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Research article

Numerical analysis of residual stresses in thin TI-6AL-4V alloy plates subjected to double-sided symmetric laser shock treatment

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Laser shock peening technology allows residual stresses of the first type (according to Davidenkov) to be generated (at a depth of more than 1 mm) in the near-surface zone of products made of metals and alloys. Extensive experimental studies demonstrate that laser shock peening significantly improves their mechanical properties, increases fatigue life, protects against corrosion. However, when applying this technology to products of rather small thickness (e.g., edges of turbine blades, blades of cutting tools) it is necessary to select such parameters of laser pulse impact that will not cause shape change. This paper presents an approach to numerical modelling of the formation of residual stress fields under laser shock treatment when reducing the thickness of products from 3 to 0.35 mm and by varying the magnitude and sequence of laser pulse application. The Johnson-Cook constitutive relation was used for modelling the propagation of elastic-plastic waves. After that, the static calculation of residual stress distribution was performed taking into account the created plastic strain fields. The obtained residual stress fields were compared with each other under different conditions of impact on the workpiece: single-sided treatment; double-sided sequential treatment; double-sided symmetric treatment. Analysis of the calculated stress fields indicated that double-sided symmetric impact is an effective technique for creating a compressive residual stress field in the near-surface zone of products with a thickness of less than 1 mm. At such hardening, it is possible to avoid bending of products and formation of tensile stress fields. It was revealed that, on the one hand, increasing laser intensity (modulo) increases the value of the minimum main residual (compressive) stress in the treatment zone, and, on the other hand, it also increases the maximum main residual (tensile, balancing) stress at a distance from the impact zone.

Keywords: laser shock hardening, residual stresses, finite element modeling, titanium alloys

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