



## Improving Heat Flux Performance of Flat Surface in Spray-Cooling Systems

*Goddard Space Flight Center, Greenbelt, Maryland*

A method has been developed for improving heat flux performance relative to flat surfaces in spray-cooling systems. Similar enhancement techniques have been used for convective heat transfer, but, to the best knowledge at the time of this reporting, never spray cooling of foam. Previous studies have shown that spray-cooling heat flux enhancements may be attained using enhanced surfaces. However, most enhanced surface spray-cooling studies have been limited to extended and/or embedded surface structures. This

study investigates the effect of foam on spraycooling heat flux.

The foam used was graphite Poco Foam. The foam piece was attached to a copper block with a cross-sectional area of 2 cm<sup>2</sup> using high-thermal-conductivity epoxy as the thermal interface material. Measurements were also obtained on a heater block with a flat surface for purposes of baseline comparison. A 2×2 nozzle array was used with PF-5060 as the working fluid. Thermal performance data was obtained under nominally degassed conditions, with a chamber pressure of 41.4 kPa.

Results show that the highest heat flux attained was 113 W/cm<sup>2</sup> using the graphite Poco Foam. The use of the foam does not require a significant amount of time dedicated to machining the heat exchange surface, and thus is a time-efficient enhancement technique. In addition, with foam, the thermally controlled surface does not experience abrupt catastrophic failure.

*This work was done by Eric A. Silk of Goddard Space Flight Center. For further information, contact the Goddard Innovative Partnerships Office at (301) 286-5810. GSC-15553-1*

## Treating Fibrous Insulation To Reduce Thermal Conductivity

*Lyndon B. Johnson Space Center, Houston, Texas*

A chemical treatment reduces the convective and radiative contributions to the effective thermal conductivity of porous fibrous thermal-insulation tile. The net effect of the treatment is to coat the surfaces of fibers with a mixture of transition-metal oxides (TMOs) without filling the pores. The TMO coats reduce the cross-sectional areas available for convection while absorbing and scattering thermal radiation in the pores, thereby rendering the tile largely opaque to thermal radiation.

The treatment involves a sol-gel process: A solution containing a mixture of transition-metal-oxide-precursor

salts plus a gelling agent (e.g., tetraethylorthosilicate) is partially cured, then, before it visibly gels, is used to impregnate the tile. The solution in the tile is gelled, then dried, and then the tile is fired to convert the precursor salts to the desired mixed TMO phases. The amounts of the various TMOs ultimately incorporated into the tile can be tailored via the concentrations of salts in the solution, and the impregnation depth can be tailored via the viscosity of the solution and/or the volume of the solution relative to that of the tile. The amounts of the TMOs determine the absorption and scattering spectra.

*This work was done by Alfred Zinn and Ryan Tarkanian of The Boeing Co. for Johnson Space Center. Further information is contained in a TSP (see page 1).*

*Title to this invention, covered by U.S. Patent No. 7,198,839 B2, has been waived under the provisions of the National Aeronautics and Space Act (42 U.S.C. 2457 (f)). Inquiries concerning licenses for its commercial development should be addressed to:*

*The Boeing Company*

*5301 Bolsa Ave,*

*Huntington Beach, CA 92647-2099*

*Refer to MSC-23394-1, volume and number of this NASA Tech Briefs issue, and the page number.*

## Silica-Aerogel Composites Opacified With La<sub>0.7</sub>Sr<sub>0.3</sub>MnO<sub>3</sub>

Sizes of La<sub>0.7</sub>Sr<sub>0.3</sub>MnO<sub>3</sub> particles affect their effectiveness as opacifiers.

*Marshall Space Flight Center, Alabama*

As part of an effort to develop improved lightweight thermal-insulation tiles to withstand temperatures up to 1,000 °C, silica aerogel/fused-quartz-fiber composite materials containing La<sub>0.7</sub>Sr<sub>0.3</sub>MnO<sub>3</sub> particles as opacifiers

have been investigated as potentially offering thermal conductivities lower than those of the otherwise equivalent silica-aerogel composite materials not containing La<sub>0.7</sub>Sr<sub>0.3</sub>MnO<sub>3</sub> particles. The basic idea of incorporating opaci-

fying particles into silica-aerogels composite to reduce infrared radiative contributions to thermal conductivities at high temperatures is not new: it has been reported in a number of previous *NASA Tech Briefs* articles. What is