THERMAL CONDUCTIVITY MEASUREMENT OF POWDER INSULATION

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Introduction

We have developed a new instrument to measure the temperature dependence to the thermal conductivity of porous insulating materials. The instrument is capable of measuring the thermal conductivity over the temperature range between 20 K and 300 K, also allowing measurements as a function of residual gas pressure. This thermal conductivity instrument is a precision device capable of conducting similar measurements as new materials are developed. In this report, we describe the instrument and recent thermal conductivity results on aerogel measured during cool-down in a liquid nitrogen bath.

Experimental

The experimental apparatus was designed based on two concentric cylinders with the annular gap filled with the insulating material [1]. The outer cylinder is 610 mm long and has a 190 mm inner diameter while the inner cylinder is 584 mm long and has a 165 mm outer diameter. These dimensions provide a uniform annular gap for the insulation of about 12.7 mm. The outer cylinder is designed to be removable so that the insulation material can be changed. The inner cylinder is supported from the outer by three low thermal conductivity tension members. It is filled with helium gas and contains a heater and two thermometers. The outer cylinder is also vacuum-tight so that the annular space can contain insulation material and possibly a residual gas pressure. At the initial phase of experiment, the annular space between two copper cylinders is filled with aerogel and evacuated several times in order to ensure the complete settling of powder. In these first experiments, the experimental apparatus is immersed in liquid nitrogen bath and slowly cooled to near liquid nitrogen temperature. During cool-down all temperatures are measured, from which the effective thermal conductivity of powder insulation is evaluated.

Results and Discussion

During the cool-down, with a vacuum in the powder annular space around 5×10^{-4} millibar, the temperature of inner cylinder decreases very slowly, at approximately 5 mK/min, allowing a quasi-steady state condition to be achieved. Thus, the effective thermal conductivity of the powder can be calculated from the net heat transfer rate during the cool-down. In the present experiments, the effective thermal conductivity of aerogel, measured over the temperature range between 90 K and 200 K, shows an increasing value from 0.3 ~ 0.8 mW/m-K, at the highest temperatures. The effective thermal conductivity of aerogel decreases with temperature, which is consistent with previous results [2]. Compared to the apparent thermal conductivity of aerogel when the boundary temperatures are fixed at 293 K and 77 K [2], we note that our experimental data is about 20 % lower. Further experimental data in steady-state is required to increase our experimental confidence in these results.

Conclusions

A new instrument was successfully developed for measurement of the thermal conductivity of powder insulation material. Utilizing this instrument, preliminary data during cool-down in a liquid nitrogen bath was obtained, from which the effective thermal conductivity of powder insulation material was evaluated. The thermal conductivity of aerogel decreases with temperature, and it is in the range of 0.3 ~ 0.8 mW/m-K for temperature between 90 K and 200 K.

Acknowledgements

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References

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