GRADUATE STUDENT RESEARCH SEMINAR SERIES (2018)

OPTIMIZATION OF LASER SHOCK PEENING PROCESS USING FINITE ELEMENT MODELING

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Laser shock peening is a cold working process which is used to improve material properties like fatigue life, wear and corrosion resistance, etc. It is widely used to treat turbines, fans, compressor blades, aircraft and automotive parts. When the material is irradiated by high power density laser beams, shock waves are generated which plastically deform the material surface and induce high compressive stresses within subsurface area. The amount of residual compressive stress and plastically affected depth depend on laser parameters (laser power density, pulse duration, wavelength, repetition rate spot size and shape), materials, ambient environment, etc. To improve the application of laser shock peening, it is of critical importance to optimize the process by fully understanding the effects of different parameters. This research studies the effects of laser repetition rate and spot size on the final shock peening results by finite element modeling.

A two-dimensional finite element model is developed to simulate the interaction between metal samples and laser-induced shock waves. Multiple laser impacts are applied at each location to increase plastically affected depth and compressive stress. The in-depth and surface residual stress profiles are analyzed at various repetition rates and spot sizes. It is found that the residual stress is not sensitive to repetition rate when it is not very high. However, at extremely high repetition rate (100 MHz), the delay between two shock waves is even shorter than their duration, and there will be shock wave superposition. It is revealed that the interaction of metal with shock wave is significantly different, leading to a different residual stress profile. Stronger residual stress with deeper distribution will be obtained comparing with longer repetition rate cases. The effect of spot size is also studied. It is found that with larger laser spot, the peak compressive residual stress and the distribution depth are increased with deeper distribution.

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