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Directed energy deposition - Arc vs. casting: Enhancements of mechanical and thermal properties of hot-work tool steels through additive manufacturing

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The additive manufacturing of complex shapes and medium-sized parts by Directed Energy Deposition-Arc (DED Arc/M) presents a promising approach by eliminating the need for specific tooling and minimizing resource use. However, DED-Arc/M results in microstructures differing distinctly from those observed in conventionally processed, cast materials. This is attributed to the process immanent thermal conditions, which are characterized by high cooling rates and successive re-heating during DED-Arc/M processing. Whereas the mechanical properties of additively manufactured tool steels are documented reasonably well, the thermophysical properties are highlighted insufficiently in previous works. Thus, the present study focusses on the investigation of DED Arc/M-induced microstructural effects on the mechanical and, additionally, thermophysical properties of the hot-work tool steel AISI H13 (X40CrMoV5-1). Therefore, the DED-Arc/M processed material's properties are contrasted to those of cast material in this work. An innovative statistical approach that incorporates quantitative EDS data was employed to investigate the distribution of alloying elements within the material. Additionally, the mechanical properties were examined at elevated temperatures through hardness, tensile and compression testing. Moreover, the thermal conductivity was studied in the temperature range of RT to 500 °C. This study thus facilitates a more comprehensive understanding of the DED Arc/M-induced effects on the microstructure, thereby providing insight into the material's enhanced mechanical and thermal properties. The findings indicate that DED-Arc/M-processing is a promising approach for manufacturing more efficient tools for hot-working applications.

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