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TOWARD MICROSTRUCTURE AND COMPOSITION HOMOGENEITY IN LASER POWDER BED FUSED METALLIC ALLOYS: DESIGN, FABRICATION, AND EVALUATION

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Abstract

Nickel-based and Titanium-based alloys are among the most important materials that are promising for use in the production of a large variety of aerospace, automotive and medical instrument applications. With recent advances in additive manufacturing (AM) technologies, and specifically laser powder bed fusion (LPBF) techniques, highly complex structures can be fabricated via rapid and cost-effective protocols as promising alternatives to the sophisticated, costly, and time-consuming traditional fabrications. Despite tremendous efforts over the last few decades, an effective LPBF methodology capable of creating high quality parts with microstructure homogeneity is still not on the horizon. In this study, comprehensive research has been conducted to identify the routes of microstructure inhomogeneity in LPBF-fabricated parts, and novel techniques have been proposed to accordingly address this critical issue. This research encompasses three primary objectives, as described in the following: (i) to study the spatial variation of microstructure, composition, and metallurgical properties of LPBF fabricated samples, (ii) to address the issue of microstructure variation within LPBF processed parts through considering borders surrounding the parts during fabrication, and (iii) to study the effect of microstructure uniformity on resultant mechanical performance. The research findings demonstrated that the properties of LPBF processed parts significantly varies among the different heat affected areas (e.g., near surface, away from surface) due to the difference in heat transfer mode. Moreover, it was revealed that the use of a border surrounding a main part during the fabrication can highly control the heat transfer modes toward improved structure uniformity. The optimum value for the gap between the main part and border was identified, which yielded a significant reduction in the defects at the surface of LPBF processed parts, e.g., un-melted powders, porosities, cracks, shallow melt pools. Accordingly, the use of that specific gap value yielded higher ductility and tensile strength. The method used in this study was found to be capable of widening the horizons of in-situ properties optimization of LPBF processed products as an alternative solution for the post processing techniques.