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Research and development of laser shock processing technology

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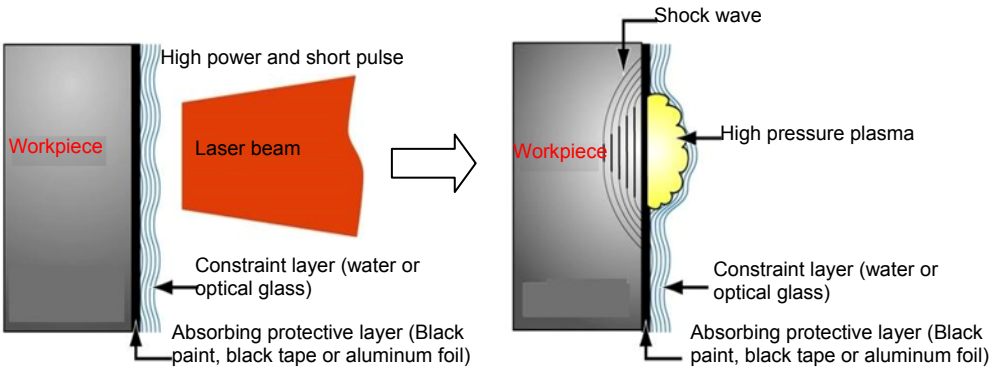

Technical principle diagram of laser shock processing.

Abstract: The concept of "laser" was proposed at the beginning of 20th century. Since then, laser research had always been a popular research area. Laser is widely applied because of its characteristics, such as good direction, high brightness, and good color. Laser processing technology is one of the most promising areas for laser applications. Laser shock processing (LSP) is a new and efficient type of laser surface treatment technologies. Modern society makes higher requirements of the service to mechanical parts, and mechanical properties of parts are needed to improve to meet the use. As a typical laser surface treatment technology, LSP can achieve a greater increase of the performance, compared with other traditional surface treatment technologies. LSP strengthening process is similar to that of shot peening, except that the mechanical effect of laser is used instead of the impact of the projectile. The impact pressure and the influence of depth on the surface of the material are larger. It also has a smaller change to the surface topography of parts. LSP can bring a deeper residual stress layer to the material and make surface grain refinement or even appear nano-crystalline, meanwhile significantly improving the fatigue life of the material. The LSP utilizes the mechanical effect of the laser rather than the thermal effect. The high-energy laser irradiates the material of the confinement layer (usually is black paint, black tape or aluminum foil), and the material of the confinement layer is instantaneously melted and gasified to produce high-temperature and high-pressure plasma. The plasma continues to absorb laser energy and expands to form a shock wave. The plasma shock wave can be seen as a detonation wave of a physical property, and C-J model is used to calculate and predict the variation of the peak pressure of the plasma shock wave. The plasma propagates to the interior of the material under the constraint of the confinement layer (usually is water or optical glass). The pressure of the shock wave far exceeds the elastic yield limit of the material. Therefore, the material undergoes elastic-plastic deformation and eventually forms a stable residual stress field and a slight plastic deformation. The research and development of LSP are introduced, including the key of this technology: the selection and perfection process of absorbing and protective layer. The development direction of the technology is also forecasted.

Keywords: laser shock processing; surface strengthening; residual stress layer; nanocrystalline; plasma shockwave; plastic deformation

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