MATERIALS ENGINEERING

SEMINAR

"Microstructure Evolution and Strengthening Effects of Carbide Phases in Mar-M 509 Cobalt Alloy Fabricated by Laser Powder Bed Fusion"

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ABSTRACT

Laser powder bed fusion (LPBF) is a rapidly emerging manufacturing technology capable of producing complex part geometries through the repeated, precise laser melting of metallic powder layers. At present, the process is primarily employed in high-value-added applications which exist in the aerospace, biomedical, and dental industries. As industrial implementation of LPBF has matured, research has focused on established materials for which there are already large bodies of literature and regulatory approval, such as Inconel 718, Inconel 625, Ti-6Al-4V, and 316 stainless steel. However, the rapid solidification process inherent to LPBF leads to vastly different microstructures with improved strength compared to these traditional materials in cast or wrought forms.

This work examines laser powder bed fusion of Mar-M 509, a carbide-strengthened cobalt alloy that is typically investment cast directly into complex-shaped components such as nozzle guide vanes. As-printed, the cellular and dendritic Mar-M 509 LPBF microstructures lead to the formation of continuous, fiber-like, eutectic carbide structures in the intercellular and interdendritic regions, which limit macroscopic ductility. ThermoCalc is used for calculation of phase diagrams (CALPHAD) to estimate the equilibrium transformation temperatures of MC, M23C6, and M7C3-type carbides, which informs design of isothermal heat treatments to engineer microstructures with enhanced ductility over the as-printed or cast versions of Mar-M 509 while maintaining tensile strength. Scanning electron microscopy and transmission electron microscopy reveal the composition and distribution of carbide phases as a function of heat treatment temperature. Lastly, heat treatment recommendations for nozzle guide vanes are made.

Date: Monday, April 3, 2023
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Place: HAMP 2107 or via Webex: https://purdue.webex.com/meet/xzhang98

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