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A continuum model for pumping performance of turbomolecular pumps in all flow regimes

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Abstract

In the present study a continuum model for one-dimensional plane Couette–Poiseuille flow is implemented to turbomolecular pumps in different flow regimes. Pumping performance of various turbomolecular pumps including 6 single rotors, a rotor–stator row, a rotor–stator–rotor row, and a multi-row with 13 alternative rotor–stator rows is considered here. The obtained results show that the model provides good quantitative values for pumping performance of turbomolecular pumps over the whole regimes ranging from molecular flow to transition to slip flow.

Keywords: Turbomolecular pump; Couette–Poiseuille flow; Slip flow; Free molecular flow

1. Introduction

Although the invention of the turbomolecular pumps (TMPs) is attributed to Becker [1], the pumping performance of TMP in free molecular flow was first investigated experimentally and theoretically by Kruger and Shapiro [2]. Their study was based on parallel flat-plate blades with infinite height, and calculations were made on single-row and multi-row blades using Monte Carlo method. Sawada et al. [3] studied flat blades with finite height for a single rotor using an integration method. Sawada extended his work to rotor–stator rows [4] and then evaluated the pumping performance of multi-row TMPs by multiplying of the transmission probabilities of individual blade rows [5]. Katsimichas et al. [6] simulated free molecular flow within a single rotor machine with a three-dimensional flat-plate blade using Monte Carlo method. Their calculations were done in the rotational reference of frame where the molecular paths are not straight lines. Also Hosseinalipour et al. [7] and Amoli et al. [8] simulated free molecular flow within three-dimensional single rotor and multi-row TMPs in an inertial reference of frame regarding the real topology of the blades.

In the above researches the simulations were limited to free molecular flow where TMPs have appropriate operation. At this situation the

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