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DESIGN GUIDELINE REQUIREMENTS FOR THE QUALIFICATION OF ADDITIVE MANUFACTURING IN METALLIC SPACECRAFT STRUCTURES.

Abstract

The Additive Manufacturing (AM) process Laser Powder Bed Fusion (LPBF) has enabled the manufacture of intricate metallic component designs with reduced weight, reduced part numbers and quicker production times. This makes it attractive for the manufacturing of complex metallic parts in the space industry. However, design related issues such as the inherent surface roughness of LPBF produced components could impede part performance, especially from a structural perspective. While also increasing the complexity of a critical parts route to qualification. Costly and or time-consuming post-processing rough surface or support structure removal is an option, but in cases such as enclosed consolidated parts as needed for optimised rocket engine turbomachinery, it can be impossible. Spacecraft engineers therefore require design methods, processes and guidelines that educate designers on the influence of design related issues, such as the effect of surface roughness, on part performance and how to consider them during the initial Design for AM (DfAM).

Through an analysis of recent advancements in the use of AM in space applications and the design issues surrounding its adoption in critical spacecraft structures. This paper presents the results of a systematic literature review of research related to LPBF design methods, surface roughness, AM design and qualification of AM for spacecraft structures. Identifying current and future research on proposed AM design methods and developing them to provide proposals on how AM design support should look like for spacecraft design engineers wishing to utilise the benefits of AM in space applications. Also, a description is given of a proposed DfAM process that uses AM Design Artefacts to investigate the relationship between design, surface roughness and fatigue performance of a metallic rocket engine component.

The results show that today there is an apparent lack of DfAM guidance available for spacecraft engineers wanting to utilise AM without compromising on performance. Hence a suggested path towards appropriate design guidance is outlined. In the long term, robust DfAM methods are needed to provide a path to qualification for critical AM spacecraft components. These methods and processes will need to provide guidance on LPBF process factors, their interactions, and their relation to different part properties. A goal being to enable the use of this innovative technology in the creation of low cost and low weight reusable rocket engine technology.