Materials & Coatings

Elevated-Temperature, Highly Emissive Coating for Energy Dissipation of Large Surfaces

This coating can be used in high-temperature rocket nozzles, control surfaces, industrial furnaces, and transfer lines.

Marshall Space Flight Center, Alabama

This coating demonstrates high emittance above 80% or better at broad wavelengths within the infrared spectrum. It has shown to have an extremely stable emittance at lower wavelengths within the infrared (IR) spectrum, where energy dissipation is critical at elevated temperatures. The coating has demonstrated increases in surface texturing, and ultimately an increase in emissivity when exposed to temperatures up to 2,050 °F (≈1,120 °C). It is also stable at continuous run, elevated temperatures, and shows no signs of spalling or erosion.

Radiation-cooled nozzles for liquid rocket engines require high emissivity, approaching near black body, in order to properly dissipate energy from the component. A common means of increasing the emittance of metallic components is to perform a high-temperature heat treatment of the material, allowing the surface to oxidize, thus increasing the emissivity. However, an oxidized surface will reduce when exposed to the hydrogen-rich steam from the propellant by-products of liquid hydrogen/liquid oxygen (LH2/LOX) combustion in addition to being reduced when exposed to a hard vacuum environment. Another disadvantage of the high-temperature material oxidation is reduction of the base material properties. Some materials, such as superalloys, require a minimum heat treatment temperature to be obtained; otherwise, the structural properties of the material can be reduced due to carbide precipitation. Additionally, distortion of larger parts can occur at elevated temperatures when performing heat treatment oxidation cycles of the material.

A unique silica-based coating was adapted from industry to meet the emissivity needs of the rocket nozzle. The Cetek coating system is an aqueous-based material that is applied using a handheld sprayer that could be readily adapted to an automatic robot sprayer. Spray application allows even distribution of the coating over the entire surface of the component exposed to both hot gas and the vacuum of space. The coating is applied in a series of air-sprayed layers that combine to produce a total thickness of less than 0.005 in. (127 μm). The thin coating allows for minimal weight impact by increasing the emittance of the surface, ultimately decreasing component temperatures and allowing for reduced weight of the engine component. The cure cycle for the coating consists of an ambient air cure under controlled humidity conditions, followed by oven heating at low temperatures for a period of a few hours.

The development of this coating was necessary to increase the emittance of the surface of the nozzle extension for the radiation-cooled metallic nozzle extension for the J-2X Upper Stage Engine. Because the temperatures of the nozzle wall are dependent upon the radiation effectiveness, emissivity is extremely important. The material properties of the nozzle extension are dependent on the temperature in which they operate. A lower temperature wall (based on emissivity) would allow a higher strength of the base material, and eventually weight savings of the nozzle based on optimization of the design. Thus, a higher emittance for the nozzle results in weight savings for the design and also a design that yields additional thermal margin. This coating successfully completed a series of high-temperature emissivity and durability certification testing and has been shown to survive a rocket nozzle's extreme operating environment through both subscale and full-scale testing.

This work was done by Paul Gradl of Marshall Space Flight Center, Jeff Haynes of PWR WPB, and Naiping Zhu of Cetek Ltd. For more information, contact Sammy Nabors, MSFC Commercialization Assistance Lead, at sammy.a.nabors@nasa.gov. Refer to MFS-32856-1.

Catalyst for Treatment and Control of Post-Combustion Emissions

This oxidation/reduction catalyst can be used in diesel and natural gas applications, and in non-automotive pollution sources.

Langley Research Center, Hampton, Virginia

Emissions from fossil-fuel combustion contribute significantly to smog, acid rain, and global warming problems, and are subject to stringent environmental regulations. These regulations are expected to become more stringent as state and regional authorities become more involved in addressing these environmental problems. Better systems are needed for catalytic control.

In general, existing catalytic converters used for NO_x and Hc emission control use precious metal (PM) or their combinations as wash coats with various architectures over alumina on ceramic