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Direct energy deposition of chromium-molybdenum-vanadium LMD Vanadis 4 Extra© cold work tool steel

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For cold work tool steel applications, additive manufacturing is an attractive technology that provides opportunities to manufacture tools with complex geometries with minimal machining to the net shape. In the present work, a chromium-molybdenum-vanadium LMD Vanadis 4 Extra© cold work tool steel was manufactured using the direct energy deposition (DED) method. Process parameters were varied in a wide range to determine the influence of different build rates and cooling conditions on defect formation and resulting microstructure. The main parameter was the feed rate varied 400-800 mm/min, while laser power was maintained constant at 600W. Consequently, the powder mass flow was adjusted to result in an even layer thickness independent of the feed rate. Optical light microscopy proved a high relative part density above 99.5 % for different parameter combinations. Electron microscopy revealed dendritic microstructure with a developed network of V- and Mo-rich carbides. Interdendritic cracks or cracks between colonies were not observed in the DED build. Nevertheless, an increase in built height resulted in the formation of cracks between the substrate and the built. An increase in feed rate from 400 to 800 mm/min resulted in the formation of pores 100 µm and larger. At the same time, the microstructure looked finer in the material manufactured with higher feed rate, presumably due to higher cooling rates. The hardness of the build exceeded 900 HV1 and decreased to 700 HV1 in the dilution zone. The observed results confirm printability of chromium-molybdenum-vanadium Vanadis 4 Extra© cold work tool steel by DED. However, further optimization of process parameters and an investigation of the influence of the substrate material on crack formation in the dilution zone still need to be performed.

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