Porosity control of in-situ forming tungsten carbide in laser additive manufacturing

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In laser additive manufacturing (AM) process, the hard-facing and abrasive materials are formed by re-melting of the matrix metals present in specifically sintered powders which contain already formed ceramic particles (example – tungsten carbide in a cobalt matrix). Such sintered powders are widely available off the shelf. However, the process limits the hardness of the deposit, lacks control over the forming microstructure and has a very narrow processing window, often with low processing speed. These limitations have hindered the widely adoption of AM in hard-facing applications.

An approach using in-situ formation of carbide particles from elemental powders with increased hardness have been reported [1, 2]. In addition, greater control over the forming microstructure can be achieved by modifying the powder composition. The in-situ formation process, however, is not well represented in the AM industry.

This study looks at in-situ formation of WC-12wt%Fe hard-facing materials for AM applications. In particular, the effect of powder packing density on the porosity of the deposit is investigated.

Commercially available elemental powders of tungsten, graphite and iron have been prepared in untapped and closely packed (compressed under 100MPa) forms. The samples were exposed to a laser heat source and the resulting microstructures have been analysed. Contrary to expectations, the closely packed powders have formed more porous microstructure than the loose powders.
It is hypothesised that the porosity of the deposits can be controlled by varying the packing density of the powder during the process. Closely packed powder particles formed evenly distributed pores and an increased heat-affected zone (HAZ) around the laser scanned area. Loosely packed powders produce large, localised and agglomerated pores with a reduced HAZ.

The ability to control the porosity can be used to create tailored deposits with varying properties.

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[2] D. Shu, Z. Li, K. Zhang, C. Yao, D. Li, Z. Dai (2017) In situ synthesized high volume fraction WC reinforced Ni-based coating by laser cladding. Materials Letters, vol. 195, pp. 178-181