWS2016-25

THERMAL TRANSPIRATION IN COMPLEX GEOMETRIES

Irina Graur , Pierre Perrier*[1], Stefan Stefanov[2], Martin Wüest[3]
[1]Aix-Marseille Université, CNRS, IUSTI UMR 7343, 5 rue Enrico Fermi,
13453 Marseille, France
irina.martin@univ-amu.fr, pierre.perrier@univ-amu.fr,
[2]Institute of Mechanics, Bulgarian Academy of Sciences, Sofia, Bulgaria
stefanov@imbm.bas.bg
[3]INFICON, CH-4002 Basel, Switzerland
Martin.Wuest@inficon.com

KEY WORDS

Thermal transpiration, rarefied gas, microfluidic

ABSTRACT

The thermal transpiration (thermal creep) is one of the most interesting phenomena to obtain a mass flow when the Knudsen number is relatively high. This flow is induced by a temperature gradient along a surface, and it is directed from the cold side to the hot side. The Knudsen number is defined as a ratio between the molecular mean free path and characteristic length of a system. This number can become significant in a low pressure environment and/or in a small-scale flow field. Recently, it has attracted much attention due to the rapid development of micro and nano-technologies. The manifestation of this phenomenon may be the solution to convey a gas using only a temperature gradient [1]. Conversely, the additional flow within a pressure sensor may disturb the pressure measurements.

This project aims to study experimentally the properties of the gas flow driven by a temperature gradient in complex geometries. The magnitude of the temperature driven mass flow rate depends on the gas nature, the surface properties, the intensity of the temperature gradient and the geometry of a channel. In the past some results on the temperature transpiration flow in complex geometries like a porous media were obtained [2-5].

The experimental system was developed and has been already used to measure the thermal creep effect in micro-channels of different cross-section shapes [6-9]. A new experimental setup will be designed to measure the temperature driven flow through various porous structures. We will start by measuring the pressure gradient driven flow. From these measurements we can extract a geometrical characteristic of the studied porous media. Then, we will apply the temperature gradient along a porous membrane and we will measure the corresponding mass flow rate. The various gases will be used to quantify the influence of the gas nature on the intensity of the temperature driven mass flow rate. The further step will be an attempts to analyse experimentally the gas permeability of various porous structures to find an uniform low of their characteristics.

* Corresponding author

The classical DSMC method with some modifications will be applied to simulate the gas flow through the porous media [10]. Then, the comparison between the experimental and numerical data will be carried out in terms of the mass flow rate and the macroscopic flow velocity. The time dependent characteristic of the macroscopic flows will be also analysed.

ACKNOWLEDGEMENTS

This work has been carried out in the framework of the Labex MEC (ANR-10-LABX-0092) and of the A*MIDEX project (ANR-11-IDEX-0001-02), funded by the 'Investissements d'Avenir' French Government programme managed by the French National Research Agency (ANR).

REFERENCES AND CITATIONS

[1] Martini, V., Bernandini, S., Bendahan, M., Aguir, K., Perrier, P., Graur, I. (2012) *Microfluidic gas sensor with integrated pumping system*. Sensors Actuators B 170, 45–50.
[2] Reynolds, O. (1879). *On certain dimensional properties of matter in the gaseous state*. part i and part ii. Philosophical Transactions of the Royal Society of London, 170, 727{845. xx, 2, 39, 40
[3] Han, Y-L., and E. P. Muntz. *Experimental investigation of micro-mesoscale Knudsen compressor performance at low pressures*. Journal of Vacuum Science & Technology B 25.3 (2007): 703-714.
[4] Gupta, N. & Gianchandani, Y. (2008). *Thermal transpiration in zeolites: A mechanism for motionless gas pumps*. Applied Physics Letters, 93, 193511. 54
[5] Maxwell, J. (1867). *On the dynamical theory of gases*. Philosophical Transactions of the Royal Society of London, 157, 49{88. 13, 16
[6] Rojas-Cardenas, M., Graur, I., Perrier, P. & Meolans, J. G. (2011) *Thermal transpiration flow: A circular cross-section microtube submitted to a temperature gradient*. Physics of Fluids 23, 031702.
[7] Rojas-Cardenas, M., Graur, I., Perrier, P. & Meolans, J. G. (2013) *Time-dependent experimental analysis of a thermal transpiration rarefied gas flow*. *Phys. Fluids* 25, 072001.
[8] Yamaguchi, H., Rojas-Cardenas, M., Perrier, P., Graur, I. ,Niimi, T. (2014) *Thermal transpiration flow through a single rectangular channel*. Journal of Fluid Mechanics 744, 169–182.
[9] Rojas-Cardenas, M., Graur, I., Perrier, P. & Meolans, J. G. (2015) A new method to measure the thermal slip coefficient. *Intl J. Heat Mass Transfer* 88, 766–774.
[10] Stefanov, S.(2010), *A DSMC algorithm for gaseous flows through rough microchannels*, CD Proceedings of the 1st GASMEMS Workshop- Eindhoven, GASMEMS09-07, www.gasmems.eu