Dynamic stability and simulation of the laser shock peening of titanium samples obtained by laser additive technology and welding

Isakov V.V.[1,@], Kostrica S.A[1], Korolev D.D,[2], Kozhevnikov G.D.[2], Tokachev D.A.[2], Zybenko E.V.[2], Lyakhovetsky M.A.[2] and Petrov M.A[3]

[1] FAI Central Institute of Aviation Engine Engineering named after P.I. Baranov, Aviamotornaya St. 2,, Moscow, 111116, Russian Federation
[2] Moscow Aviation Institute, Volokolamskoe Shosse 4, Moscow, 125993, None
[3] Moscow Polytechnic University, Avtozavodskaya 16, Moscow, 115280, None

[@] vvisakov@ciam.ru

The paper presents the results of theoretical and experimental studies of the laser shock peening (LSP) process of additive grown and welded samples, made from titanium alloy. A theoretical model of the dynamic stability of the process has been developed, taking into account the multi-factorial impact of the modes and conditions of laser induced hardening on the characteristics and properties of the samples. A mathematical model of the loss of stability phenomena has been presented for titanium sample based on the theory of bifurcations, which describes the transition from a stable wave process to an unstable one through pitchfork bifurcation caused by the non-linear interaction of a shock wave with the substrate material. The critical laser flux density corresponding to the optimal value of the pulsed pressure of the plasma torch on the sample surface has been calculated. Numerical modeling of 3D printing and welding of samples was performed as well. The optimization was performed using the Hopfield neural network model. On the treated surface and in underlaying material the micro-hardness, strengthening degree, roughness, residual stresses, and samples deflection were experimentally determined. Digital image correlation was performed using the OpenCV Python library. The obtained results were used to validate the evolutionary mathematical model of the LSP process.