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Influences of depositing materials, processing parameters and heating conditions on material characteristics of laser-cladded hypereutectoid rails

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Abstract

The effects of different cladding materials, processing parameters and heating regimes on the underlying microstructural features and mechanical properties of laser-cladded premium rails were investigated by using a hypereutectoid rail grade as a substrate, which is extensively used in heavy-haul rail systems. Cladding materials of 410L, 420SS, Stellite 6 and Stellite 21 with single and double depositions were considered for the comparative study of different cladding materials and processing parameters. To ensure the constant thickness of the claddings for comparison purposes, transverse speed and powder feed rate were modified concurrently in the ranges of 1000 - 1200 mm/min and 3 - 4 RPM, respectively. Two heating conditions, i.e. preheating only (HTA) and a combination (HTB) of preheating and post weld heat treatment (PWHT) were applied after the preferable parameters for each cladding material were obtained. The most suitable cladding material for rail-wheel contact was established by assessing all crucial aspects, i.e. surface defects, hardness, microstructural and mechanical properties. Process parameters for each considered cladding material were determined to achieve no surface defects. For cladding layers, application of HTA was not able to significantly modify the microstructures of the deposits, whereas HTB was observed to cause severe cracks in Co-base alloys, i.e. Stellite 6 and Stellite 21. In the heat affected zones (HAZs), irrespective of the cladding materials, the formation of untempered martensite was not avoided by the application of preheating at 350 ^{0}C. Consequentially, cracking in the HAZ was observed. An uncracked and desirable microstructure in the HAZs was established using HTB, regardless of the depositing materials. The addition of a second layer did not change the thickness of the HAZs but refined the HAZ's microstructures. Shear punch testing (SPT) and Vickers hardness testing were utilized to characterize mechanical properties for the considered cladding materials and good correlations with the obtained microstructural morphologies were shown.

Keywords: Laser cladding; Cladding materials; High carbon rail grade; Microstructures; Mechanical properties; Heating conditions.