



Technology Focus: Test & Measurement

Instrument for Measuring Thermal Conductivity of Materials at Low Temperatures

Applications include development of novel materials as well as quality control for materials and process requirements.

John F. Kennedy Space Center, Florida

With the advance of polymer and other non-metallic material sciences, whole new series of polymeric materials and composites are being created. These materials are being optimized for many different applications including cryogenic and low-temperature industrial processes. Engineers need these data to perform detailed system designs and enable new design possibilities for improved control, reliability, and efficiency in specific applications. One main area of interest is cryogenic structural elements and fluid handling components and other parts, films, and coatings for low-temperature application. An important thermal property of these new materials is the apparent thermal conductivity (k -value).

Thermal conductivity testing is needed as part of the physical characterization of these various new and innovative polymers and composites. The Cryogenics Test Laboratory (CTL) at Kennedy Space Center designed and built a cryostat test instrument to measure the thermal conductivity of these types of materials at low temperatures. The instrument, known as the Cup Cryostat, is a small-scale cryogenic boil-off calorimeter designed to de-

termine the apparent thermal conductivity (k -value in milliwatt per meter-Kelvin) of materials for cryogenic temperatures and specifically at large temperature differences. Boundary temperatures are typically 300 K and 80 K, or any temperature difference in this range. The instrument's direct measure of the rate of thermal-energy transfer (power, in watts) provides relative thermal performance among materials (i.e., comparative k -value).

The Cup Cryostat method provides thermal conductivity data under representative-usage conditions, including a large temperature difference (ΔT) that is typical for most cryogenic applications. The materials are tested in a way that approximates the way such material would be implemented to solve engineering design problems. The new method is therefore complementary to the small temperature difference data generated by existing standard methods. The Cup Cryostat uses moderate size 75-mm-diameter round specimens, which is reasonable for the production of novel research materials. Thicknesses of up to 13 mm are permitted, but a 6.5-mm thick specimen is typical. The Cup Cryostat also provides mechanical compression loading capability so that thermal

performance data can be obtained under representative mechanical loading. In addition to nitrogen, the Cup Cryostat can be operated with other fluids, such as Freon and other suitable liquid refrigerants. For porous materials, residual gases such as helium, air, nitrogen, argon, or carbon dioxide may be selected for the environmental condition. All tests are performed at ambient (room) pressure. The compact design of the Cup Cryostat allows for specimen installation, system preparation, and cryogenic testing to be completed in less than one day, which means that costly set-up within a vacuum chamber is avoided.

The Cup Cryostat is designed to determine the apparent thermal conductivity under representative-use conditions of large ΔT and also with appropriate compressive loading, as desired. The test is comparative in nature, so absolute values must be obtained by direct comparison with known materials.

This work was done by James Fesmire, Jared Sass, and Wesley Johnson of Kennedy Space Center. For more information, contact the Kennedy Space Center Innovative Partnerships Program Office at (321) 867-5033. KSC-13217

Multi-Axis Accelerometer Calibration System

Langley Research Center, Hampton, Virginia

A low-cost, portable, and simplified system has been developed that is suitable for *in-situ* calibration and/or evaluation of multi-axis inertial measurement instruments (e.g.,). This system overcomes facility restrictions and maintains or improves the calibration quality for users of accelerometer-based instruments with applications in avionics, experimental wind tunnel research, and force balance calibration applications. The apparatus quickly

and easily positions a multi-axis accelerometer system into a precisely known orientation suitable for *in-situ* quality checks and calibration. In addition, the system incorporates powerful and sophisticated statistical methods, known as response surface methodology and statistical quality control. These methods improve calibration quality, reduce calibration time, and allow for increased calibration frequency, which enables the monitoring

of instrument stability over time. This technology overcomes the limitations and restrictions on accelerometer calibration facilities by:

- Minimizing reliance on a fixed calibration system,
- Leveraging the user's data acquisition system,
- Allowing for increased calibration frequency due to improved accessibility, and
- Automatically compensating for local gravitational field.