Hans Ueltschi  
Vice President  
Cylindrical Division  
United Grinding North America Inc.

HVOF Coating Puts Grinding Machines to the Test

Manufacturers continually seek ways to make their products stronger and last longer. High Velocity Oxygen Fuel (HVOF) spray coatings help achieve those goals. However, grinding the coatings can be a challenge.

In the HVOF process an oxygen-fueled supersonic jet of flammable gas or liquid melts ceramic or metallic powder and deposits it on components as a hard coating. The coatings add significant wear and corrosion resistance, but little weight. HVOF coatings offer greater protective performance than chrome plating, without the environmental liabilities of the plating process.

Some HVOF coatings are used in an “as-sprayed” condition. In more precise applications, machining or grinding can produce tight tolerances and finishes of 1 µin. Rₐ or finer. The coatings are usually ground with vitrified-bond diamond grinding wheels dressed with rotary vitrified-bond diamond dressing tools.

Grinding machines best-suited for processing HVOF-coated parts must have bases with high-static stiffness and vibration damping capabilities that preserve micron-level accuracy and fine surface finish. Machine rigidity also lessens impact shock on stiff vitrified-bond diamond grinding wheels.

Linear scales eliminate inaccuracies resulting from backlash. Thermal control of the grinding system is crucial. Grinding wheels with metal bodies react to temperature changes quickly. As a result, coolant temperature needs to be tightly controlled, usually via coolant chillers. Coolant distribution is also important.

In some cases, a machine will have multiwheel turrets and capability for multiple setups. Different wheel and setup configurations can facilitate roughing and finishing of a part and compensate for overspray or unevenness of the coating.

Uneven coating stock makes it difficult to obtain consistent dimensions and surface finish. Other challenging circumstances may require grinding of different materials in the same operation, such as grinding a groove through the HVOF coating and into the host substrate. Using the same wheel for both operations requires a compromise involving the choice of an appropriate grinding wheel and altered process and dressing parameters.

Accurate, consistent dressing of the grinding wheel is critical to achieve micron-level finishing. Advanced grinding machines feature touch dressing technology that uses acoustic sensors to determine the exact position of the wheel and dressing tool.

In noncritical applications without touch dressing on a conventional grit wheel, an operator programs an amount to be removed in each dressing. The dresser is set up and its position determined by touching it off at the beginning of the operation. When dressing is required, the original setup data enables the wheel and dresser to find each other. However, the location and depth of dressing is somewhat approximate.

When using vitrified-bond diamond wheels to produce micron-level finishes on HVOF coatings, dressing amounts are in the range of 0.00002–0.00004” (0.00058–0.00102 mm), as opposed to 0.002 or 0.005” (0.051 or 0.127 mm). To remove microns of wheel material in each dressing, the relationship of the wheel and dressing tool must be precisely determined for every dressing session or the dresser may miss the wheel altogether.

Using acoustic sensing, touch dressing locates the grinding wheel and dressing tool by the sound of their contact. The sensors pick up that sound while filtering out extraneous noise. The type of machine used usually determines the sensor positions. When OD grinding, for instance, sensors typically are on the wheel mount. For ID grinding, they are on the spindle. Acoustic sensors are usually part of a closed-loop dressing monitoring system that reports the effectiveness of the dressing operation.

Variable-speed, programmable, CNC-governed grinding and dressing drive motors permit manipulation of grinding wheel and dressing tool speeds to maximize effectiveness. An ability to reverse rotation of the dressing wheel makes the dressing process more flexible. Variable speeds also let a machine be set up to achieve different surface finishes, permitting operators to achieve the correct ratio between the rotation speeds of the workpiece, grinding wheel and dressing tool.

HVOF coatings have typically been applied to the outer surfaces of parts, but recent years have seen an increase in ID coating and subsequent finish grinding of HVOF-coated internal bores. Automated rotary dressing of wheels for ID grinding provides the same benefits in accuracy and consistency as it does for vitrified-bond diamond OD grinding wheels.