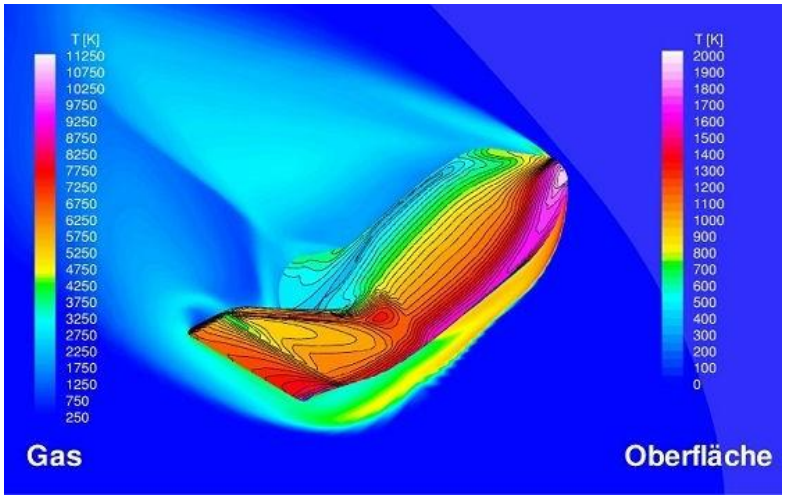
Category: Materials and Processes

Reference: TD-DE-1031

High-performance plasma coating process

Re-entry into the Earth's atmosphere is, apart from take-off, the phase of flight during which the greatest stresses are exerted on a spacecraft. In order to simulate on the ground, the loads experienced by a space-crafts thermal protection system on its return flight through the Earths atmosphere or during entry into the atmosphere of another planet, one relies on plasma sources used to qualify the thermal protection materials for re-entry vehicles in ground test facilities. To exclude the possibility of failure of the heat protection materials in question, plasma flows must be generated in these systems that simulate the actual load on the surface of the vehicle. During the ground test, the plasma composition and the plasma temperature near the surface must therefore be adjusted so that the thermal and chemical loads correspond to those of the flight.



For the plasma sources used for soil tests, this means:

- The plasma generators must be able to generate plasma currents whose composition corresponds to that of the planet whose atmosphere the spacecraft enter. Examples are air plasmas for the case of Earth re-entry, carbon dioxide plasmas for an entry into the atmosphere of Mars or nitrogen-argon-methane plasmas for an entry into the atmosphere of Saturns moon Titan.
- The temperature in the plasma jet must be very high. It can be several tens of thousands of degrees when returning from an interplane-tar mission.
- During entry into the atmosphere, the pressure may change by several orders of magnitude. The plasma sources must be able to simulate this change.
- A very large number of plasma particles must be transported to the surface of the sample material so that the chemical processes on the surface are replicated.

The performance of the plasma generators is the key to a new coating technology, the high-performance plasma coating process, which is characterized by the following properties:

- The plasma generators operate at high power levels. Correspondingly large quantities of material are converted.
- Wide range of primary gases or admixture gases (e.g., N2, H2, O2, CO2, CH4) is available.
- All substances can be melted and evaporated in the plasma. They can also react in the plasma.
- The reactions in the plasma beam can be controlled. This also makes the layer structure controllable, which enables a layer design.
- The coating has good interlocking with the base material, resulting in maximum adhesion.
- High coating speed is possible.

Three different types of plasma generators are used for the development of coating technologies:

1. DC plasma generators.
2. Inductive heated generators.
3. Hybrid plasma generators (direct current generator with inductive afterburner).

This provides a tool that makes it possible to apply known coating systems much faster and more economically than many established processes. Examples include mirror coatings for solar applications made of aluminium, titanium, or silicon. In addition, this equipment technology offers considerable potential for the development of new coating systems. Both multilayer coatings and gradient coatings can be considered. The possible material diversity of the generated plasma beams in particular offer great potential.

Innovative Aspects:

The innovative plasma source technology increases the coating speed, a better adhesion of the coatings and a new coating system.

Application Areas:

The high-performance plasma coating process is an innovative surface technology. Its areas of application are in the field of corrosion, wear protection and solar technology.

Cooperation:

There is interest in establishing a joint venture or licensing agreements.