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Alloy Design for Additive Manufacturing

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Additive Manufacturing (AM) processes may present advantages over conventional ones as they allow an easy fabrication of geometrically complex parts with modified and/or sometimes improved properties [1]. However, their efficient use and development need the design of new alloys, able to support the specific conditions of “building” the massive material in an AM process (‘printable alloys’) [2]. In this study, a computational method based on Bayesian machine learning combined with physical models and a thermodynamic approach (CALPHAD), integrated in a multi-objective genetic algorithm, is proposed to design AM-optimized alloys. The model optimizes both processing parameters, to avoid the defects frequently observed in AM-fabricated parts (solidification cracking, porosity, balling and geometrical distortions), and the material structure and properties (austenitic structure requested, high solid solution strengthening, high yield strength).The method was applied to design improved grades of austenitic stainless steels, searching for alloys containing up to 12 chemical elements: their complex composition bring them often to the class of “high entropy alloys”. An alloy, containing Fe-Cr-Ni-Mn-Co-Al, was elaborated and experimentally evaluated. Its structure and behavior are in agreement with predictions and expectations. Both numerical and experimental results of this study will be shown and discussed.

Keywords: alloy design, additive manufacturing, computational thermodynamics, machine learning

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