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Effect of deposition efficiency on microstructure and property of 316L stainless steel fabricated by laser engineered net shaping

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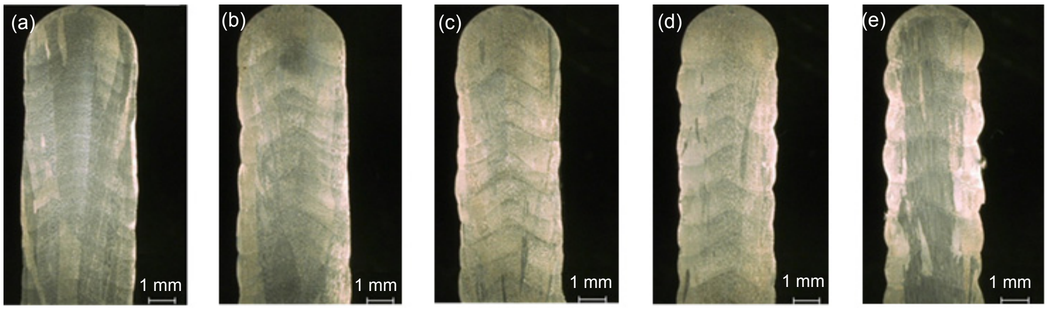

Local low magnification of the longitudinal section of the 316L stainless steel thin-walled parts: (a) Q=7.2 g/min, (b) Q=9.6 g/min, (c) Q=12 g/min, (d) Q=14.4 g/min, (e) Q=16.8 g/min.

Abstract: Laser engineered net shaping is a promising additive manufacturing technique that can be used for building three-dimensional components directly from CAD models by layer-wise deposition. Components with high performance and complex geometry can be achieved rapidly by this technology, and components of metal, ceramic or composite material have been successfully fabricated and used in many industrial field. High properties of fabricated specimens and high deposition efficiency are both important for laser engineered net shaping, but few researches have been done on the relationship between them. In this paper, single-bead multilayer structures of 316L stainless steel are fabricated by laser engineered net shaping system. Using the same laser power and scanning speed, different deposition efficiencies are achieved by adjusting powder flow rate and layer increment. Microstructure of each specimen is analyzed by SEM. Tensile strength and micro-hardness of the deposited structures under different deposition efficiencies are tested, respectively. Effect of deposition efficiency on microstructure and properties of fabricated 316L stainless steel are discussed. The results show that, for certain laser power and scanning speed, the deposition efficiency increases from 12.41 mm^3/s to 22.62 mm^3/s with the increase of the powder flow rate and layer increment, which increases by 86.3% compared with the initial process. Laser energy consumed by depositing unit effective volume reduces from initial 98.84 J/mm^3 to 53.06 J/mm^3 and the energy efficiency increases by 46.32%. Microstructure of the specimen consists of columnar dendrite and the dendrite length increases obviously with the deposition efficiency. Property test results show that properties of the specimens under different deposition efficiencies are consistent and do not decrease with the deposition efficiency. Tensile strength and yield strength are stable in 510 MPa and 290 MPa, respectively, and the elongation rate is around 40%. The precipitation of inclusions between grain boundaries is the main reason for the generation of tensile initial defects. Micro-hardness near the substrate of all specimens is higher than other position due to finer microstructure resulted from faster conduction heat dissipation through substrate. As a whole, the micro-hardness is stable at 173~184 MPa. Both the tensile property and micro-hardness of fabricated specimens have reached the same levels of forging. The research in this paper illustrates that the deposition efficiency of laser engineered net shaping and mechanical properties of fabricated structures can be optimized together during certain process window, which achieves fabrication of high performance parts with low energy consumption and high efficiency.

Keywords: laser engineered net shaping; 316L stainless steel; deposition efficiency; microstructure; mechanical property

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