CERAMIC COATING HEATER ELEMENTS – THERMALLY SPRAYED

THE TASK

Thermal spray processes and in particular atmospheric plasma spraying (APS) and high velocity oxygen fuel spraying (HVOF) are flexible and industrially established coating technologies. Single layered coating systems are made from ceramics, metals or hard metals. Multilayers have an especially high application potential.

For example, by combining conductive and nonconductive coatings it is possible to apply heater elements of nearly any geometry directly to a part that requires heating. There are several advantages including the low profile of the heater elements, the possibility to cover a large area, and their direct contact to the part, which minimizes heat losses.

To generate heat from electrical energy the conductive coatings should have a defined and temperature stable resistance. Previously metallic materials were tried. However, the approach failed due to the thermal and oxidative damage, which limited the lifetime of the coatings.

A fully ceramic heater element was developed in cooperation with Fraunhofer Institute for Ceramic Technologies and Systems (IKTS). The DKG / AiF funded the project.

OUR SOLUTION

Current state-of-the-art ceramic technology uses aluminum oxide (Al₂O₃) materials for electrically insulating coatings. Conventional APS and HVOF processes fabricate insulating coatings from spinel (MgAl₂O₄), which do not suffer the known disadvantages of thermally sprayed Al₂O₃ coatings such as phase changes during the spraying process and the reduction of insulating properties in high humidity.

Electrically conductive ceramic coatings offer a so far rarely used alternative. The material selection depends on the application temperature. The material titanium dioxide (TiO₂) plays an important role. Coating formation in thermal spray processes often occurs under reducing conditions. Here it is possible to form a sub-stoichiometric titanium sub-oxide (TiOₓ). The temperature stability can be improved by adding Cr₂O₃. Other materials are available for even higher temperatures.

During the project conductive and insulating ceramic coatings were analyzed with respect to the microstructure, phase composition and electrical properties. Optimal coating composites were selected for different working temperatures.
RESULTS

Spinel coatings offer the best insulating properties at high humidity (>70 % RH). These coatings do not suffer from phase changes during the spraying process and the electrical breakdown strength exceeds that of Al₂O₃ coatings.

Insulating coating, conductive heater and cover coating can be freely selected, which provides numerous opportunities for heating and tempering applications. A roll with applied heater was used as a technology demonstrator. During the successful test the roll was heated at 300 °C for more than 300 h (Fig. 3 and 4). Long-term thermo-cycling experiments proved the stability of the coated heater elements for different temperature ranges (Fig. 5). The so far developed coating heater elements can be combined with a selection of appropriate cover coatings to offer application-optimized solutions.

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