Design and optimization of a Holweck pump via linear kinetic theory

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Abstract

The Holweck pump is widely used in the vacuum pumping industry. It can be a self standing apparatus or it can be part of a more advanced pumping system. It is composed by an inner rotating cylinder (rotor) and an outer stationary cylinder (stator). One of them has spiral guided grooves resulting to a gas motion from the high towards the low vacuum port. Vacuum pumps may be simulated by the DSMC method but due to the involved high computational cost in many cases manufactures commonly resort to empirical formulas and experimental data. Recently a computationally efficient simulation of the Holweck pump via linear kinetic theory has been proposed by Sharipov et al [1]. Neglecting curvature and end effects the gas flow configuration through the helicoidal channels is decomposed into four basic flows. They correspond to pressure and boundary driven flows through a grooved channel and through a long channel with a T shape cross section. Although the formulation and the methodology are explained in detail, results are very limited and more important they are presented in a normalized way which does not provide the needed information about the pump performance in terms of the involved geometrical and flow parameters. In the present work the four basic flows are solved numerically based on the linearized BGK model equation subjected to diffuse boundary conditions. The results obtained are combined in order to create a database of the flow characteristics for a large spectrum of the rarefaction parameter and various geometrical configurations. Based on this database the performance characteristics which are critical in the design of the Holweck pump are computed and the design parameters such as the angle of the pump and the rotational speed are optimized. This modeling may be extended to other vacuum pumps.