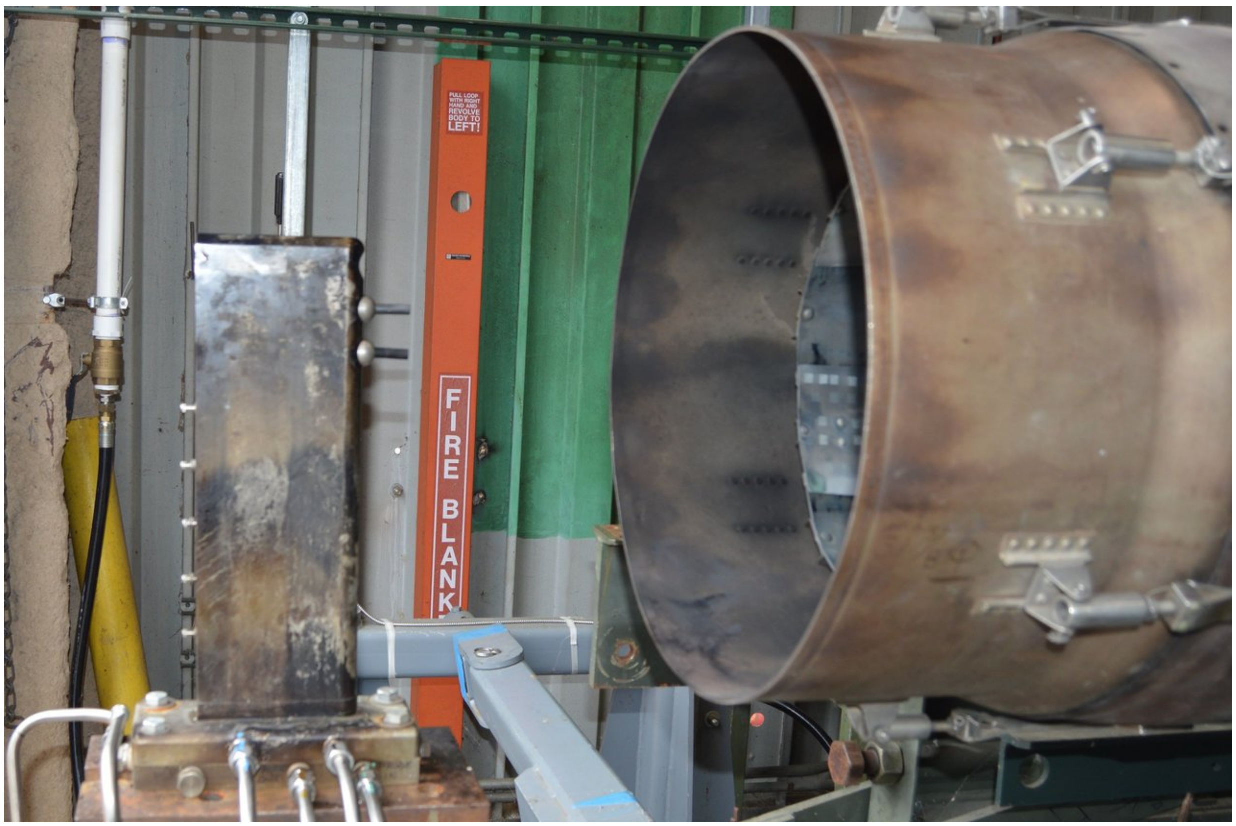
Air Force looking to additive manufacturing to expand hypersonic flight capabilities

April 4 2018



A sample of additively manufactured silicon oxycarbide (SiOC) material is tested at Arnold Air Force Base. The testing was conducted as part of a Cooperative Research and Development – Material Transfer Agreement between the Air Force Research Laboratory Aerospace Systems Directorate and HRL Laboratories. Credit: Air Force Office of Scientific Research

The Air Force is testing materials produced through ceramic additive manufacturing to advance their potential future use in hypersonic flight vehicles.

Scientists with the Air Force Research Laboratory Aerospace Systems Directorate recently entered into a Cooperative Research and Development – Material Transfer Agreement with HRL Laboratories to test additively manufactured silicon oxycarbide (SiOC) materials.The geometric complexity of components that can be produced through additive manufacturing in conjunction with the refractory nature of ceramics holds enormous potential for a variety of future Air Force applications. One such possible application is hypersonic flight, which exposes materials to extreme environments including high temperatures.

The potential of the HRL-produced materials for demanding Air Force applications became apparent while Aerospace Systems Directorate scientists were searching for new thermocouple radiation shields. The SiOC materials were produced through an additive manufacturing process utilizing a pre-ceramic resin. Following part fabrication, the pre-ceramic resin was heat treated to convert the component to a fully ceramic state. AFRL scientists became interested in HRL's novel process taking advantage of state-of-the-art 3-D printing capabilities and pre-ceramic resin chemistry as well as the possible performance of the final SiOC materials at high temperatures.

"If a material can withstand those temperatures – roughly 3,200 degrees Fahrenheit – it could be used for hypersonic aircraft engine components like struts or flame holders," said Jamie Szmodis, a hypersonic research engineer with the Aerospace Systems Directorate.

Hypersonic flight is a compelling area of study for the U.S. and international aerospace industry. Current aircraft fly at supersonic speeds, over 768 miles per hour, or MACH 1. If achieved, hypersonic fight, that is speeds exceeding Mach 5, would allow for much faster military response times, more advanced weapons and drastically decreased travel times for the military and commercial sectors with speeds over 4,000 miles per hour.

The CRADA-MTA, a type of technology transfer agreement that allows for the transfer of materials for testing, was instrumental in facilitating a working relationship between AFRL and HRL to test the material.

"Without the material transfer agreement, we would have purchased the samples to test them. We would have been a customer, as opposed to a collaborator," said Szmodis. "With the agreement we are able to provide test results to HRL and provide feedback that is valuable to both parties."

Under the agreement the directorate received 5 thermocouple radiation shields and 15 sample cylinders manufactured from the SiOC resin. To conduct the tests, Szmodis established a small team of scientists from multiple directorates and specialties. Scientists from the AFRL Materials and Manufacturing Directorate, Structural Materials Division, Composite Branch, led by Dr. Matthew Dickerson, conducted materials analysis and heat treatments. The Aerospace Systems Directorate, Aerospace Vehicle Division, Structural Validation Branch scientists, led by Bryan Eubanks, performed mechanical analysis focusing on thermal expansion analysis at temperatures ranging from 500 – 3,500 degrees Fahrenheit. Additionally, scientists at the Arnold Engineering Development Complex's Propulsion Research Facility performed analysis of the material's characteristics in a high-enthalpy instrumentation test facility.

A final report of the results was completed in March and delivered to HRL. During the course of their collaborative study, AFRL and HRL pushed the additively manufactured components far beyond their design envelope. The data which emerged from this extreme testing provided the partners with valuable information that is currently being utilized to guide the production of next-generation additively manufactured ceramics. These recommendations and further advances by HRL have the potential to produce materials that can meet the hypersonic requirements.

"The extreme temperature testing that AFRL performed revealed the limits of our new material and challenged us to improve it," said Dr. Tobias Schaedler, a senior scientist from HRL.

Provided by Air Force Office of Scientific Research