Laser Shock Peening Evaluations of Ti-6Al-7Nb Alloy: Residual Stress, Microhardness, and Microstructure

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ABSTRACT

By introducing deep compressive residual stress, laser shock peening (LSP) benefits the fatigue strength of metallic materials. This study investigates the effects of LSP on the residual stress, microhardness, microstructure of Ti-6Al-7Nb alloy. Surface modification by LSP was conducted by laser energy of 3J, 5J, 7J, overlay of 33%, 50%, and 67%. Microhardness was evaluated by Vickers indentation. Surface and cross-section residuals stresses are measured separately by X-ray diffraction (XRD) and incremental hole drilling method. What is more, a Scanning Electron Microscopy (SEM) with Back Scatter Electron Diffraction (EBSD) was employed to investigate the texture and strains of Ti-6Al-7Nb subject to LSP. Additionally, the residual stress affecting layers were analysed by grain orientation spreading maps in EBSD. The results showed that LSP introduced compressive residual stresses on the surface varying from -110MPa (3J at 33%) to -520 MPa (7J at 67%). Compared to as-machined sample (328 $HV_{0.01}$), surface microhardness of Ti-6Al-7Nb samples were improved by LSP with increase range from 12.1 % (368 $HV_{0.01}$) to 30% (425 $HV_{0.01}$). The grain size subject to LSP, evaluated by SEM and EBSD, were also refined by 47% to 71% with different LSP parameters. In addition, after LSP, the low angle misorientations and formation of sub-grain boundaries were increased. This study would optimize the residuals stress of Ti-6Al-7Nb using LSP parameters (laser energy and overlap?) for improving the performance of medical implants. This in turn will improve user satisfaction, reduce failures and the number surgical operations needed to replace the otherwise worn Ti-6Al-7Nb alloy.

Keywords: Ti-6Al-7Nb; Laser shock peening; Residual stress; Microhardness; Microstructure