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A New Procedure for Designing Blade Arrangements of a Turbomolecular Pump

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Abstract. The designing curves of turbomolecular pumps are usually obtained assuming the Maxwellian velocity distribution for inlet and outlet sides of a single rotor or a rotor-stator row. In these procedures the relative velocity of molecules flying into both sides of the stage is not considered which yields a rough estimation of designing curve and correspondingly a rough method to design the blade arrangements for a multi-row turbomolecular pump. The present work attempts to improve the designing curve of a rotor-stator row by considering effects of adjacent stages. An iterative procedure is used to modify the flow conditions at both sides of the rotor-stator row. The results show the greater compression ratio comparing to the ones without considering the effect of adjacent stages.

INTRODUCTION

The TMPs (turbomolecular pumps) are widely used in scientific and industrial applications for their provision of higher and cleaner vacuum compared to oil diffusion pumps. Different numerical and experimental works have been carried out in order to investigate the performance of TMPs. The pumping performance of TMPs in free molecular flow regime was first investigated experimentally and theoretically by Kruger [1]. His study was based on parallel flat-plate blades with infinite height, and calculations were made on single-row and multi-row blades by both numerical and Monte Carlo methods. He studied the effects of the blade geometrical characteristics on the performance of the single rotor and provided TMP performance curve.

Sawada et al. studied flat blades with finite height for a single rotor using an integration method [2]. The method was based on some geometrical calculations for the transmission of molecules from elements of the blade and integration of these elements on the blade boundary. Using this method, Sawada presented the design curve of a plane three-dimensional single rotor for the first time [3]. He then used these results to obtain a multi-row TMP designing curve. He assumed the same performances for rotor and stator and the Maxwellian velocity distributions in the both sides of the single rotor in his work. Also he did not consider the effect of blade height on the designing curve of TMP.

Hosseinalipour et al. [4] presented an improved designing curve using a fully three-dimensional simulation for a single rotor by considering the effect of blade height in their calculations. They considered Maxwellian velocity distributions for both sides of the single rotor. Amoli et al. [5] improved their work by extending their method for a rotor-stator row. However, the Maxwellian velocity distributions were already assumed for the both sides of the rotor-stator row.

In all aforementioned studies the performance curve of a single rotor or a rotor-stator row are used to obtain the designing curve for a multi-row TMP. As the velocity distribution between the stages is not Maxwellian in real situations, due to the effects of the adjacent stages, the previous efforts are faced with some draw backs. To