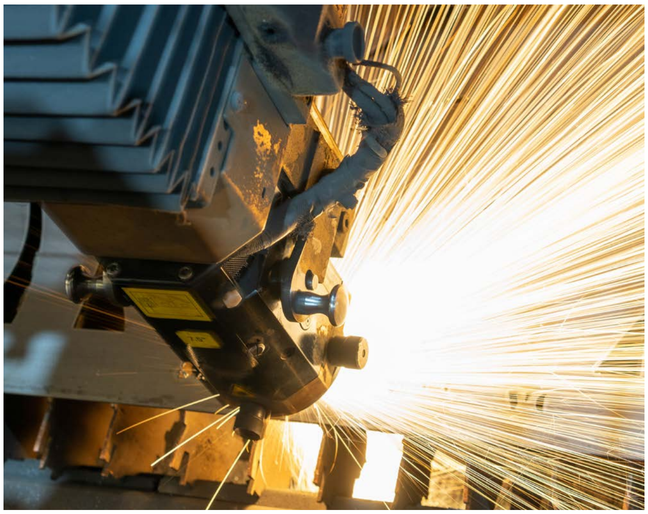
REMADE INSTITUTE

HIGH SPEED LASER CLADDING FOR ENGINE COMPONENTS

A process to repair components that require high strength could be applied to auto parts, heavy duty machines, and more.



To reduce wear and tear, crankshafts and camshafts are heat-treated to obtain a high surface hardness. Remanufacturing these components requires both restoring not only their original dimensions but original surface hardness to meet stringent reliability and durability requirements. As a result, these components are more likely to be scrapped than repaired.

This project demonstrated that high speed laser cladding (HSLC) of crankshafts and camshafts, as well as thin cross-sectional components used in fuel injection systems, is a feasible remanufacturing process for these components. Remanufacturing restores end-of-life products to like-new condition.

Laser cladding is a precision welding process that feeds powder into a laser beam, which melts the powder before it is deposited on a surface. HSLC melts the powder, prior to deposition, thirty times faster than traditional laser cladding technology. The increased speed reduces the amount of heat input into the component, which decreases the chance of distortion during coating application and, in turn, the potential for damage to the component's surface. This method also may enable thinner cross-sections to be repaired.

Components restored with HSLC can go into remanufactured engines, hydraulic pumps, and fuel injection systems. Most of these components are cast iron or steel, energy-intensive materials that are important to conserve and reuse. The HSLC repair technology developed in this project has great potential to serve other components that have similar characteristics and requirements.

PROJECT DESCRIPTION

Synergy Additive Manufacturing (Synergy) led the HSLC process development for this project, while equipment company Caterpillar provided component knowledge and performed the ultrasonic testing of the cladding. Rochester Institute of Technology led the overall project, developed analytical process models, and conducted mechanical and microstructural analyses.

This project had two goals: first, to understand how HSLC interacts with the base material so that the coating process can be optimized to restore the worn surfaces with minimal impact on the substrate; and second, to determine whether it is feasible to reach the coating requirements for a high strength application. For this project, the HSLC process consisted of applying AISI 431 stainless steel powder to AISI 4140 steel.

The project evaluated the effect of process variables including laser power, laser travel speed, traverse speed, and powder flow rate on the cladding rate and critical coating characteristics, such as, porosity, dilution level, fusion, hardness, and the heat-affected zone.

The team started with baseline process development trials using 431 stainless steel powder and 4140 steel base metal. Then they ran successive development trials to explore key parameters of the process, such as the maximum achievable cladding rate (measured in square centimeters per minute).

The results showed that the HSLC process, if applied using the correct process parameters, had greater surface and volume deposition rates that were higher compared to traditional laser cladding. In addition, HSLC specimens showed 50% improvement in fatigue life compared traditional laser cladded specimens.

PROJECT NUMBER: 18-02-RM-02

PROJECT IMPACT

On average, approximately 70% of the crankshafts and camshafts in heavy duty remanufactured engines are either reused or repaired parts. This reuse rate in engine remanufacture could increase to approximately 95% with HSLC, which would enable up to 4 reuse cycles rather than the current 1.5 or 2. Using this improved repair process in the heavy duty and automotive industries would reduce embodied energy by 3.8 petajoules, the equivalent of 1,000 gigawatt hours. It would also avoid 54 million metric tons of carbon dioxide emissions and save 40,000 metric tons of material per year. This equates to a relative embodied energy reduction of 26% and carbon reduction of 46%.

NEXT STEPS

This project made a major step toward making HSLC accessible to U.S. manufacturers. Through this project, Synergy is now equipped with the HSLC process technology and is now applying this repair method in production on fuel systems components. Caterpillar has added the capability to their technical center.

The HSLC process is ideal for many applications, but it currently has some critical limitations. The high surface speeds required are most easily accomplished by spinning the part, so alternative arrangements will be required to repair more irregularly shaped parts. The process also uses a short standoff distance, which could cause overheating during extended runs, resulting in surface damage. System improvements will be required to accommodate longer duration or higher power runs.

Further development will be required to validate the process for specific applications. Future research areas to explore include increasing the material systems tested, increasing the powder efficiency, decreasing excess heating of the nozzle, and validating the process on remanufactured parts. HSLC's high deposition rates and strong metallurgical bond also give HSLC the potential to replace current methods for wear- and corrosion-resistant coatings.

PROJECT PARTNERS

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PUBLICATIONS

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FOR MORE INFORMATION

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