Analysis of elastic-plastic wave during laser shock peening of metal

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One of the perspective methods for surface hardening of various metals and alloys is the laser shock peening (LSP). The technology is based on the effect of generation shock waves and plastic deformation in metallic materials by means of high-energy laser short-pulse impact. Optimization of operation parameters is an ongoing challenge for efficient application of LSP. As a material model, we use the Johnson-Cook (J-C) model with optimized parameters. The J-C model describes the propagation of a shock wave at strain rates orders of magnitude lower (10^3–10^4 s^{-1}), however it is widely used by researchers [1] [2] to describe the laser shock peening. The J-C model parameters are fitted using Bayesian calibration directly from the free surface velocity history obtained in LSP experiments at different laser power densities (6 – 19 GW/cm^2). The study was carried out on copper plate thicknesses of 0.25, 0.5, 0.8 and 1 mm. The dynamic loading was made by high energy pulse (10 ns) laser with 1064 nm wavelength. As a result, this approach made it possible to verify the numerical model and describe the propagation of an elastic-plastic wave in accordance with experimental data. Obtained results allow for large-scale numerical study to determine the optimal operating conditions during the LSP. The work was carried out as part of a major scientific project funded by the Ministry of Science and Higher Education of the Russian Federation (Agreement No. 075-15-2024-535 dated 23 April 2024).

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