

pellet width, only a thin outer layer is utilized effectively. A TiO₂ loading of 13 weight percent has been found to result in the best removal of Hg, both with and without ultraviolet light. Humidity has been found to impede adsorption, thereby reducing the overall Hg-removal efficiency. An examination of the effects of flow velocity revealed that adsorption

is the rate-limiting step, suggesting a need to improve mass-transfer characteristics to obtain better performance.

This work was done by David Mazyck, Danielle Londeree, Chang-Yu Wu, Kevin Powers, and Erik Pitoniak of the University of Florida for Johnson Space Center.

In accordance with Public Law 96-517, the contractor has elected to retain title to this

invention. Inquiries concerning rights for its commercial use should be addressed to:

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Refer to MSC-23624, volume and number of this NASA Tech Briefs issue, and the page number.

Lightweight Tanks for Storing Liquefied Natural Gas

These tanks are also relatively inexpensive.

Marshall Space Flight Center, Alabama

Single-walled, jacketed aluminum tanks have been conceived for storing liquefied natural gas (LNG) in LNG-fueled motor vehicles. Heretofore, double-wall steel tanks with vacuum between the inner and outer walls have been used for storing LNG. In comparison with the vacuum-insulated steel tanks, the jacketed aluminum tanks weigh less and can be manufactured at lower cost. Costs of using the jacketed aluminum tanks are further reduced in that there is no need for the vacuum pumps heretofore needed to maintain vacuum in the vacuum-insulated tanks.

The single-walled, jacketed aluminum tanks are members of the class of composite overwrapped pressure vessels; that is, they comprise basically, seamless aluminum tank liners overwrapped in composite (matrix/fiber) materials. On each

such tank, the composite overwrap is further encapsulated in a layer of insulating foam, which, in turn, is coated with a flexible sealant that protects the foam against abrasion, ultraviolet light, and other adverse environmental phenomena.

The innovative tank concept admits to a number of variations. For example, the aluminum tank liner can be a common, commercially available aluminum tank liner that is already certified by the United States Department of Transportation for use at pressure up to 3,000 psi (≈ 20.7 MPa). The composite-material overwrap can be made by winding high-strength-carbon-fiber/poly(phenylene benzo-bisoxazole)-fiber hybrid filaments with an epoxy matrix material. The insulating layer can be made by spraying polyurethane foam, waiting for the foam to cure to rigidity, then machining the

foam to final size and shape. The protective outer layer can be formed by brush application of a ductile epoxy or spray application of a truck-bed-liner material.

Of course, if the tank liner is a pressure vessel as in the example above, then the tank can be used to store a high-pressure gaseous fuel. Moreover, in the case of storage of LNG, the high-pressure capability of the tank helps to conserve stored fuel by reducing the need to vent gas to relieve pressure as heat leaks into the tank, causing slow vaporization of the LNG.

This work was done by Tom DeLay of Marshall Space Flight Center.

This invention is owned by NASA, and a patent application has been filed. For further information, contact Sammy Nabors, MSFC Commercialization Assistance Lead, at sammy.a.nabors@nasa.gov. Refer to MFS-32024-1.

Hybrid Wound Filaments for Greater Resistance to Impacts

PBO fibers are used in addition to high-strength carbon fibers.

Marshall Space Flight Center, Alabama

The immediately preceding article includes an example in which a composite overwrap on a pressure vessel contains wound filaments made of a hybrid of high-strength carbon fibers and poly(phenylene benzobisoxazole) [PBO] fibers. This hybrid material is chosen in an effort to increase the ability of the pressure vessel to resist damage by low-speed impacts (e.g., dropping of tools on the vessel or bumping of the vessel against hard objects during installation and use) without significantly increasing the weight of the vessel. Heretofore, enhancement of the impact resistances of fila-

ment-wound pressure vessels has entailed increases in vessel weight associated, variously, with increases in wall thickness or addition of protective materials.

While the basic concept of hybridizing fibers in filament-wound structures is not new, the use of hybridization to increase resistance to impacts is an innovation, and can be expected to be of interest in the composite-pressure-vessel industry. The precise types and the proportions of the high-strength carbon fibers and the PBO fibers in the hybrid are chosen, along with the filament-winding pattern, to maximize the advan-

tageous effects and minimize the disadvantageous effects of each material. In particular, one seeks to (1) take advantage of the ability of the carbon fibers to resist stress rupture while minimizing their contribution to vulnerability of the vessel to impact damage and (2) take advantage of the toughness of the PBO fibers while minimizing their contribution to vulnerability of the vessel to stress rupture.

Experiments on prototype vessels fabricated according to this concept have shown promising results. At the time of reporting the information for this article, research toward understanding and