Development and simulation of laser shock peening process for additively manufactured samples made from titanium alloy

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The report presents the results of comprehensive studies of the laser shock peening (LSP) process of additively grown samples made from titanium alloy. A theoretical model has been developed in respect of the multifactorial impact of laser hardening modes and boundary conditions on the characteristics and properties of the samples. The key parameters and the order parameter to which the other variables of the laser-plasma system are subordinated are established. The critical laser flux density was calculated corresponding to the optimal value of the pulsed pressure of the plasma torch on the sample surface. Numerical simulation of 3D printed samples was performed in the module Print 3D of the Altair Inspire software; optimization was performed using the Hopfield neural network. The distribution of residual stresses in a titanium alloy has been studied theoretically and experimentally as well. The triadic relationship "mode–structure–properties" was featured out and substantiated for the LSP process. The surface, subjected to laser shock peening, as well as the layers in cross-section were investigated, whereby such characteristics as microhardness, strain hardening, roughness, residual stresses, and critical deflection were determined experimentally. In particular, residual stresses were measured both by X-ray diffraction analysis using the "$\sin 2\psi$"-method on a StressX GNR residual stress analyzer and by non-contact surface photometry. Image analysis was performed using the OpenCV library for Python.