Thermal spray coatings and solid particle erosion

Jan Lourens, MD of thermal spray coating specialist, Thermaspray, talks about reducing costly erosion damage to components, equipment and systems.

Erosion is caused when a gas or liquid carries entrained solid particles that impinge on a surface with velocity. During flight a particle carries momentum and kinetic energy, which can be dissipated during impact due to its interaction with a target surface. It has been experimentally observed that, during the impact, the target can be locally scratched, extruded, melted and cracked in different ways. The surface damage will vary according to target material, erodent particle, impact angle, erosion time, particle velocity, temperature, atmosphere, etc.

“Erosion of materials and components caused by the impact of solid particles can be a life-limiting phenomenon,” explains Lourens. “Solid particle erosion is a concern in any erosive environment industry. It is typically a problem in industrial plants, where solid particles such as coal flow onto equipment surfaces; aerospace, with sand erosion on helicopter or jet engine blades and vanes; and in the power generating industry on draft fans and turbines, for example, with fly ash or solid oxide particles impacting on downstream blades.”

Thermal spraying allows overlay protective coatings of a great variety of materials to be deposited on a range of substrates, almost without limitations as to its components, phases and constituents. Consequently wear and corrosion resistant coatings account for significant utilisation of thermal spray processes.

According to Lourens, while erosion testing allows an assessment of the coating toughness and adhesion, erosion behaviour of thermally sprayed coatings is not clearly understood by South African industry.

There are two main groups of erosion processes, namely ductile material and brittle material, which are distinguished by erosion rate – the material loss per unit of erodent mass or volume – versus impact angle. During the ductile material erosion process, impact at lower angles causes surface damage predominately by plastic deformation resulting in cutting, extrusion, adiabatic shear and forging on ductile materials such as most metals at room temperature.

During the brittle material erosion process – impact at higher angles – particle impact produces different types of cracks and chipping, with negligible plastic deformation. “Other evidences suggest that erosion of materials combines ductile material and brittle material modes simultaneously, the ratio of them depending on impact angle and material properties,” adds Lourens.

The erosion wastage of thermal sprayed coatings is strongly affected by particle impact angle. However, material behaviour depends on mechanisms of material removal while hardness could be of lesser importance. Lourens advises that the following factors must be taken into consideration before considering a coating for an application where erosion damage can be present:

- If the angle of impact <45°, the coating should be harder and more abrasion resistant.
- If the angle of impact >45°, the coating should be softer and tougher.
- For high service temperatures, the coating should have high heat hardness and oxidation resistance.
- When the carrier is a liquid, the corrosion resistance of the coating should also be considered.
- If subjected to environmental factors such as thermal shock, the erosion resistant material bond strength should be considered.

While erosion resistance is complex and its combination of so many variables makes it next to impossible to duplicate field environments in laboratory tests, Thermaspray has designed and built a customised erosion rig at its Olifantsfontein, Johannesburg workshop, which is built according to the ASTM standard G76-13 for the erosion testing of thermal coatings by solid particle impingement.

During recent erosion rig tests conducted by Thermaspray in conjunction with a customer, coatings were applied onto aluminium substrates, which were sprayed using the high velocity oxy-fuel (HVOF) spray system. Results indicated that among the materials tested, the polymers and the thermally sprayed aluminium showed the highest erosion resistance.

“With close to 20 years of experience, we are well positioned to provide expert advice in terms of applying the correct coating for a particular application,” Lourens concludes.

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The HVOF thermal spray coatings process can be used to reduce erosion damage to components, equipment and systems.