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Directed energy deposition for functionalization of steel components with NiTi

Shape memory alloys (SMAs) such as Nickel-Titanium (NiTi) offer promising functional properties for a wide range of industrial applications. In this study, a cost-effective approach is presented for functionalizing low-cost steel components with NiTi, using laser-based Directed Energy Deposition (DED) with coaxial wire feeding. This research project implements NiTi to compensate for load cycles. Moreover, this approach seeks to offer an alternative to conventional thread locking media in liquid environments, providing a non-toxic and environmentally friendly solution. Nevertheless, compared to conventional steel, shape memory alloys are significantly more expensive and challenging to machine. For this reason, the approach presented here uses the shape memory alloy exclusively for a functional layer. A Directed Energy Deposition technique with wire is employed as the manufacturing method. However, the DED process requires a certain penetration depth and intermixing at the interface to ensure a stable metallurgical bond between the base substrate and the deposited layer. In the case of this dissimilar metal combination of steel and NiTi, such intermixing leads to the formation of brittle intermetallic phases, which negatively affect mechanical stability. Moreover, the resulting local changes in alloy composition can significantly alter the martensitic transformation behavior of NiTi. To address this issue, a process strategy was developed to minimize dilution and preserve the functional properties of the NiTi layer. Energy Dispersive X-ray Spectroscopy (EDX) and Electron Backscatter Diffraction (EBSD) were used to characterize microstructure and chemical gradients. The shape memory effect was successfully demonstrated for samples processed with optimized parameters.

This talk is a joint work by Vladimir Cara, Universität Duisburg-Essen, Werkstofftechnik, Prof. Stefanie Hanke) and myself on our project LaufFGL.