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To Outer Space & Beyond

Laser Coating Method Enhances Valve Surface Integrity at NASA

GRAND VIEW MEDIA GROUP

by Paul J. Phelan

Laser-Based Surface Enhancement

NASA Employs New Treatment Method to Protect Valves in Harsh Conditions

What do NASA (*www.nasa.gov*), the oil and gas industry, mining, pulp and paper, and the chemical processing industries have in common? They represent a group of industries that operate in extremely harsh environments characterized by a high level of exposure to corrosion, abrasion, and wear. As such, they require solutions that address problems related to protecting and preserving the metal components that make up the tools and equipment they depend on every day. Rotating parts, valves, pumps, and screws used by these industries are performing better and lasting much longer than ever before due to advancements in laser-cladding technology.

Laser cladding is a metal surface enhancing process that deposits a material of desired physical properties over a substrate. It is performed when powdered metal material is fed into the path of a laser beam. The beam melts the powder and a very thin layer of the base metal where the melted powder is deposited. The dissimilar metals are fused in a way that ensures a unique full metallurgical bond.

This fusing or cladding technology for dissimilar metals in the reduction of component failure has been used by Laser Cladding Services Ltd. (LCS, *www.lasercladding.com*) to salvage worn and corroded metals across many industries. In May 2005, the company worked on an application for NASA to reduce component failure rate, which took the technology to a new level of sophistication. For better perspective on the most recent innovation in laser-cladding technology for the space exploration industry, we will take a look back at some of the earliest uses of coating technology and how the process has evolved over the years.

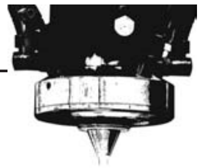
Early Laser-Coating Technology

When Gremada Industries (*www.gremada.com*), the parent company of LCS, began performing laser-overlay work for a major off-highway equipment manufacturer, the objective was simple — get worn components reconditioned and back out into the field. Laser applications emerged when traditional welding techniques proved insufficient for many of the steel parts found on the transmissions, drive trains, and other equipment components presented to the company for repair. Laser overlay provided a cost-efficient alternative to scrapping severely worn parts. It also provided a high-quality metallurgical structure that distinguished it from traditional weld-repair processes. The laser solution increased reliability and extended the life of the part. Long-term, laser-weld overlay saved the manufacturer a significant amount of time and money.

It wasn't long after initial success with laser technology for off-highway equipment that applications arose in the oil and gas industry. By the late 1990s, research and testing of stainless steels revealed that the laser could be used to apply hardfacing for downhole oil tools. Laser-clad tungsten carbide powder was applied to downhole tools made of stainless steels and exotic nickel-based alloys. This approach proved to be an effective alternative to traditional hardfacing methods, such as welding, thermal spray, and plating. The finished product was a rough exterior suited for the downhole environment. For example, downhole tools such as stabilizers typically employ a hardfacing applied by laser. This hardfacing makes contact with the hole, protecting the very expensive tool during drilling operations. As the use of laser-coating technology con-

Laser Cladding Services' proprietary laser technology bonds a metallic powder, which is blown through the brass nozzle at the laser's base and intersects with the beam and metal being clad. The result is a bead of metal that is metallurgically bonded to the object. Photo courtesy of Laser Cladding Services Ltd.

Shown are tools used in a downhole drilling application that have been coated horizontally on a raised portion of the circumference with a tungsten carbide-based hardfacing. Photo courtesy of Laser Cladding Services Ltd.



tinued to be proven in the downhole environment, demand to service downhole markets have grown and offshore application opportunities soon emerged.

New Applications Emerge

Offshore application for laser-coating technology is completely different from the downhole experience, primarily because of its finishing requirements. Alloys other than hardfacings are needed to protect base metals from corrosion and abrasive elements common at sea. Offshore coatings are typically corrosion-resistant alloys with various levels of abrasion and wear resistance. The clad surface is then machined or ground to fit particular service requirements. Today's offshore laser coating applications are used to protect critical sealing surfaces like those found in transmission lines for subsea well heads on rigs and vessels, choke and kill lines, and hydraulic cylinder rods.

In addition to downhole and offshore oil and gas environments, laser-coating technology has proven effective for process industries where pumps and valves for severe services found in refineries, chemical plants, power plants, and pulp and paper facilities demand maximum performance and reliability. Efforts in deriving the best value from laser technology for process industry applications have enhanced the durability of commonly used alloys. Powdered metals previously applied by traditional welding and thermal spray are now used for laser cladding.

Unlike traditional weld processes, the laser's minimal heat output and fast cooling ability decreases the probability of part distortion and ensures a clad material of a fine and pure metallurgical structure.

Nevertheless, as industries evaluate laser cladding and coating technologies, the fact that the laser application is very much a line-of-sight process should be considered. The laser process may not always be the best solution for every situation. Over the years, it has proven most appropriate for very high-value, critical components. These are important parts or assemblies that may halt operations when failure occurs. A recent breakthrough in laser-coating technology applied to benefit NASA's Stennis Space Center in Mississippi highlights the value of applying the technology to a high-value component.

Breakthrough Technology for NASA

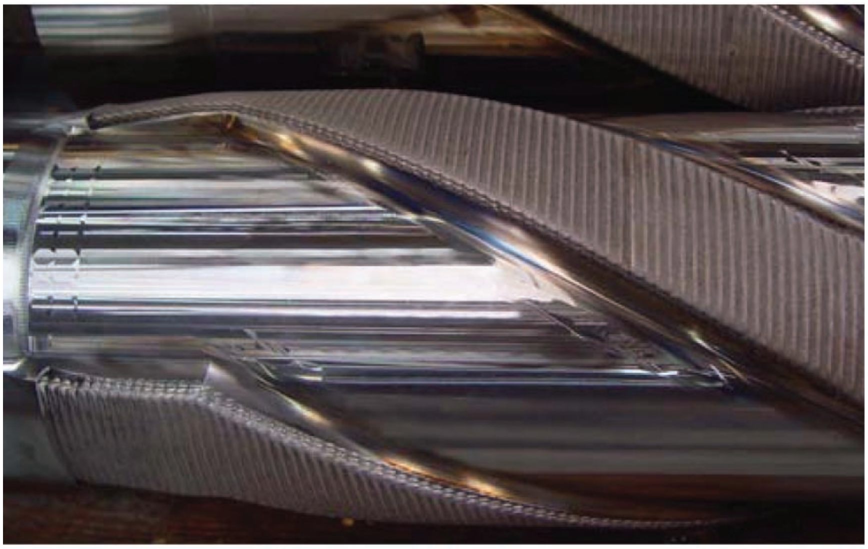
At NASA's Stennis Space Center (*www.ssc.nasa.gov*), rocket engines are tested. Giant test stands used for this purpose support a pipeline of industrial gases required to execute each test. Oxygen, hydrogen, and sometimes nitrogen products pressurized up to 15,000 PSI are stored in tanks and transferred into lines that feed the engines. Temperatures on the lines average -300 to -400 degrees Fahrenheit. A vast array of control valves and switches manages fluid flow, enabling flow to be turned on, off, and anywhere in between as needed. The largest of these valves is made from stainless steel and measures approximately six feet tall, six feet long, and weighs many tons.

Two years ago NASA's Stennis Space Center announced that it was hosting a seminar at Rice University in Houston. A government program designed to get commercial industries to help NASA solve problems was underway, and a select number of participants were invited to attend. Houston-based LCS was included. The team at Stennis Space Center faced a serious challenge regarding a critical control valve seal on a rocket engine test stand. The plug for the valve — the mechanism that slides in and out to choke the flow or stop it entirely — was composed of stainless steel, and its sealing surface needed to be softer and more ductile than the base stainless in order to effectively shut off flow and eliminate the possibility of sparking. A properly designed sealing surface would spring from the valve seat and conform to its original form when pulled back.

After conducting research regarding LCS and its capabilities with laser coating technology, NASA determined that the company might be able to help develop a solution. Following a series of discussions and visits to LCS facilities in Houston and Fargo, North Dakota, NASA and LCS collaborated to develop a test program to evaluate the chemistry, thickness, and ductility of various metal alloys applied by laser. NASA hired a third-party consultant to evaluate the results, and an optimum material was decided upon that consisted of an alloy high in copper content.

This was a significant breakthrough for NASA's Stennis Space Center because it had previously used an oven-sintered process in an attempt to create a better seal for the valve. The process was unreliable and very time-consuming. It entailed applying a copper alloy to the end of the plug and holding it into place with a substance that acts much like tape. The assembly was then shipped to a special facility in California where the copper alloy was fused to the base metal using an oven-sintering process. This process was cumbersome and had a very high application failure rate. The process typically would need to be repeated three or four times before resulting in the required physical and metallurgical properties. NASA had to pay for the processing and absorb the long lead times, whether it was successful or not. The laser-cladding process has reduced lead times by 75 percent and costs by 80 percent or more.

Interestingly, at the same that



LCS has applied tungsten carbide hardfacing via the laser cladding process in order to protect these tools in downhole service. Photo courtesy of Laser Cladding Services Ltd.

Sample of cladding of dissimilar metals on a downhole drill bit. This photo illustrates laser cladding being used to protect critical component wear surfaces and extend service lives. A similar process was used for the NASA-SSC project. Photo courtesy of Laser Cladding Services Ltd.

research for the valve seal issue was being conducted and materials were being selected, another type of problem with an entirely different type of valve on the same test stand was identified. Previous research enabled a solution to be quickly placed in action. Laser coating was used to enhance the integrity and reliability of another valve in the test stand system. This particular less time-intensive application was actually the first production piece LCS performed for NASA, demonstrating the versatility of the technology for similar applications.

Typically the type of materials flowing through a valve or the pressures on the lines determines which types of materials are appropriate for laser coating. Since a valve simply represents a means of stopping, starting, and controlling flow, general processing conditions will help the user decide what type of valve is right. In some cases a gate valve that behaves much like its name implies, lowering or lifting a barrier to start or stop flow is appropriate. In other instances, a ball valve that uses a turning mechanism to start or stop flow may be needed. Or, as discussed in the case of NASA's Stennis Space Center, a custom solution may be required. Regardless, innovation in laser-coating technology is helping industries protect multi-million dollar assets. Lessons learned and continued research and testing of metal alloys will increase the reliability of components on land, at sea, in space, and beyond. FC

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