Investigation of the Cavitation Bubble Oscillation Period During Laser Shock Peening

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Abstract

Laser Shock Peening (LSP) under a thick water confinement layer produces cavitation bubbles that rapidly expand and collapse emitting at least two shock waves in the surrounding water. The time between the first shock (laser pulse) and the second shock (first bubble collapse) is understood as the first bubble oscillation period or bubble lifetime and is evaluated here for use as a real time process diagnostic in the LSP process. Within this study, it was found that first bubble oscillation periods could be correlated to an increasing laser power intensity up to $6\,\mathrm{GW/cm^2}$. Thereafter, systematic saturation in laser energy transfer occurs. The saturation, apparent in all tests above this power intensity, is attributed to the laser energy being absorbed in dielectric breakdown of the water before reaching the target. The stability of bubble lifetimes was most appreciably improved with the presence of flowing water along the beam path. The target geometry (corners, cavities, semi-cylinders) produced an overall change (increase or decrease) in cavitation bubble lifetime that is present regardless of beam energy, water flow or laser pulse rate. Promising applications for this diagnostic at present would be in cases of unchanging or predictable target geometries such as large flat or uniform panels (pressure vessels and aircraft skin structures) with the use of high water flow rates to maintain the confinement layer along the beam path.