NASA TECH BRIEF
Marshall Space Flight Center

Refractory Porcelain Enamel Passive-Thermal-Control Coating for High-Temperature Superalloys

Porcelain enamels are widely used as coatings for metal protection. They feature hardness; resistance to abrasion, corrosion, and caustic chemicals; low thermal expansion coefficients; stability to heat shock; and ease of cleaning and decontamination. Their principal use is in chemical reaction vessels, light reflectors, storage tanks and containers, and high-temperature process equipment.

Space vehicles use porcelain enamels as external reflectors of solar radiation in the 200- to 2500-nm wavelength region. When the space vehicles are subjected to high temperature, such as during re-entry, porcelain enamels often crack because of mismatch between the thermal expansion coefficients of the substrate metal and the enamel. Because nonferous superalloys (e.g., Hastelloy X) often used on space vehicles to sustain the high temperatures have a 10 to 20% greater thermal expansion than the porcelain enamels, a study was conducted in an attempt to match the thermal expansion coefficients thereby preventing the enamels from cracking. The results are published in a report.

The report discusses various enamel coatings that are applied to two different high-temperature superalloys, Hastelloy X and Haynes 188. The most promising enamels consist of a zirconia recrystallizing frit and a zirconia mill. Their composition is formulated from a high-silica, boroaluminumsilicate glass, containing substantial amounts of ZrO_2, LiF, and ZnO, and a submicron ZrO_2 dispersion phase (18 to 20% by volume of fired enamel).

With fired coating thickness of 0.020 to 0.023 cm on Hastelloy X, a zirconia enamel exhibits a solar absorptance of 0.18 to 0.20. Its initial coating adherence is good and is retained after repeated thermal soak and shock from approximately 1193 K to room temperature.

Notes:

1. This study may be of interest to manufacturers of chemical equipment, furnaces, and metal components intended for high-temperature applications.
2. Requests for further information may be directed to:
   Technology Utilization Officer
   Marshall Space Flight Center
   Code A&PS-TU
   Marshall Space Flight Center, Alabama 35812
   Reference: B73-10215

Patent status:

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to:

Patent Counsel
Marshall Space Flight Center
Code A&PS-PAT
Marshall Space Flight Center, Alabama 35812

Source: H. Levin, B. H. Auker, and
M. N. Gardos of
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