# UNSTEADY VACUUM GAS FLOW IN CYLINDRICAL TUBES

D. Valougeorgis, J. Lihnaropoulos

*Department of Mechanical Engineering, Univesrity of Thessaly, 38334 Volos, Greece*

*Corresponding author: diva@mie.uth.gr*

Over the years time independent gas vacuum flows through channels of various cross sections have been successfully studied, based on kinetic theory. The implementation of a mesoscale kinetic solution provides reliable results in the whole range of the Knudsen number with modest computational effort [1, 2, 3]. Relative work examining the corresponding time dependent vacuum flow configurations is limited.

It is obvious however, that there is both theoretical and practical interest in the investigation of transient gas vacuum flows. Some unsteady rarefied flows, which have been solved following an unsteady linear kinetic formulation, include the unsteady Couette and Stokes problems. Assuming an oscillatory motion of the non-stationary plate yields a time-independent set of governing kinetic equations to be solved, while the transient nature of the problems is examined through the non-dimensionalized frequency of oscillation, which is included as a parameter.

In this work the starting gas flow in a cylindrical channel is investigated in the whole range of the Knudsen number by numerically solving in a fully deterministic manner the governing time dependent kinetic equations. The gas is initially at rest and then due to a suddenly imposed uniform pressure gradient, it is starting to flow. The motion is time dependent up to the point where the steady-state flow conditions are recovered. The flow field is modeled by the linearized unsteady BGK equation subject to diffuse boundary conditions. The solution provides a detailed description of the evolution of the flow field with regard to time from the starting point, where the gas is at rest up to a certain time where almost steady-state conditions are recovered. Based on the results some insight of how rapidly a vacuum flow will respond to a sudden change, related to an externally imposed pressure gradient coming from a vacuum pump or a valve, is obtained.

[1] S. Naris, D. Valougeorgis, Physics of Fluids, 19 (6), 2007, pp 067103.1-15.
[2] S. Varoutis et al., Journal of Vacuum Science and Technology A, 27 (1), 2009, pp 89-100.
[3] S. Varoutis et al. Journal of Vacuum Science and Technology A, 27 (6), 2009, pp 1377-1391.