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Effect of texture on the residual stress response from laser peening of an aluminium-lithium alloy

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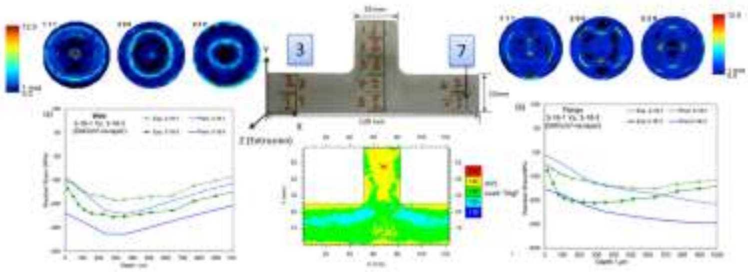
Graphical abstract



Abstract

Laser shock peening can improve the damage tolerance of metallic materials by introducing deep compressive residual stress that inhibits crack initiation and growth. This study investigates the laser peening of aluminium alloy in a product form – an extruded T-section – that has different crystallographic textures in different locations. The alloy studied is Al 2099, an aluminium-lithium alloy that shows anisotropy in the mechanical properties when texture is present. Specimens extracted from different regions of the extrusion were laser shock peened with a power density of 3 GW/cm^2 in single shocks as well as in a pattern. Residual stresses were characterized primarily using incremental hole drilling. The results show 20% higher residual stresses in the web area of the extrusion compared to the flange after peening with a single laser shock, with this difference decreasing as the number of shocks increases. This effect can be explained by the difference in yield strength between those locations. No significant differences were observed in the residual stresses from peening onto different planes of a textured sample at a given location.

1. Introduction

Al 2099 alloy is a third-generation aluminium-copper-lithium alloy used for aerospace structural applications, particularly in airplane internal structure and lower wing stringers. The lithium content in an Al-Li alloy increases the specific properties over traditional aluminium alloys. For example, Giummarra et al. 1998 reported that compared to the commercially-used non-lithium Al 2024 alloy, Al 2099 shows a 5% reduction in density with 20% increase in longitudinal tensile yield strength. In common with many aluminium alloys, Al 2099 shows significant in-plane and through-thickness anisotropy, particularly in the rolled products, and axisymmetric flow anisotropy in the extruded products as explained by Rioja 1998. Generally, this anisotropy results from the strong