Composite Materials for Low-Temperature Applications

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Propellant Loading/ Servicing/Storage

Composite materials with improved thermal conductivity and good mechanical-strength properties should allow for the design and construction of more thermally efficient components (such as pipes and valves) for use in fluid-processing systems. These materials should have wide application in any number of systems, including ground support equipment (GSE), lunar systems, and flight hardware that need reduced heat transfer. Researchers from the Polymer Science and Technology Laboratory and the Cryogenics Laboratory at Kennedy Space Center were able to develop a new series of composite materials that can meet NASA's needs for lightweight materials/composites for use in fluid systems and also expand the plastic-additive markets. With respect to thermal conductivity and physical properties, these materials are excellent alternatives to prior composite materials and can be used in the aerospace, automotive, military, electronics, food-packaging, and textile markets. One specific application of the polymeric composition is for use in tanks, pipes, valves, structural supports, and components for hot or cold fluid-processing systems where heat flow through materials is a problem to be avoided. These materials can also substitute for metals in cryogenic and other low-temperature applications.

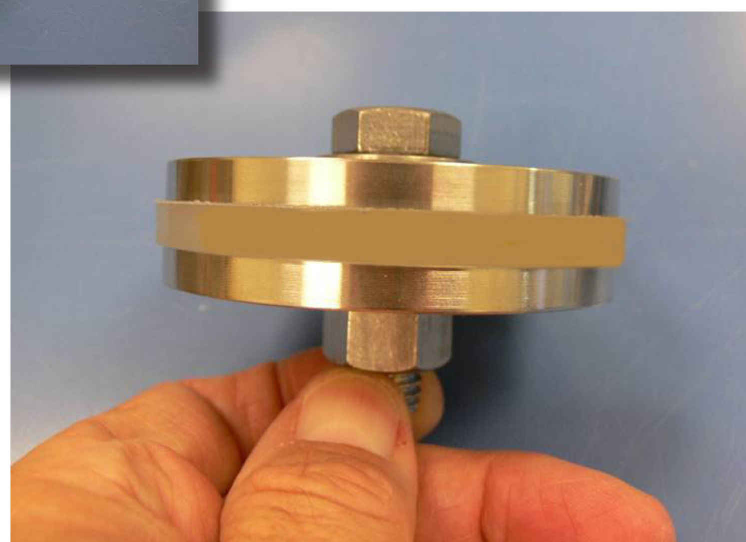
These organic/inorganic polymeric composite materials were invented with significant reduction in heat transfer properties. Decreases of 20 to 50 percent in thermal conductivity versus that of the unmodified polymer matrix were measured. These novel composite materials also maintain mechanical properties of the unmodified polymer matrix.

These composite materials consist of an inorganic additive combined with a thermoplastic polymer material. The intrinsic, low thermal conductivity of the additive is imparted into the thermoplastic, resulting in a significant reduction in heat transfer over that of the base polymer itself, yet maintaining most of the polymer's original properties. Normal polymer processing techniques can turn these composite materials into unique, custom parts for ground support, Shuttle, and Constellation needs.

We fabricated test specimens of the composite and base materials for thermal and mechanical characterization and found that the strength of the composite material at nominal-percentage loading remained relatively unchanged from the base material. In some polymer materials, the composite was noticeably more flexible at lower and cryogenic temperatures. In all cases, the heat transfer of test articles was reduced compared to the parent polymer.

Prototype GSE test articles were manufactured for use as seals and gaskets in cryogenic piping applications (see the figure). These articles are being evaluated on a proof-of-concept basis as candidate replacement materials for current polymer materials found to crack upon repeated thermal cycling. Additional testing will be required to raise the technology readiness level for continual GSE use. Future relevant environmental testing will prove the feasibility of composite materials in space and commercial applications.

By incorporating a hydrogen-sensing pigment, we developed and fabricated another composite technology. This composite can sense hydrogen at cryogenic temperatures and was demonstrated in a tape form on Launch Pad 39A in the Orbiter Midbody Umbilical Unit deployment for STS-117, STS-118, STS-120, and STS-122.



Composite seals for performance evaluation at low temperatures.

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