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Process and materials design via statistical modeling for Inconel-625/tungsten carbide wear-resistant composite coatings fabricated by laser direct metal deposition technique

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It is critical that coating's microstructural characteristics are designed to meet its wear-resistance functional requirement. To the best of our knowledge, no study had related carbide dissolution ratio (CDR) in laser deposited Inconel 625 composite coating and its microstructural parameters to its wear performance. This study explores how laser processing and materials parameters influence CDR, microhardness (MH) and wear resistance (measured in terms of volume of materials loss: VML) of fibre-laser deposited composite coatings by employing response surface methodology (RSM). The nature of inter-relationship between the CDR, coating's microstructural parameters (average mean free path and size of retained particles, and MH) as well as VML was explored to determine appropriate process and materials parameters to optimise wear resistance of the coatings. CDR increases with laser energy density while MH and wear resistance increase with laser energy density up to a threshold of 19.70J/mm2. Above the energy density threshold, MH and wear resistance reduce. Inconel 625 content varies directly with CDR and VML while it has an indirect relationship with MH. The shielding gas flow rates have no effect on micro-hardness whereas it varies indirectly with CDR and VML. A fully consolidated coating characterised with uniformly distributed retained reinforcement's particle size of 40 μm; mean free path of 30 μm within the Inconel 625 matrix; MH = 852 HV0.5; and CDR = 77.08% has the most desirable wear resistance (VML = 9.42mm3) when processed with laser energy density (19.70 J/mm2), Inconel content (70wt%) and shielding gas flow rates (6.00 l/min). This study provides new insight, for coating manufacturers, on how CDR and microstructural parameters can be manipulated as laser process and materials variables are altered in designing most desirable wear resistant composite coating.