Development of High Wear Resistance Coating via High Speed Laser Cladding

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Abstract

The development of surface coatings with exceptional wear resistance is critical for prolonging the service life of components in demanding industrial applications. This study focuses on the deposition of a high-carbon, vanadium-, and chromium-enriched precipitation-hardening martensitic steel coating via high-speed laser cladding (HSLC). Compared to conventional laser cladding, HSLC offers improved deposition quality, higher efficiency, minimal thermal distortion, and a smaller heat-affected zone.

Coatings were deposited on two substrate types: forged steel with a ferrite-pearlite microstructure and carburized steel with a martensitic microstructure - covering a wide range of industrial applications. A range of HSLC parameters, including laser power, travel speed, powder feed rate, and overlap distance, were explored. Microstructural analysis revealed the formation of solidification cracks, particularly on the carburized steel substrate, regardless of processing parameters. Preheating the substrates to 250°C effectively mitigated these cracks by reducing thermal gradients.

The resulting coatings exhibited a columnar dendritic microstructure, with coarser dendrites near the substrate-coating interface and finer dendrites near the surface. Hardness measurements aligned with this microstructural gradient, showing the highest hardness at the coating surface and a gradual decline toward the substrate. Notably, all hardness values exceeded the target of 60 HRC, even with preheating, which only marginally reduced the hardness. Finally, reciprocating sliding wear tests demonstrated that the defect-free coatings achieved superior wear resistance compared to the baseline steel substrates.

These findings underscore the potential of HSLC for producing high-performance, wear-resistant coatings tailored to meet the demands of industrial applications.