Investigation of elastic-plastic wave propagation during laser shock peening by PDV data

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This work studies the elastic-plastic wave propagation in metals as a result of laser shock peening. Laser shock peening (LSP) is used to improve the strength, corrosion resistance and fatigue failure resistance of materials and structures. The essence of the technique is the formation of a residual stress, which prevents the initiation and propagation of fracture. A powerful laser pulse interacts with matter and generates plasma, which expands hydrodynamically and creates an elastic-plastic wave. The aim of this work is to establish the elastic-plastic wave velocity, magnitude and shape of the pressure pulse at different power densities of laser pulse and to correlate the obtained data with the magnitude and depth of the resulting residual stress field. The study was carry out on metal specimens. The elastic-plastic wave velocity profile was recorded using a photonic Doppler velocimeter (PDV) at different laser power densities (3 — 30 GW/cm^2). Measurements are carried out under near-process conditions, allowing optimisation of the treatment process for the benefit of specific qualified customers. As a result, the pressures applied to the material and the pulse shapes of elastic-plastic waves generated by laser shock with different power densities were obtained. These data were used as boundary condition in the numerical solution of the problem for determining the residual stresses in the material. 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).