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SCHOOL OF MECHANICAL, INDUSTRIAL & AERONAUTICAL ENGINEERING

Tailoring Surface Finish and Residual Stress Profile of Aeronautical Additive Manufactured Parts by Laser Shock Peening

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Abstract

This project was aimed at the advancement of the Laser Shock Peening (LSP) process for additive manufactured aluminium alloy, specifically AlSi10Mg, for aeronautical applications. The samples that were manufactured by Additive Manufacturing (AM) Selective Laser Melting (SLM) had thicknesses of 1.2, 2.6, 5.6, 9.6, and 13.6 mm and were then surface treated with LSP. The samples were treated with 3 different Power Intensities (PI) of 1.5 GW/cm^2, 3.0 GW/cm^2, and 4.5 GW/cm^2, with a fixed round spot size of 1 mm diameter and 80% coverage. It was found that there was an increase of the average surface roughness (Ra) from approximately 1.66 µm for the as-built AM samples to 3.77 µm for the AM and LSP'ed samples, and an increase of surface roughness with an increase in PI of the LSP was observed. However, the published data for surface roughness for AM aluminium alloy AlSi10Mg indicate a value of about 6-8 µm. The surface and the cross-section of the AM AlSi10Mg samples post-processed by LSP was characterized using optical and Scanning Electron Microscopy it was found that there were defects, such as cracks, pores and solidification of material that had not melted correctly, within the cross-section of the material for the as-built AM samples and the AM and LSP'ed samples. The published data of as-built AM aluminium alloy AlSi10Mg has a Vickers' hardness of 124Hv at 500 gf. The microhardness close to the surface of the AM aluminium samples that had undergone LSP experienced an increase of 33% for PI of 1.5 and 3.0 GW/cm^2 and an 18% increase in microhardness for a PI of 4.5 GW/cm^2 in comparison to the as-built AM sample. The Incremental Hole Drilling (IHD) technique was used to measure the residual stress of the as-built AM AlSi10Mg samples with different thicknesses and after LSP processing. The maximum tensile residual stress of the 9.6 mm thick as-built AM sample was 237.78 MPa. After LSP, the change in residual stress from tensile to compressive was 143% for a PI of 1.5 GW/cm^2, 165% for a PI of 3.0 GW/cm^2 and 183% for a PI of 4.5 GW/cm^2 for a 9.6 mm thick sample. The results compared favourably between the as-built samples and the peened samples concluded that LSP has not only the beneficial effect of removing the tensile residual stress of the as-built AM samples but also inducing compressive

residual stress. A clear trend of the curve of the residual stress depth profile after peening had shifted upward, which is attributed to the fact that there is less elastic material to respond to the plastic deformation induced by LSP. This corresponded to the trend for AA7075.