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LASER ENGINEERED NET SHAPING TECHNOLOGY TO MANUFACTURE TUNGSTEN CARBIDE IN A STEEL BINDER

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ABSTRACT

In this research work the feasibility of using direct energy deposition by means of Laser Engineered Net Shaping® technology in the manufacturing of WC-FeCr hardmetals was investigated. A martensitic stainless steel (AISI 420-FeCr) alloy was chosen as the binder material to cement the tungsten carbide (WC) particles. This steel was chosen for its corrosion resistance, high hardness and toughness at elevated temperatures. A comprehensive analysis into the deposition of the WC-10wt%FeCr (AISI 420) alloy was conducted by carrying out a full factorial design of experiments (DOE) to fabricate thin wall samples and optimization models were used in order to establish near optimal parameters. Continuous refinement of the laser power, traverse speed, powder feed rate and the z-increment by the use of ANOVA regression analysis, single objective optimization and multi-objective optimization techniques were used. The required sample height, lowest porosity combination was obtained at a laser power of 200 W, traverse speed of 3.2 mm/s, powder feed rate of 12.2 g/min and a z-increment of 0.2 mm which yielded a porosity of 2.80 %. Samples with a cube geometry were deposited onto a substrate for further refinement of the process parameters and in conjunction to the thin wall samples the lowest porosity of 2.87% was attained at the same process parameters. The porosity was a result of both lack of fusion and gas entrapment during deposition. Inhomogeneous bimodal microstructures composed of spherical WC with a surface reaction zone, herringbone carbides at the bottom of the sample, trapezoidal and stripe shaped carbides in the middle and top of the sample and partially melted columnar grains at the top of the sample were observed. The different reaction phases were inhomogeneous across the sample built and were also dependent on the process parameters. The variations in the microstructure led to the variation in the hardness profile of the samples from the substrate end to the top layers and was dependent on process parameters. Different crack restraining methods were investigated after initial depositions showed a high crack intensity. Preheating the substrate to 250 °C and laser re-melting resulted in the reduction of cracks. The LENS® process was also used to fabricate a prototype cylindrical rotary burr which was tested against a conventionally manufactured component in terms of its ability to remove previously deposited welds. The conventionally manufactured component performed far better than the prototype. Further work is required in order to improve the prototype's material properties and performance.