

Delivering the Surface AT HITEMCO

While HVOF (High Velocity Oxy-Fuel) presents a reasonable, in some ways better, replacement for hard chrome coatings in aerospace applications, it presents a tough grinding challenge. With new requirements for Hitemco to deliver ground surfaces, upgrading its expertise to meet that challenge meant collaboration and teamwork with their suppliers.

Hard chrome plating is a proven, effective method to reduce wear. However, the process of plating chrome uses and releases chromic acid that contains hexavalent chromium that is toxic to workers and potentially bad for the environment. The HVOF coating process has emerged as a replacement for hard chrome coatings, after years of research and development. One specialty aerospace coating firm, Hitemco (Old Bethpage, NY) is using it to coat a variety of aerospace parts where chrome was once used. Hitemco was one of the original members of the

HFOV is a tough grind, requiring this supplier to upgrade its expertise—with help.



HVOF system uses high energy to produce coatings in compression, so it is applied in thicknesses from 0.001 to 0.015" (0.03–0.38 mm) or more, according to Hitemco.

Hard Chrome Alternatives Team (HCAT), a nonprofit consortium funded by government and industry to develop alternatives to hard chrome. "As it became clear that there was going to be legislation to limit hexavalent chrome because of its toxicity and environmental hazards, HCAT was formed to develop alternatives. HVOF emerged early on as an alternative that represented quite a breakthrough," explains Teb Barnard, president of Hitemco. "Although we were motivated by replacing hard chrome, we were pleasantly surprised that HVOF had some distinct advantages over chrome."

Bruce Morey
Contributing Editor

Compared with hard chrome, HVOF exhibits superior wear, fatigue and impact resistance, while corrosion resistance appears to be equal, according to HCAT. "HVOF coatings approach the density of wrought material with less than 1% porosity and much better bonding compared to other coating technologies," said Barnard. The coating material is usually a metal or alloy, or a cermet, such as cobalt-cemented tungsten carbide, WC-Co. HVOF coating materials cited by HCAT include WC-17Co, WC-10Co₄Cr and Tribaloy.

The first applications where Hitemco will replace chrome with HVOF are in aircraft landing gear, a common application for hard chrome. The advantages in landing gear could be enormous. Barnard cites one example of an early test on a Boeing 767-300 operated by Delta Airlines. The axle for the main landing gear was HVOF coated by Hitemco and placed into service in May 1998. It experienced 12,000 cycles (landings) before it was removed for inspection, making it the longest serving HVOF coated part, according to Barnard. He relates that it showed little signs of wear, confirming the long life expected of HVOF coated parts. "Parts coated this way will probably last the life of an aircraft, quite an improvement over hard chrome," said Barnard.

Developing a process is more than buying the right equipment. In its Bethpage facility, Hitemco uses HVOF spray guns and coating powder supplied by Sulzer Metco (Westbury, NY), combined with an ABB IRB-440L six-axis articulated-arm robot inside a sealed spray booth. The robot provides 0.07–1-mm accuracy with path repeatability of

ing usually takes about two to three days, according to Roger Maragh, Process Engineer for Hitemco.

Aerospace companies that have approved Hitemco's HVOF processes include Boeing Commercial Air, Boeing Helicopter Division, Sikorsky Aircraft, Parker Aerospace, Messier Dowty, Goodrich, and Hamilton Sundstrand.

Grinding has become an important new step for Hitemco. Only coating parts is no longer sufficient. A change in customer demand forced them into a different mindset. "We are now in charge of creating the surface, not just supplying the coated part," explained Barnard. "Grinding is critical to creating that surface. We need to ensure no stresses are induced in the part, that we achieve the proper finishes, run-outs and tolerances. We need to do this ourselves, because it is becoming so critical."

As Barnard explains it, developing the process to create the right surface required a team effort between Hitemco, the grinding machine supplier and the abrasive wheel supplier. The first step was selecting United Grinding's (Miamisburg, OH) Studer brand S33 cylindrical grinding machine, a unit Barnard describes as the top of the line. Studer's S33 boasts a number of features critical to grinding HVOF coatings, such as its Granitan polymer concrete base. "Granitan provides a thermally stable, vibration-dampening base for consistent accuracy and surface finish. Glass scales and the rigidity of the S33's heavy-duty workhead and tailstock also contribute to achieving the required accuracy," said Hans Ueltschi, a manager with United Grinding.

"Freedom from vibration is especially important in grinding HVOF because the application requires diamond

"There is a level of art along with the science of process development."

0.25–0.4 mm. Hard tooling provides the masking rather than the soft-wax masking used in other schemes. The HVOF process blends fuel and oxygen into a high-velocity torch. A powder feed injected into the hot stream deposits the coating onto the exposed part. Because of the hot gases and particle velocity, hard masking is required.

Barnard is quick to point out that for HVOF coatings, purchasing the equipment is only the starting point. Parts for use in aerospace applications must have their manufacturing process approved and certified to meet rigorous quality requirements. "The coater has to understand the details of the metallurgy to engineer an HVOF process that will be flight-qualified," explains Barnard. "The guns consume themselves and need constant maintenance and replacement. The process must be monitored as conditions change. That is why we have a fully equipped metallurgical laboratory and trained engineering staff." Initial qualification of a coating material might take one to two months. Engineers need to understand the right mix of powder flow, gas flow, control temperatures and surface-feed-per-minute rate. Qualifying new parts using an already approved coat-

wheels. Because diamond wheels are both expensive and unforgiving, driving the wheel at a constant speed across the part is important, as measured in surface feet per minute," said Ueltschi. The Studer S33 is designed to meet this challenge with an accurate variable speed spindle driven by a frequency converter.

With a grinder came the need for a grinding wheel. To complete the team, Hitemco and United Grinding selected Krebs and Riedel Schleifscheibenfabrik GmbH (Bad Karlshafen, Germany), as the supplier of vitrified bond diamond grinding wheels. Kaiser Diamantwerkzeuge GmbH (Celle, Germany) provided the rotary diamond dressers for the project. Because of the hardness of the HVOF coatings—as much as 1200 Vickers (VHN), according to Maragh—a diamond wheel was chosen because of its superior performance on such hard material. Hitemco decided to use the latest technology in vitrified bonded diamond wheels for the project. While these wheels are more expensive, they generally last longer than resin-bonded wheels and can be precision dressed, an added benefit. Developing the surface, as Barnard describes it, meant developing the wheel.

"There is a level of art along with the science of process development," explained Lyman Munson of S. L. Munson & Company (Columbia, SC), the North American importer for Krebs and Riedel, and Kaiser, who acted as an application specialist for the project. "If you move a grinder to a different building, you may encounter environmental issues, such as varying hardness of cooling water which could affect coolant properties, requiring the need for a slightly different wheel. That is why Krebs and Riedel works with customers and guarantees them that we will develop a wheel that meets their needs."

The wheel has a 30° angle approach to the workpiece for grinding both a shoulder and the part OD. Using a segmented vitrified diamond wheel with two specifications in the same segment section reduces glue lines that join segments, allowing Hitemco to combine operations.

"The multiple specification segments are important since a customer's workpiece can need different specifications in the same wheel to accommodate differing part finishes, material hardnesses, and part configuration," explained Munson. "The Hitemco-produced parts have the shoulder, which requires a coarser, more open structure specification to reduce burning, while the OD portion of the part required a second specification which has a finer grit size and is less porous to improve finish. They achieve a final finish without an additional polishing operation." The coarser section of the wheel is FEPA D126 and the finer section is FEPA D64.

"Grinding these parts requires in-process wheel dressing as well. Using a rotary diamond dresser on a diamond wheel presents a challenge for controlling wear on both parts of the process," said Munson. The Studer S33 uses a Sensitron acoustic sensor to automatically detect contact between the wheel and the dressing disk. Determining the exact dimensions of the wheel after grinding is both difficult for an operator to do accurately and critical to avoid overdressing. The acoustic sensor reduces operator time, extends wheel life, and reduces wheel cost—a critical factor for grinding wheels that might cost upwards of \$5000 apiece. "When we give our customers tours of our facility they frequently rec-

ognize Studer because of its reputation for quality," explained Teb Barnard.

Maragh, Hitemco's process engineer, describes working with applications engineers from Complete Grinding Solutions (Springboro, OH), referred by United Grinding, over a period of about three weeks to establish a grinding process for the WC-Co coating. "We still continue to work with Complete Grinding Solutions on new challenges," said Maragh.



The Studer model S33 grinder satisfied Hitemco's need for an accurate, durable grinder for HFOV.

Photo courtesy United Grinding

The future of aerospace parts contracting is a movement towards "one-stop shopping," at least as much as realistically can be accomplished, says Barnard. "The whole industry is a little bit in flux. The movement towards HVOF will grow as more landing gear and other aerospace parts are specified with it as a replacement for hard chrome."

To aid in this movement, Hitemco is looking at establishing combined coating and grinding services inside companies with expertise in machining, forging, and painting so that end-customers can indeed have one-stop shopping. One of their first partnerships is with CP Tech (Montréal, Québec, Canada) a division of the Technimeca International Corp. They replicated their HVOF coatings and grinding equipment at the CP Tech facility in Montreal and hired a Hitemco process engineer to work on-site to create what Barnard calls a "company within a company."

"The key to making this concept work is to replicate the equipment and the conditions exactly as they are here and closely monitor what they do," explains Barnard. "Since our system has been flight-qualified by a number of organizations, we are going to use that expertise to ensure that as equipment and conditions deviate, we can track what is happening and know how to adjust for it." →