National Aeronautics and Space Administration

High Melt Carbon-Carbon Material Successful in Creating a Highly Durable Rocket Nozzle Extension

Nozzle extension stub skirt and adapter ring. (Person for scale.) Photo courtesy of C-CAT.

A partnership between NASA's Glenn Research Center and Carbon-Carbon Advanced Technologies (C-CAT) has led to the creation of a rocket nozzle extension that will provide equal or better performance than current options for about half the cost. The success comes as the result of a Small Business Innovation Research (SBIR) contract awarded by NASA to Texas-based C-CAT to develop the nozzle using an ACC-6 High Melt Coating. The material is known for its strength and resiliency; however, until recently the use of ACC-6 with High Melt Coating in large components had not been demonstrated. With the SBIR contract and additional funds and support from Aerojet Rocketdyne, C-CAT has shown the feasibility of building larger nozzle structures with ACC-6 High Melt. The fabrication method used by C-CAT will also allow for a slightly longer nozzle to provide greater engine specific impulse, allowing it to provide up to an additional 100 pounds of vehicle payload with the same propellant load. Therefore, in addition to greatly reducing product and material costs, the technology may potentially cut launch costs by providing larger payloads on the same vehicle. A larger nozzle extension fabricated by C-CAT would also provide an alternative domestic source for the nozzle.

Benefits of Technology Transfer

- **Lowers material and launch costs:** Potential savings include hundreds of thousands of dollars per launch.
- **Provides greater control:** C-CAT provides NASA and the U.S. Department of Defense (DoD) with access to a domestic supplier of rocket nozzle extensions.
- **Benefits small business:** The SBIR contract provided C-CAT with resources otherwise unavailable to innovate using a material previously untested for larger nozzle-like structures.
- **Bolsters commercial spaceflight:** This achievement can potentially benefit private players in the private spaceflight industry.

success

On the Record

"This technology aligns to NASA's stated goals of maximizing mission success, assuring long-term launch services, and promoting evolution of the commercial launch market. A new nozzle with greater costs savings and increased engine performance could enable NASA missions to realize launch vehicle savings. This C-CAT nozzle extension is a great example of how SBIR-developed technologies can be infused into commercial products."
— *Mark Klem, Branch Chief, Ascent and Thermal Propulsion, NASA Glenn Research Center*

"Without the SBIR contract from NASA, we would not have the money to prove this technology would work on a large scale. This contract has opened a lot of doors with NASA for continued development of the nozzle extension for various different rocket engines. We also hope to leverage this effort to continue our interactions with Aerojet Rocketdyne."
— *James Thompson, Vice President, Carbon-Carbon Advanced Technologies*

About Carbon-Carbon Advanced Technologies

C-CAT is a privately owned corporation and high-tech manufacturer based in Kennedale, Texas, specializing in development of carbon-carbon structures for aerospace and commercial applications. The company was founded by Francis Schwind in 1988. Schwind gained extensive experience working on thermal protection systems for the NASA Space Shuttle Program during the 1970s.

Technology Origins

Currently, a European provider remains the sole supplier for RL10 engine nozzle extensions. Increasing prices in recent years, however, have made the nozzles an expensive element of the propulsion system. To reduce costs and support a domestic source for this important component, NASA awarded C-CAT the SBIR contract to develop a two-dimensional process that offers an equally capable and reliable product that meets NASA's goal of ensuring long-term launch services and mission success. Manufacturing these nozzle extensions with ACC-6 High Melt keeps engine mass to a minimum for better performance while also withstanding the high temperatures of nozzle exhaust. The C-CAT nozzle extension has tested in the Arc Jet environment at over 3,000 °F. ACC-6 High Melt has proven to be a top performing high-temperature material.

The Transfer Process

NASA awarded an SBIR contract to Carbon-Carbon Advanced Technologies in 2009. In Phase I, C-CAT proved it could "make shapes," more complex than just flat panels, using the ACC-6 carbon-carbon High Melt Coating with a contract of $100,000. In 2011, the company received $650,000 in Phase II to use the material in creating a prototype 6-inch "stub" nozzle that could be mated with an RL10 engine supplied by Aerojet Rocketdyne. The companies worked in tandem to design the nozzle extensions and ensure they possessed satisfactory strength and thermal integrity. In 2012, the stub nozzle prototype successfully demonstrated the feasibility of fabricating a nozzle extension using ACC-6 High Melt. Now in Phase III, the company will receive up to $1.3 million from NASA to further develop the technology as a 30- to 34-inch long nozzle extension. C-CAT will continue to work with Aerojet Rocketdyne to refine the extension. NASA expects this technology, manufactured by C-CAT, will offer a desirable alternative to foreign-made nozzle extensions within a few years. C-CAT also received additional and matching funds from NASA's Human Exploration and Operations Mission Directorate (HEOMD) Launch Services Program (LSP) and Aerojet Rocketdyne.

Looking Ahead

NASA's advanced combustion devices stand to gain from nozzle extensions made by C-CAT. Programs that can potentially benefit include robotic and human lunar or Mars missions. In addition, further development of the ACC-6 High Melt material may lead to more in-depth understanding that can be applied to future spacecraft.

Aerojet Rocketdyne is currently interested in the C-CAT nozzle extension as a means to offer significant engine cost, weight, and launch schedule savings.

Other commercial spaceflight developers may also benefit from the use of this material.

For More Information

If you would like additional information about GRC's technology transfer opportunities, please contact:

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