Modeling of Head-on Collision Between Stress Waves Induced in Ti–6Al–4V Alloy Plate by Two Sided Laser Shock Processing

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Two sided laser shock processing (TSLSP) is often employed to improve the surface quality of thin section components, which can reduce excessive plastic deformation induced by one sided laser shock processing.

In the paper, a 3D finite element model was developed to predict the residual stresses (RS) induced in Ti–6Al–4V alloy plate subjected to TSLSP. The effects of key parameters, viz., metal plate thickness, shock wave pressure and number of laser shocks, on RS field were analyzed. The interaction mechanism of two head-on stress waves in the plate has been investigated, and the effects of parameters on RS distributions have been analyzed with simulations and experiments.

The following important conclusions can be drawn.

1. The intensity of stress wave decays with the increasing of its propagation distance, and the head-on collision between two stress waves leads to its intensity double transiently at the mid-plane in plate. The stress waves propagate, collide and are reflected constantly, and they completely vanish in the end. As a result of the interaction between stress wave and solid, the systematic RS field is formed.

2. The profiles of the surface compressive residual stresses (CRS) induced by TSLSP are affected by the plate thickness, peak pressure of shock wave and the impact time. Under the same conditions, thinner thickness, higher pressure of shockwave and more impacts can easily lead to the obvious “RS hole” effect in plate surface.

3. The multiple TSLSP impacts at the same location have a considerable effect on RS distribution. After four successive laser shocks with 2 GPa, the surface maximum CRS is progressively piled up to 604.5 MPa, and the CRS penetrated depth is increased to 0.94 mm.