2012 R&D 100 50th ANNIVERSARY

MAKING BORING CUTTING EDGE

NanoSHIELD is a nanostructured protective coating that can extend the life of cutting and boring tools. Lasers fuse a specially formulated iron-based amorphous alloy powder onto a steel substrate, forming a metallurgical bond to create the superhard coating. During operation of a modern tunnel-boring machine, wear on the disc cutters is so severe that they must be replaced frequently, typically every few days depending on the type of host rock, which is costly in terms of both time and money. NanoSHIELD (superhard inexpensive laser-deposited) coatings can extend the life of disc cutters by at least 20 percent, potentially saving millions of dollars over the course of a project. A team of scientists and engineers from Lawrence Livermore and Oak Ridge national laboratories and collaborators at Strategic Analysis, Inc.; Ozdemir Engineering, Inc.; Colorado School of Mines; and Carpenter Technology Corporation developed the award-winning technology.

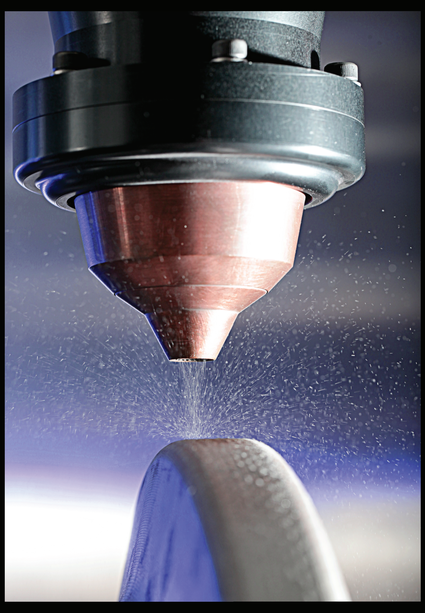
A Choice of Fabrication Methods

To apply the NanoSHIELD coating, the team uses a method that involves depositing SAM (structurally amorphous material) powder by aspiration onto a disc cutter with a polymer-based binder. The binder retains the powder in place until laser fusing. A sufficient coating thickness for improving the wear resistance of a cutting disc is only 0.1 to 0.7 millimeters. Another method involves fusing the NanoSHIELD coating to a steel substrate using a direct metal deposition free-form laser and robotic system. Binders are not applied; rather, the powder is delivered by argon gas to an area where it is fused by the laser and solidified in place. The sophisticated software controlling the laser and robot allows the system to coat more complex geometries.

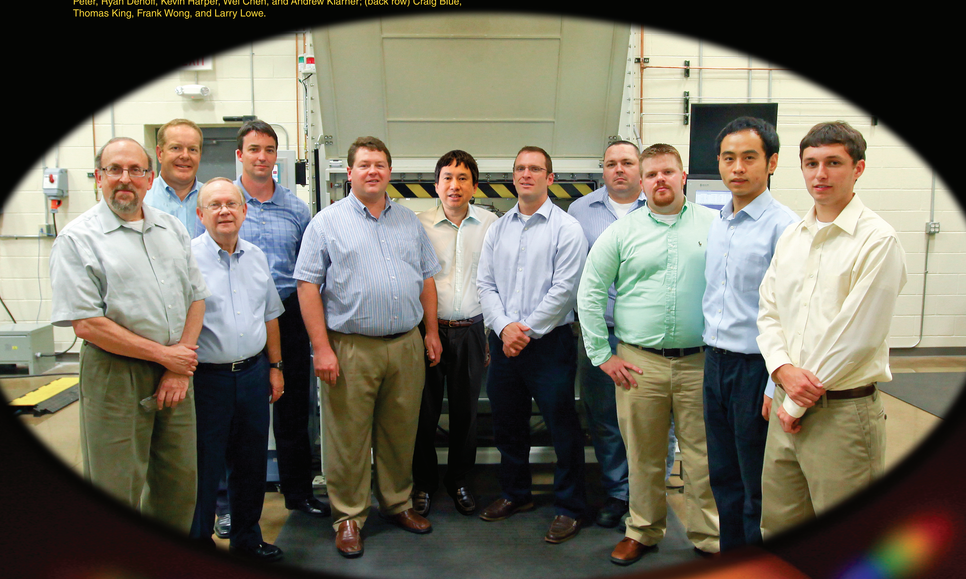
Performing Field and Laboratory Experiments

According to the Colorado School of Mines, in over 25 years of testing and research and development on coated disc cutters, NanoSHIELD-coated discs are the first to not spall or fracture after one linear cut of granite on a linear cutting machine used for simulating full-scale rock-cutting conditions in the laboratory. The coating showed no signs of spalling even after more than 100 cuts on granite. Following these positive laboratory tests, full-scale field tests were performed at the Combined Sewer Overflow Tunnel Project in Atlanta, Georgia. The coated cutters maintained their sharpness at least 20 percent longer than the uncoated cutters, resulting in less down time for disc replacement, higher penetration rates, and lower energy consumption. While the NanoSHIELD coating was first designed to prolong the life of cutting discs used for tunnel boring, it can also be used in other applications such as rock-mixing paddles, machining tools, and geothermal drilling tools.

Glassy alloy powder is delivered onto a metal substrate and fused using lasers to form a NanoSHIELD (superhard inexpensive laser-deposited) coating. (Courtesy of Oak Ridge National Laboratory.)



The development team for NanoSHIELD coatings: (front row, from left) Peter Blau, Art Clemons, William Peter, Ryan Dehoff, Kevin Harper, Wei Chen, and Andrew Klarner; (back row) Craig Blue, Thomas King, Frank Wong, and Larry Lowe.



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