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RESEARCH NEWS

Fraunhofer at the Hannover Messe Press Preview

Repairing Mining Tools With AI and Laser Technology

Researchers from the Fraunhofer Institute for Laser Technology ILT have teamed up with project partners to develop an AI module to help with laser material deposition. This technique is used to repair worn bucket teeth and other tools used in mining. The project partners include research organizations and companies from Canada. The Fraunhofer researchers will be presenting their solution at the Hannover Messe Preview on February 19, 2025.

Tools used in mining are exposed to tremendous wear. Excavator buckets with worn teeth or dull chisels and rock crushers are typically melted down and replaced with new ones. But that is expensive and resource-inefficient.

Laser material deposition (LMD), also known as cladding, presents an alternative to this. In this method, a metallic powder and the laser beam are guided through an optical system in such a way that the laser beam creates a localized weld pool on the component, where the powder is deposited. The system moves over the tool, depositing high-quality metal alloys path by path and layer by layer. This restores the original contour of parts such as a worn excavator tooth or drill bit exactly as they were before. In the Artificial Intelligence Enhancement of Process Sensing for Adaptive Laser Additive Manufacturing (AI-SLAM) project, Fraunhofer researchers are combining laser technology with artificial intelligence. "The goal of the project was to automate all the steps, from mapping the defects to planning the paths and parameters to be used during welding and then to the actual execution and quality control," explains Max Zimmermann, the project manager responsible for LMD coating and heat treatment at the Laser Material Deposition department at Fraunhofer ILT.

Project partners are the National Research Council of Canada, McGill University, and companies including Calgary-based AI firm Braintoy and Apollo Machine and Welding, which is based in Edmonton. BCT, a software development company based in Dortmund, is also involved.

Ultra-hard tungsten carbide and stainless steel

During the repair process, the laser optical system follows a pre-calculated path over the surface of the tool. Stainless steel is smelted at approximately 1300 °C and deposited, while nozzles simultaneously aim jets of tungsten carbide particles at the same

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area. The particles combine with the molten steel to form an ultra-hard coating on the tool after cooling, protecting it against both wear and corrosion.

One of the challenges for the team of researchers was to find the optimum ratio of tungsten carbide particles to steel. "Too high a proportion of particles makes the coating brittle and prone to cracking, but with too much stainless steel, it's too soft, so it wears down quickly," Zimmermann explains. The laser power also has to be calibrated so the temperature is high enough to melt steel but not so high that the tungsten carbide particles melt as well (at approximately 2900 °C). If that were allowed to happen, the tungsten carbide would become too soft. There are many other parameters besides: the distance between the nozzles and the surface, the speed at which the system traces its path, overlap between paths, the power of the laser and much more. In all, there are 150 parameters to set and coordinate when planning a single repair process.

AI plans and controls repairs

For the AI-SLAM project, the Fraunhofer researchers developed a several-part AI module that governs this complex planning and control process. As the first step, a line laser uses a CMOS camera to capture the worn contours of the tool, such as an excavator tooth. This produces an image of the current surface geometry. The image is compared against the contour of the tooth when new, which is also stored in the software. Finally, the module uses the difference to calculate the path and thickness of the metal coating that should be applied. A camera feeds images to the AI during the coating process so it can detect any discrepancies or errors while the work is under way.

Much faster and less error-prone

Project partner BCT incorporated the researchers' AI module into its OpenARMS operating software, which translates the parameters recommended by the AI for the welding process into control commands. This means human operators no longer need to type in the machine codes, a time-consuming and error-prone step. Calgary-based Braintoy is responsible for the machine learning algorithms. It also provides the platform for data analysis in the LMD system.

All of the solutions work together, so the repair process takes place automatically and without errors. "All the human operator needs to do is push the start button," Zimmermann says.

The experts from Fraunhofer ILT will be presenting the AI-SLAM project in person at the Hannover Messe Preview on February 19, 2025. Attendees at Hannover Messe from March 31 to April 4, 2025, can watch a software demo of laser material deposition at the Fraunhofer booth (Hall 2, Booth B24). The Fraunhofer researchers will also be on hand to answer questions.

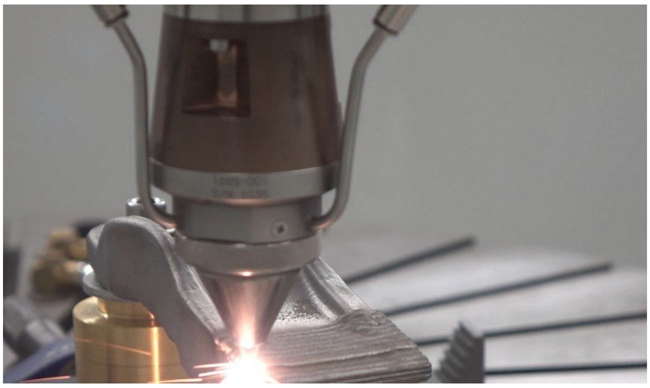

Fig. 1 To be able to deposit the metal coating on the tools' complex surface geometry from a consistent distance, the laser head moves on three axes and also features two axes of rotation.

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Fig. 2 Mining tools like this excavator bucket tooth are subject to extreme wear. Ultra-accurate AI-assisted laser material deposition is used to perform repairs quickly and cost-effectively right on the machine.

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