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Modeling of Vacuum Systems: Discrete and Continuum Physical-Mathematical Approaches

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This work presents analytical and numerical results for modeling of general vacuum system using discrete and continuum physical-mathematical approach. In traditional vacuum technology, in other words, in discrete approach, the three main parts of the vacuum system –vacuum chamber, pumping line and vacuum pumps – are dealt in separated and watertight parts. This approach simplifies the treatment, but at the price of giving only, in some cases, average values for the pressure of the vacuum chamber of the vacuum system. To solve this kind of approach we have in general an ordinary differential equation. By other hand, we have the possibility to find the pressure field and its gradient in vacuum chamber and in pumping line of the vacuum system. This approach we are calling the continuum approach, because the mathematical approach is the same in transport phenomena. This work presents and describes in detail the pressure profile in along of the several high-vacuum systems with transient gas source plus the steady-state outgassing. The fundamental assumption to perform this analyse using continuum approach is consider the transport gas flow in the molecular regimen is a diffusion phenomenon. Mathematical and physical formulations are given and detailed; specific conductance and specific throughput are defined; and a detailed discussion about the boundary conditions, in all possible situations, is presented. These concepts and approach are applied to usual realistic cases and we compare the discrete and continuum approaches to some high vacuum systems. The results obtained by the discrete and continuum approaches to the same cases and analysed.

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