EVACUATED SUPERINSULATIONS

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ABSTRACT

Thermal insulations with apparent thermal conductivities less than 0.0072 W/m·K (0.05 Btu·in./ft2·h·°F) are often termed superinsulations. The important class of superinsulations based on evacuated porous media will be discussed in this presentation. This category of thermal insulation includes powder-filled, fiber-filled, and composite-filled evacuated regions bounded by a barrier material. The filled region has low gas-phase conductive transport, low radiative transport, negligible convective transport, and moderate solid-phase conductive transport.

The reduction of gas-phase thermal conductivity results from lowering the system pressure to reduce the rate of molecular collisions. If, in addition, the gas phase is partitioned by the presence of fine particles, then the number of gas-phase molecular collisions is further reduced. The design objective is for the dimensions of typical void spaces in the powder to be less than the average distance a gas molecule travels between collisions. This distance increases as the pressure is reduced.

Fine powders with minimum solid-solid contact exhibit the best thermal performance. Special processing is used to produce spherical particles; milling can also be used to reduce particle size. The filler powder serves to reduce radiative transport, so the opacity of the powder is an important design consideration.

The thermal resistance of evacuated superinsulations decreases with time if there is inward diffusion of air or water. Materials used to package the evacuated powders must be selected to reduce mass transfer as much as possible without increasing the heat transfer around the edges of the powder-filled region.

The physical basis for superinsulations will be discussed along with the important design considerations. The special factors needed in testing and evaluation of evacuated superinsulations will be identified along with projections concerning their use in refrigerators and freezers.

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