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Composite Cryotank Technologies and Demonstration

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Sponsoring Program(s)

Space Technology Mission Directorate
Game Changing Development

Project Description

NASA is exploring advanced composite materials and processes to reduce the overall cost and weight of liquid hydrogen (LH_2) cryotanks while maintaining the reliability of existing metallic designs. The fundamental goal of the composite cryotank project was to provide new and innovative technologies that enable human space exploration to destinations beyond low-Earth orbit such as the Moon, near-Earth asteroids, and Mars.

In September 2011, NASA awarded Boeing the contract to design, manufacture, and test two lightweight composite cryogenic propellant tanks.

The all-composite tanks shown in figures 1 and 2 are fabricated with an automated fiber placement machine using a prepreg system of IM7 carbon fiber/CYCOM 5320-1 epoxy resin. This is a resin system developed for out-of-autoclave applications. Switching from metallic to composite construction holds the potential to dramatically increase the performance capabilities of future space systems through a dramatic reduction in weight.

Composite Cryotank Technologies and Demonstration testing was an agency-wide effort with NASA Marshall Space Flight Center (MSFC) leading project management, manufacturing, and test; Glenn Research Center leading the materials; and Langley Research Center leading the structures effort for this project. Significant contributions from NASA loads/stress personnel contributed to the understanding of thermal/mechanical strain response while undergoing testing at cryogenic temperatures. The project finalized in September 2014.

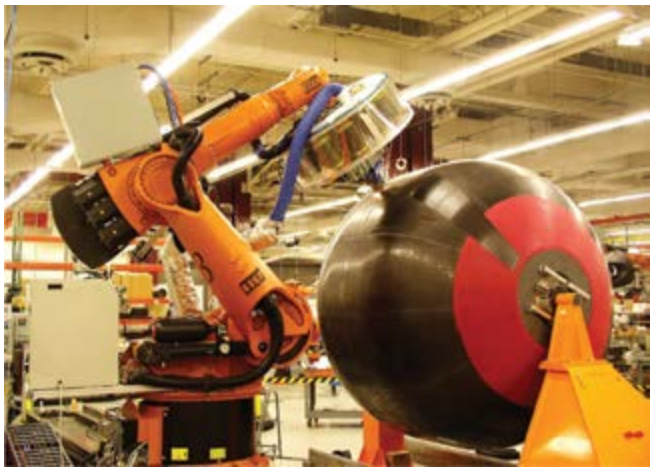

Figure 1: 8-ft- (2.4-m-) diameter, all composite tank at Boeing.

Figure 2: 18-ft- (5.5-m-) diameter, all composite tank at Boeing.

Figure 3: 5.5-m tank arrives on NASA's Super Guppy and begins testing at MSFC.

2.4-m Tank Test Summary

Built by Boeing at their Tukwila, Washington, facility, the tank arrived at NASA in late 2012. On June 25, 2013, the 2.4-m-diameter, all-composite cryogenic tank was successfully pressure tested at MSFC. The test met all requirements: stepwise fill with LH_2 (–423 °F) to 90% volume capacity followed by pressurizing the tank to 135 psig. The 2.4-m tank was then cycled through 20 pressure/vent cycles, measuring hydrogen gas permeation on the tank dome.

5.5-m Tank Test Summary

NASA's Super Guppy, a wide-bodied cargo aircraft, landed at the Redstone Army Airfield near Huntsville, Alabama, on March 26, 2014, and since then, NASA has completed a demanding series of tests inside the test stand at MSFC. Engineers added structural loads to the tank to replicate the physical stresses launch vehicles experience during flight.

In other tests, the tank successfully maintained fuels at extremely low temperatures and operated at various pressures. Engineers filled the tank with almost 30,000 gal of LH_2 chilled to –423 °F, and repeatedly cycled the pressure between 20 to 53 lb/in^2, the pressure limit set for the tests.

Anticipated Benefits

Using innovative manufacturing processes and designs, this project advanced the technologies for composite cryogenic propellant tanks at diameters suitable for future heavy-lift vehicles and other in-space applications.

Potential Applications

A potential initial target application for the composite technology is an upgrade to the upper stage of NASA's Space Launch System heavy-lift rocket.

Notable Accomplishments

The 5.5-m composite cryotank is the largest automated fiber placement, out-of-autoclave, composite LH_2 tank ever designed, manufactured, and tested.