

Abstract

This thesis delves into the transformative effects of Hot Isostatic Pressing (HIP) on components fabricated through Additive Manufacturing (AM) methods, focusing on the Electron Beam Powder Bed Fusion (EB-PBF) and Laser Powder Bed Fusion (L-PBF) of Ti6Al4V and TiAl alloys. The research is pivotal for the aerospace and biomedical sectors, where the mechanical integrity and performance of materials are paramount. It aims to refine AM processes to overcome prevalent challenges such as porosity, deformation, and inconsistent microstructures, thereby elevating the mechanical properties and reliability of produced parts.

The investigative journey begins with an in-depth exploration of EB-PBF and L-PBF techniques, spotlighting their potential and limitations in processing Ti6Al4V and TiAl alloys. The study meticulously examines the microstructural evolution influenced by varying HIP conditions, providing a nuanced understanding of how HIP treatment can significantly mitigate defects and enhance material characteristics. For TiAl alloys, a critical breakthrough was achieved by identifying optimal EB-PBF process parameters that crucially reduce aluminum evaporation— a significant hurdle that impacts microstructural uniformity and mechanical strength. This optimization ensures the production of denser components with a more uniform microstructure, tailored for high-temperature applications.

Parallely, the thesis's exploration into Ti6Al4V alloy unveils how HIP effectively diminishes porosity, fostering an improvement in overall material quality. A predictive model emerges from this analysis, offering a strategic guide to optimize LPBF process parameters and HIP conditions. This model stands as a cornerstone for manufacturing near-full density Ti6Al4V components, adeptly managing deformation to maintain structural integrity, especially in encapsulated materials tailored for specific applications.

In conclusion, this thesis significantly advances the AM field, elucidating the intricate relationship between AM process parameters, HIP treatments, and the resulting material properties. The findings not only propel the current understanding of Ti6Al4V and TiAl alloys forward but also lay a solid groundwork for future endeavors aiming to refine AM techniques and post-processing treatments. As we edge into a new era of materials engineering, this work

highlights the critical importance of ongoing exploration and innovation in AM, heralding a future where the potential of material performance continues to expand.

By bridging gaps in current knowledge and introducing novel methodologies, this research marks a pivotal step towards the realization of more efficient, sustainable, and higher quality manufacturing practices. The journey of discovery in the realms of additive manufacturing and HIP processing is far from concluded, with each new insight pushing the boundaries of what is possible in material science and engineering.