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ABSTRACT:

Hydrogen Diffusivity in Glass Fibre-Filled Volumes at Low Pressure

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The idea of adjusting the performance of thermal insulation materials according to external conditions seems attractive, but its realisation requires a deep understanding of the relevant physical phenomena. This study examines the feasibility of manufacturing a vacuum-insulating panel (VIP) in which changing the internal pressure from high vacuum (10-4 mbar) to coarse vacuum (~ 1 mbar) enables a variation in thermal insulation efficiency by an order of magnitude. The inner pressure is controlled by temperature-adjusted hydrogen pre-charging of a getter placed in a small volume connected to the main VIP.

One of the main parameters of adjustable VIP is an acceptably short transition time between steady-state pressure values. It depends on hydrogen release and its pumping by the getter, as well as on hydrogen transport within the VIP. The latter can be predicted when the gas's diffusivity is known. Unfortunately, this parameter was studied in selected porous materials mostly at high pressures, but rarely in the molecular regime [1]. For the present study, an all-metal UHV system with inert-pressure gauges was used. The effective conductance of selected glass fibre-filled tubes was determined using the dynamic method and compared to the known conductance of empty tubes. The selected porosity was ~90%, which is the typical value achieved under atmospheric-pressure loading of the VIP. Besides the hydrogen, nitrogen and argon were applied in the tests. The values of diffusivity enable the calculation of transition times of a VIP after setting a new pressure. For some selected VIP sizes and connecting tubes, the measured transient times were compared to calculated values. The agreement is good, indicating that the desired values are achievable within acceptably short transient times even for large-area VIPs.

[1] Rutherford, S.W.; Do, D.D.: Review of time lag permeation technique as a method for characterisation of porous media and membranes. Adsorption 1997, 3, 283–312.