DISCOVERING THE POTENTIAL OF LASER POWDER SURFACING

BY IULIIA MOROZOVA

The application of the wear resistant overlays offers significant savings in terms of material cost and manufacturability in many industries where the components used require abrasion, corrosion and erosion resistance.

The key manufacturing processes used to deposit these overlays include submerged arc welding, thermal spraying and plasma transfer arc welding.

However, laser powder deposition, also widely known as laser cladding, has been proven to be an effective method that provides unique advantages for the deposited layers and the process itself.

"A laser is a weak source of energy. A laser takes only a few watts of energy and focuses them to a coherent stream of light. But with a laser, you can drill a hole in a diamond or wipe out cancer."

Al Ries

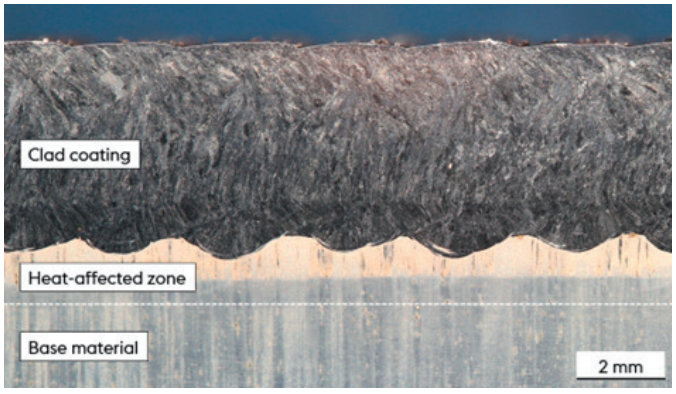
BENEFITS OF LASER POWDER SURFACING

The laser cladding process enables the precise and efficient deposition of powdered materials onto a substrate using a high-energy laser beam. The powder is transported by a stream of inert gas and melted by the laser beam upon contact with the substrate. The melted material then solidifies, bonding with the substrate or previously deposited layers, forming a solid, three-dimensional structure.

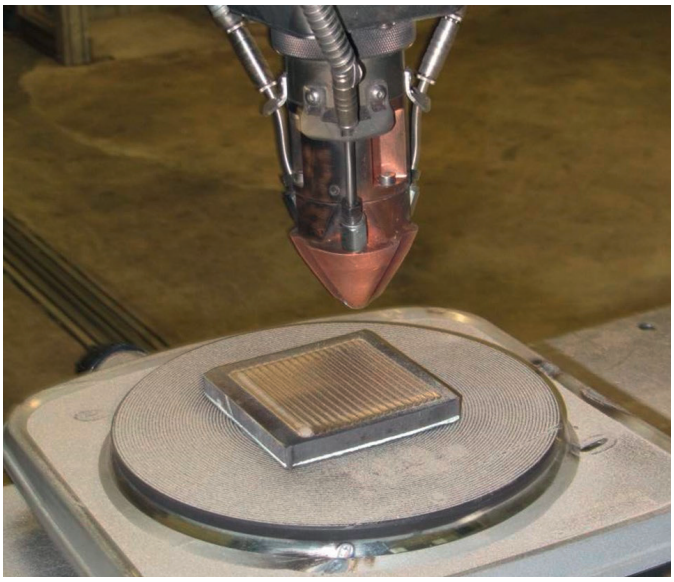
Due to the nature of the energy source, laser cladding offers numerous advantages in terms of design flexibility, material utilization, and production speed. The concentrated melting of the powder with the laser beam and the localized solidification process allows producing dense layers with very low dilution (up to <5%) yet provides a strong metallurgical bond between the overlay and substrate.

Low mixing between the deposited and base materials allows the required chemical composition to be achieved in a single layer. Moreover, low heat input of the laser process results in a minimal heat-affected zone (up to sub-millimeter range) and reduced distortion compared to conventional deposition techniques.

This makes this process particularly suitable for repairing or refurbishing high-value components, as well as for producing customized or low-volume parts with shorter lead times. When minimizing distortion becomes crucial in the case of small or thin components, laser cladding presents an alternative option for the deposition of the protective layers.



Cross-section view of a laser clad coating



One of the key benefits of laser cladding is its ability to work with a wide range of powdered materials, including metals, alloys, ceramics, and composites. This versatility allows for the creation of complex geometries and the combination of different materials, opening new possibilities in the design and production of components. For instance, wear-resisting coatings consisting of a ductile matrix and a hardening phase such as tungsten carbides can be generated by the laser. Through precise manipulation of the laser parameters, the distribution of reinforcing particles throughout the overlay can be controlled to achieve a homogeneous dispersion.

Furthermore, the laser deposition process is a cutting-edge additive manufacturing technique to print 3D high-performance parts. With its ability to work with a wide range of materials and its precise control over material properties, laser deposition has the potential to revolutionize manufacturing processes across multiple industries, leading to enhanced product performance, reduced costs and increased sustainability.

With the introduction of high-power diode laser systems and specialized laser cladding nozzles, designing and incorporating a reliable cladding process for hardfacing applications has become significantly easier. This process has proven to be highly advantageous in extending the critical lifetime of components in many segments such as steel, automotive, aerospace and natural resource extraction-based industries.

LASER POWDER SURFACING EQUIPMENT

A further advantage of laser powder cladding is the full automation of the process that ensures the superior reproducibility on the micron scale.

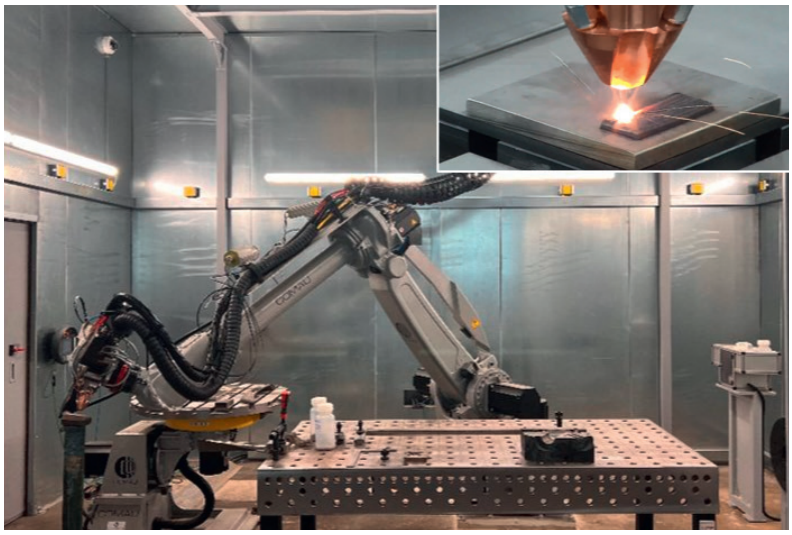
Moreover, this reduces the requirements on the skill level of the operators who need to use the prescribed process parameters and to simply observe the process.

In contrast to conventional surfacing techniques, the process speed can be significantly increased by using laser which in turn leads to a reduction in manufacturing costs and leading time.

In terms of quality control, laser powder surfacing provides superior monitoring and control capabilities. Through advanced sensing technologies, it is possible to monitor the process in real-time, ensuring consistent deposition and adherence to quality standards.

This level of control has boosted the confidence in delivering high-quality products that meet, or even exceed, customer expectations.

5 - Axis CNC laser system



Robotic 6 – Axis CNC laser system

voestalpine Additive Manufacturing Center is equipped with two forms of the automation control systems, namely the 5 – Axis computed numeric controlled (CNC) system and 6 – Axis Robot system.

The former equipment based on a 4 KW disc laser offers an exceptional repeatability and accuracy.

The robot system has an additional turn tilt table that together with the manipulated cladding head provides an ultimate freedom of movement.

Together, they make possible to process the form-complex and geometrically demanding parts in various applications such as surfacing, repairing, and freeform fabrication.

METALLURGICAL EXPERTISE

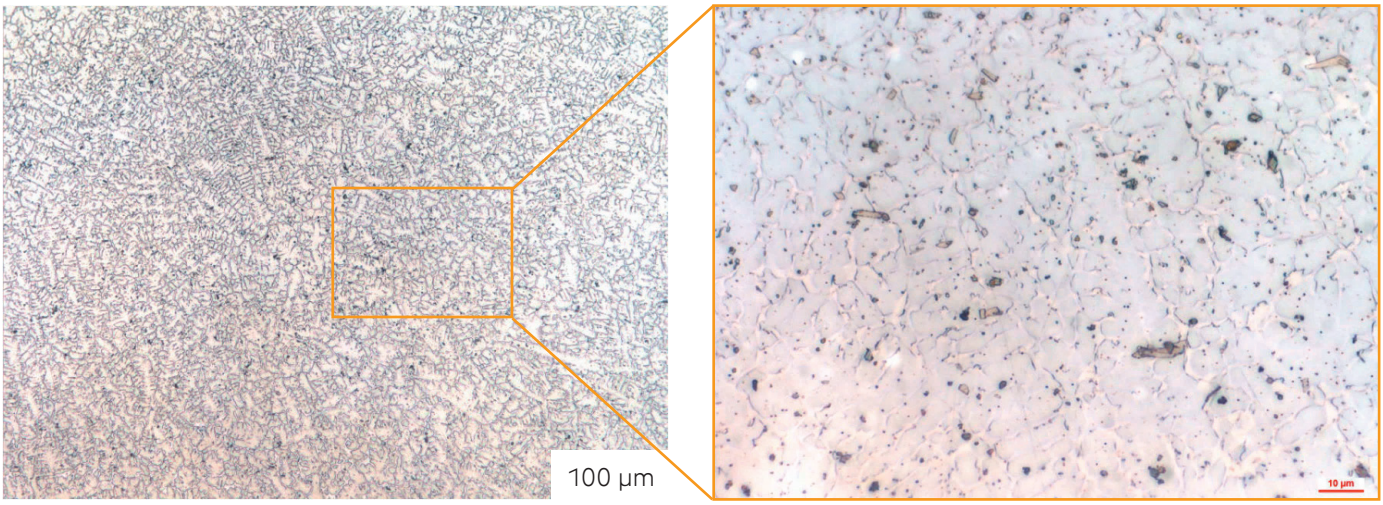
The second step of the surfacing process, besides the operating equipment, is the powder supplied. voestalpine Böhler Welding has designed a wide range of powders for laser surfacing. But a key to the efficient application of these consumables is the metallurgical expertise, as the laser process crucially influences the microstructure, and thus, the properties of deposited layers.

Due to the minimal heat input and the rapid solidification, i.e., fast cooling rate, a fine microstructure is generated in the deposits. This characteristic results in laser-clad overlays outperforming arc-welded coatings of the same initial chemistry, as they exhibit superior performance.

Furthermore, the microhardness of laser-deposited layers usually exceeds that of layers produced through conventional processes due to the enhanced solid solubility achieved through a fast-cooling rate.

The refining effect offers an additional advantage to high-performance materials whose effectiveness in combating wear and corrosion is often attributed to the presence of small, finely dispersed particles within the matrix.

The fast cooling in the laser process promotes not only fine dispersion but the uniform distribution of the hardening agents throughout the coating. The careful control of the heat input by adjusting the process parameter is therefore crucial to achieving a desirable structure that imparts high performance of the overlays.

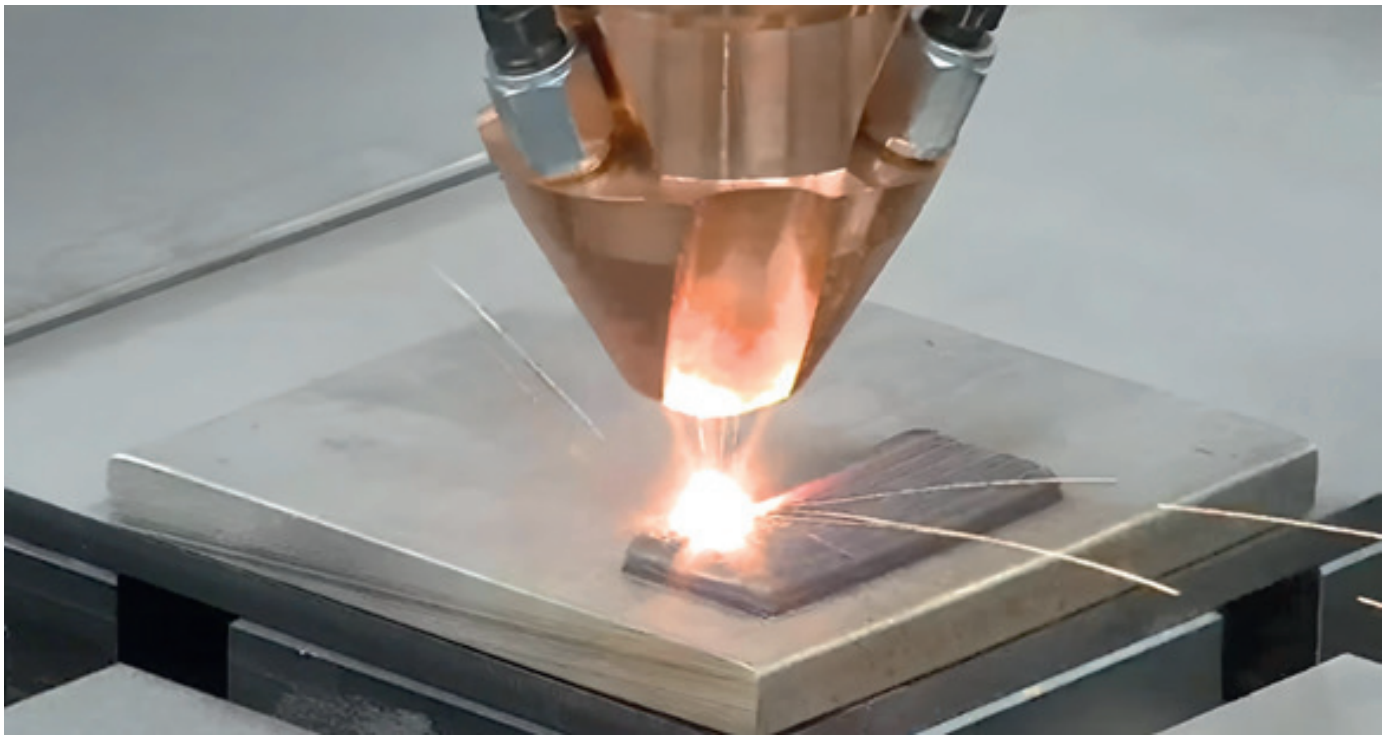


Structure of a laser-deposited Fe-Cr-Mo coating

SUSTAINABILITY

Last, but not least, there is the sustainability of the laser cladding process. Laser powder deposition enables minimizing material waste by precisely depositing the powder only where needed, reducing material consumption. The process utilizes a significant level of automation to produce coatings that require minimal post-clad machining to achieve the desired dimensional tolerances.

This has become an important aspect to consider in the application of laser cladding, in light of the constantly increased requirements for welding fumes generation. The laser-based process typically produces a lower volume of welding fumes compared to arc-based deposition due to the low heat input and a smaller quantity of molten metal involved.



WHY USE LASER POWDER SURFACING

- **Minimal dilution:** ability to achieve the chemistry required in the first layer
- **Narrow heat-affected zone:** less need for post weld heat treatment
- **Low heat input:** reduced distortion
- **Refining effect in the coating:** high mechanical performance
- **Exceptional surface finish of the deposits:** less need for machining

CONCLUSIONS

This paper discovers the advantages and possibilities of laser powder cladding which cannot be matched with other surfacing technologies.

It has revolutionized the ability to enhance the surface properties of various components, leading to improved durability, wear resistance, and overall performance.

The precision and versatility of the laser-based process have allowed us to achieve remarkable results across a wide range of industries.

However, the key to reach the potential of this process is selecting the right process parameters and the welding consumables.

It requires a special expertise from a solution provider to fully meet customer needs.

Looking ahead, voestalpine Böhler Welding constantly drives innovations both in the process and in the materials to implement them for the improvement of the surface performance.

IULIIA MOROZOVA

I studied mechanical engineering with a focus on welding metallurgy and material science, followed by six years of working in research.

In 2023, after finishing my doctoral thesis on the friction stir welding of aluminum alloys, I joined the team of Global Welding Technology for Surface Protection.

I am looking forward to a dynamic and engaging work environment in the voestalpine Böhler Welding team where I can contribute to our shared success.

JOIN! voestalpine Böhler Welding

We are a leader in the welding industry with over 100 years of experience, more than 50 subsidiaries and more than 4,000 distribution partners around the world. Our extensive product portfolio and welding expertise combined with our global presence guarantees we are close when you need us. Having a profound understanding of your needs enables us to solve your demanding challenges with Full Welding Solutions - perfectly synchronized and as unique as your company.

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