Free-molecular Gas Flow Through the High-frequency Oscillating Membrane

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Membrane technologies are essential in many areas, mainly for the filtration and purification of liquids and gases, separating mixtures and as functional components of modern micro- and nano-electromechanical systems (MEMS, NEMS). Modern production techniques allow to obtain membranes with a wide range of characteristics. One type of membranes – track membranes are produced by irradiation of polymeric films of high-energy particles (accelerated heavy ions or fission fragments). In that way the through holes ("tracks") are formed in the film. The resulting pores are linear and have small variation in diameter – less than 5%, their diameter can be 10 – 100 nm. Thus, the main distinguishing features of the track membranes – small thickness and high uniformity of the pore size.

In this paper the possibility of using a high frequency oscillating track membranes as diffusion membranes for gas separation was studied. High frequency forced oscillation of the membrane was considered because of assumption that the membrane conductivity for a given gas can be controlled by varying the frequency and amplitude of oscillation. The problem about free-molecular gas flow through a oscillating in its plane membrane was stated and the possibility of separation of gases using such a device was investigated.

The gas flow through moving membrane was studied. Membrane was simulated by rigid body with straight cylindrical channels. Channels length was L (thickness of membrane), channels radius was R, channels axis was perpendicular to the membrane surface (see Figure 1). Membrane was placed between two tanks (1) and (2) with constant pressures P_1, P_2 and temperatures T_1, T_2 ($T_1 = T_2 = T_w$, where T_w – temperature of membrane material).

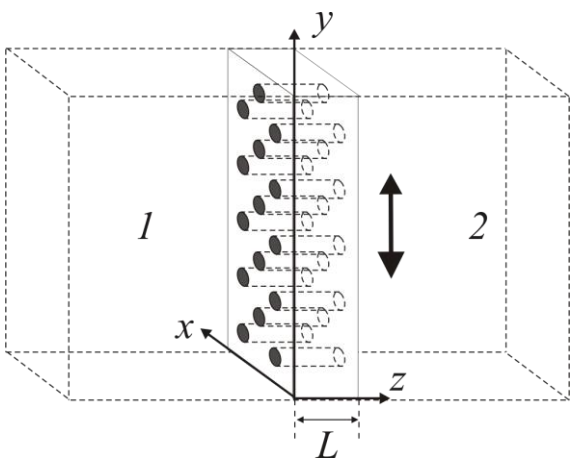

Figure 1. Problem scheme: 1, 2 – tanks, separated by track membrane, oscillation direction shown by arrow (y-axis).

Problem was solved numerically by event-driven molecular dynamics method. Passing probability was obtained in dependence on dimensionless parameters. It was shown that varying the frequency and amplitude of oscillation can lead to difference of membrane conductivity for gases with different molecular mass. This means that one can control the conductivity of the membrane for a given gas by changing the parameters of its forced oscillations.

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