National Aeronautics and Space Administration

Materials and Coatings

Layered Composite Insulation for Extreme Conditions (LCX)

A layered composite insulation system for non-vacuum applications and extreme environmental exposure conditions

NASA Kennedy Space Center (KSC) has developed a layered composite insulation system for nonvacuum applications and extreme environmental exposure conditions. This layered composite insulation system for extreme conditions (or LCX) is particularly suited for complex piping or tank systems that are difficult or practically impossible to insulate by conventional means. Consisting of several functional layers, the aerogel blanket-based system can be tailored to specific thermal and mechanical performance requirements. Mechanically, the LCX system not only withstands impact, vibration, and the stresses of thermal expansion and contraction, but can help support pipes and other structures, all while maintaining its thermal insulation effectiveness. NASA KSC is currently seeking companies interested in licensing LCX for commercial applications.

BENEFITS

- Thermal insulating performance on par with the best foam materials in new condition
- LCX (six-layer specimen) is estimated to withstand compressive mechanical loadings of more than 180 kPa (26 psi), corresponding to a compression of 75% of original thickness, with full elastic recovery.
- LCX systems do not need to be perfectly sealed to handle rain, moisture accumulation, or condensation.
- The system can increase reliability and reduce life cycle costs by mitigating moisture intrusion and preventing resulting corrosion

technology solution

THE TECHNOLOGY

The approach in developing the LCX system was to provide a combination of advantages in thermal performance, structural capability, and operations. The system is particularly suited for the complex piping, tanks, and apparatus subjected to the ambient environment common in the aerospace industry. The low-cost approach also lends the same technology to industrial applications such as building construction and chilled-water piping. The system can increase reliability and reduce life cycle costs by mitigating moisture intrusion and preventing the resulting corrosion that plagues subambient-temperature insulation systems operating in the ambient (humidity and rain) environment. Accumulated internal water is allowed to drain and release naturally over the systems normal thermal cycles. The thermal insulation system has a long life expectancy because all layer materials are hydrophobic or otherwise waterproof. LCX systems do not need to be perfectly sealed to handle rain, moisture accumulation, or condensation.

Mechanically, the LCX system not only withstands impact, vibration, and the stresses of thermal expansion and contraction, but can help support pipes and other structures, all while maintaining its thermal insulation effectiveness. Conventional insulation systems are notoriously difficult to manage around pipe supports because of the cracking and damage that can occur. Used alone or inside another structure or panel, the LCX layering approach can be tailored to provide additional acoustic or vibration damping as a dual function with the thermal insulating benefits. Because LCX systems do not require complete sealing from the weather, it costs less to install. The materials are generally removable, reusable, and recyclable, a feature not possible with other insulation systems. This feature allows removable insulation covers for valves, flanges, and other components (invaluable benefits for servicing or inspection) to be part of original designs.

Thermal performance of the LCX system has been shown to equal or exceed that of the best polyurethane foam systems, which can degrade significantly during the first two years of operation. With its inherent springiness, the system allows for simpler installation and, more importantly, better thermal insulation because of its consistency and full contact with the cold surface. Improved contact with the cold surface and better closure of gaps and seams are the keys to superior thermal performance in real systems. Eliminating the requirement for glues, sealants, mastics, expansion joints, and vapor barriers provides dramatic savings in material and labor costs of the installed system.

APPLICATIONS

The technology has several potential applications:

- Residential and Commercial Construction
- Chilled-water piping
- Piping, tanks, and vessels
- Cryogenics

PUBLICATIONS

Patent No: 9,617,069

Fesmire, J. E., Layered composite thermal insulation system for nonvacuum cryogenic applications, Cryogenics, Vol. 74, March 2016, Pages 154-165.