Abstract

Additive manufacturing is the keystone of what has been termed the 4th industrial revolution. With this prestigious title comes the need for additive manufacturing technologies to be applied to new material combinations to advance that which is possible by conventional manufacturing processes. Laser Engineered Net shaping (LENS®), a powder blown additive manufacturing process, was used to develop a process to deposit WC-9.2 wt.% Monel 400. A design of experiments matrix was successfully utilized to produce thin wall depositions which, with the application of ANOVA regression, were used to determine the best starting parameters for further refinements. Alterations to the laser beam power, laser beam spot size, z-increment, hatch overlap percentage, powder feed rate, traverse speed and stage temperature were all used to obtain an optimal parameter set. The lowest porosity of 2.5% was obtained using a laser beam power of 220 W, traverse speed of 4.5 mm/s, powder feed rate of 11.9 g/min, hatch overlap of 50% and a z-increment of 0.4 mm, with the 2.5% porosity contribution being attributed due to lack of fusion and oxygen entrapment during deposition. Multiple microstructures were observed with eutectic, fishbone and Fe/W-rich dendrites present in the fusion zone, needle-like, triangular and blocky carbides in the central region and acicular in the top region. These variations in the microstructure resulted in a gradient hardness profile from the substrate to the top layer as the grain size refined. The LENS® process was also successful in the fabrication of drill bits, which were tested against a commercially available drill bit in terms of hole circularity, hole depth, and hole diameter. The fabricated drill bits did not compare well to the commercial drill bit and had tip failure in all the tested cases due to regions of lack-of-fusion porosity which caused weakness in the component, but with further refinement with an emphasis on product development a LENS® fabricated drill bit can be competitive with a commercially manufactured drill bit. This study showed that with a well structured design of experiments and a mathematical parameter refinement process, the LENS® process can be applied to any novel cemented carbide combination with the focus on the feasibility of producing commercial components.