High-Melt Carbon-Carbon Coating for Nozzle Extensions

Ultrahigh-temperature ceramics enable novel material

Carbon-Carbon Advanced Technologies, Inc. (C-CAT), has developed a high-melt coating for use in nozzle extensions in next-generation spacecraft. The coating is composed primarily of carbon-carbon, a carbon-fiber and carbon-matrix composite material that has gained a spaceworthy reputation due to its ability to withstand ultrahigh temperatures. C-CAT's high-melt coating embeds hafnium carbide (HfC) and zirconium diboride (ZrB_2) within the outer layers of a carbon-carbon structure. The coating demonstrated enhanced high-temperature durability and suffered no erosion during a test in NASA's Arc Jet Complex. (Test parameters: stagnation heat flux=198 BTD/ft^2-sec; pressure= .265 atm; temperature=3,100 °F; four cycles totaling 28 minutes)

In Phase I of the project, C-CAT successfully demonstrated large-scale manufacturability with a 40-inch cylinder representing the end of a nozzle extension and a 16-inch flanged cylinder representing the attach flange of a nozzle extension. These demonstrators were manufactured without spalling or delaminations. In Phase II, C-CAT worked with engine designers to develop a nozzle extension stub skirt interfaced with an Aerojet Rocketdyne RL10 engine. All objectives for Phase II were successfully met. Additional nonengine applications for the coating include thermal protection systems (TPS) for next-generation spacecraft and hypersonic aircraft.

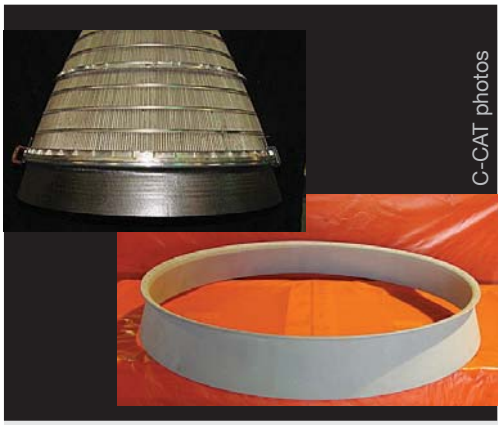
Applications

NASA

- Nozzle extensions for upper- and exoatmospheric operation:
  - Robotic lunar and planetary missions
  - Manned lunar ascent
  - J-2X rocket systems
- TPS for next-generation spacecraft

Commercial

- Lower-cost, high-performance nozzle extensions for commercial launch market
- TPS for reusable aircraft that operate in temperatures in excess of 2,800 °F (a safe operating temperature for repeated use)


C-CAT photos

Phase II Objectives

- Verify that prototype nozzle extension designs are manufacturable and meet technique requirements
- Design and fabricate layup tools that address ply shrinkage distortion yet maintain dimensional tolerances during processing
- Lay up the nozzle extensions without defects
- Process each nozzle extension through pyrolysis, heat treatment, and coating without defects
- Apply silicon carbide conversion coating to the high-melt material without spalling

Benefits

- Lighter weight than conventional metallic structures
- Able to operate in temperatures in excess of 2,800 °F repeatedly and at higher temperatures for one-time use
- Easy to manufacture

Firm Contact

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