Multilayer Thermal Insulation Blankets for Terrestrial and Space-Related Applications: Thermal Modelling and Experimental Issues

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Multi-Layer Insulation (MLI) consists of closely spaced shields of Mylar or Kapton, covered (at one side or at both sides) with a coating of aluminium, silver, or gold. MLI blankets often contain spacers (e.g. course-netting material) to keep the shields properly separated. MLI reduces the heat flux rate between a hot and a cold boundary surface, thus preventing large heat leaks. Cryogenic storage systems, sensors, payloads, and full-size satellite (sub-) systems can be wrapped in insulation blankets to thermally isolate them and reduce the thermal control requirements.

Models describing the thermal performance of evacuated MLI blankets are usually based on the simple addition of the three mutually interacting modes of energy transfer, being:

- Radiation between the shields.
- Solid conduction, via the components and their interfaces.
- Gas conduction in the interstices, determined by residual gas pressure, the outgassing of the shields and spacer materials, and the way the outgassing products migrate through the blanket.

MLI blankets for spacecraft applications are usually made of perforated shields to allow a fast depressurisation during the spacecraft launch. Unfortunately, the perforations impair the insulation quality of a blanket, because:

- The perforation holes increase the effective shield emissivity, hence the radiation transfer.
- The holes allow broadside pumping: Outgas products migrate via the holes, from interstice to interstice, gradually accumulating until they eventually escape at the blanket boundary.

Reported models concern purely edge pumped blankets, consisting of non-perforated shields (MLI blankets in Dewars, vessels to store cryogenic liquids). Outgas products can escape in these blankets only at the edges of the interstices. The pumping in MLI blankets for spacecraft usually is hybrid pumping, a combination of edge and broadside. This paper presents the model developed to account for this hybrid pumping.

Experiments have been carried out on several blanket samples using a guarded hot plate calorimeter placed in a vacuum chamber. The presented results illustrate a good agreement between theory and experiment.