Optimization of laser-cladded SS316L/IN625 functionally graded material deposited on a copper substrate for boiler pipe heat exchanger applications

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Abstract:

Laser cladding is a surface modification method that can be employed in components under severe operating conditions, such as boiler heat exchangers, to mitigate degradation. However, poor clad quality hinders performance during service. This study employed the hybrid Taguchi-grey relational analysis and artificial neural network (ANN) method to optimize the clad qualities while varying the laser cladding process parameters including laser power, scanning speed, and powder flow rate. Laser cladding process parameters were used in the backpropagation NN model as input, and the grey relational grade was employed as the output of the model to improve the clad properties. The values of performance attributes for microhardness and aspect ratio were increased, whereas surface roughness and porosity were reduced in the fabricated functionally graded stainless steel 316L/Inconel 625 coating. When the ANN model was used to optimize the experimental grey relational analysis conditions, it was found that the 600 W laser power, 700 mm/min scanning speed, and 1.5 g/min powder flow rate enhanced the experimental output. The generated model significantly improved the quality of the laser cladding process. A confirmatory experiment was carried out using ANN optimal parameters, and the fabricated samples were subjected to microscopic analysis to ascertain the influence of process parameters on clad characteristics. Heat treatment was also used to alleviate the tensile residual stresses of the fabricated functionally graded material. Thus, the ANN model and fabricated coating can be utilized effectively to modify the boiler pipe surface.