Porous Thermal Barrier Coating Formation Technology for Carbon Fiber Reinforced Composites through Flame Spraying

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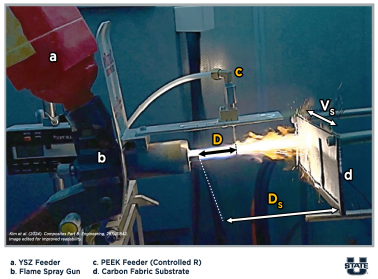

a. YSZ Feeder
b. Flame Spray Gun
c. PEEK Feeder (Controlled R)
d. Carbon Fabric Substrate

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Energy, Environment, & Aerospace

Abstract

Thermal barrier coatings are essential to protect materials in high-temperature environments. A team of researchers at the Korean Institute of Science and Technology and Utah State University has developed a flame-spraying method where a TBC is applied to a carbon fiber-reinforced plastic (CFRP) composite.

Problem

CFRP composites in high-temperature applications require a thermal barrier coating to function effectively. Current methods often use chemical adhesives to attach such a barrier, but many adhesives, such as epoxy, are flammable.

Solution

This new method using flame-spraying techniques attaches the thermal barrier coating mechanically, rather than using a flammable barrier. This is faster and more effective at delaying thermal conduction than previous techniques.

Value Proposition

This method can be used in many settings including aerospace and automotive, where slowing thermal conduction and preventing possible flame-ups is necessary.

Benefit

Compared to metal or ceramic matrix composites, carbon fiber-reinforced plastics (CFRPs) are versatile but have low durability in high-temperature environments. This characteristic requires that a thermal-barrier coating be applied to protect the CFRP. Various methods have been used to apply such a coating to metal matrix composites, such as electron-beam physical vapor deposition, chemical vapor deposition, and thermal spray. Among these, thermal spray is preferred for its simplicity, short processing time, and scalability for large applications. But despite inherent utility, this technique was previously known to be unsuitable for CFRP applications. By adjusting flame spraying coating parameters, a method was discovered that not only allows a thermal coating to be applied to CFRP materials but also allows deliberate manipulation of each individual layer. Through this method, pores can be intentionally introduced in the inside layers of the coating, further decreasing thermal conductivity.

The process has proven successful, decreasing thermal conductivity to the point of protecting CFRP composites from temperatures up to 500°C. Combining lightweight, high-strength, and extreme-environment properties into one, this paves the way for improved firefighting

equipment, aerospace body protection, and applications in the automotive industry.

Market Application

This technology is applicable in any industry that currently utilizes CFRP materials. Even in situations where high-temperature durability isn't always required, the technology provides emergency protection against fires. In firefighting, carbon-fiber equipment can be reinforced with these layered TBCs to decrease thermal degradation. In aerospace, wings and fuselages coated in layered TBCs will exemplify lightweight but durable qualities.

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Publications

- Kim, et al., "Performance-Tunable Thermal Barrier Coating forCarbon Fiber-Reinforced Plastic Composite Materials viaFlame Spraying," Elsevier, Composites Part B 287 (2024) 111842.

Intellectual Property

South Korean Patent Application Filed April 23, 2025.