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IAF MATERIALS AND STRUCTURES SYMPOSIUM (C2)
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ADVANCEMENT OF EXTREME ENVIRONMENT ADDITIVELY MANUFACTURED ALLOYS FOR NEXT GENERATION SPACE PROPULSION APPLICATIONS

Abstract

The National Aeronautics and Space Administration (NASA) has been involved in the development and maturation of metal additive manufacturing (AM) for space applications since the late 2000's. Several efforts have focused on the understanding of AM processes through material characterization and testing, standards development, component fabrication, and infusion into propulsion development and flight applications. NASA has matured commonly used aerospace alloys from various alloy families (Nickel, Stainless and Steel, Aluminum, and Titanium-based) through detailed AM process and heat treatment characterization, in addition to mechanical and thermophysical testing. While these alloys are actively used in many propulsion applications, there is a need for ongoing AM optimized alloys using integrated computational materials engineering (ICME) and process development for high performance applications that has been realized. The applications targeted are liquid rocket engines, advanced propulsion systems, and in-space propulsion with high heat fluxes, high pressure, and that utilize propellants such as hydrogen, which can degrade alloys. This paper highlights the characterization and physical properties of the more common AM alloys using laser powder bed fusion (L-PBF) and laser powder directed energy deposition (LP-DED) processes. Additionally, this paper discusses some of the ongoing novel alloy development and maturation using AM for use in these harsh environments, such as GRCop-42, GRCop-84, NASA HR-1, and C-103. The results from these processes have demonstrated that AM can enable rapid development and ongoing efforts for optimized alloys using ICME that can yield higher performances. These alloys have undergone modeling, fundamental metallurgical evaluations, heat treatment studies, and microstructure characterization and mechanical testing campaigns. This, combined with direct application-specific component fabrication and hot-fire testing, enabled the increase of the Technology Readiness Level (TRL) through high duty-cycle testing. This paper provides a background and overview of these various AM-enabled novel alloys and AM processing developments including metallurgical and mechanical property studies. It also covers the latest advancement in the parallel component development and hot-fire testing and future developments for these alloys.