National Aeronautics and Space Administration

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Development of NASA Standards for Enabling Certification of Additively Manufactured Parts

There are currently no NASA standards providing specific design and construction requirements for certification of additively manufactured parts. Several international standards organizations are developing standards for additive manufacturing; however, NASA mission schedules preclude the Agency from relying on these organizations to develop standards that are both timely and applicable. NASA and its partners in human spaceflight (Commercial Crew, Space Launch System, and Orion Multi-Purpose Crew Vehicle Programs) are actively developing additively manufactured parts for flight as early as 2018. To bridge this gap, NASA Marshall Space Flight Center (MSFC) is authoring a Center-level standard (MSFC-STD-3716)[1] to establish standard practices for the Laser Powder Bed Fusion (L-PBF) process. In its draft form, the MSFC standard has been used as a basis for L-PBF process implementation for each of the human spaceflight programs. The development of an Agency-level standard is proposed, based upon the principles of MSFC-STD-3716, which would have application to multiple additive manufacturing processes and be readily adaptable to all NASA programs.

Background

Additive manufacturing (AM) has rapidly become prevalent in aerospace applications. AM offers the ability to rapidly manufacture complex part designs at a reduced cost; however, the extreme pace of AM implementation introduces risks to the safe adoption of this developing technology. The development of aerospace quality standards and specifications is required to properly balance the benefits of AM technologies with the inherent risks. NASA design and construction standards do not yet include specific requirements for controlling the unique aspects of the AM process and resulting hardware. While a significant national effort is now focused on creating standards for AM, the content and scheduled release of these consensus standards do not support the near-term programmatic needs of NASA.

Aerojet-Rocketdyne

RS-25 Engine

SpaceX

SuperDraco Engine

MSFC Standard and Application to Human Spaceflight Hardware

NASA MSFC has led with the development of a Center-level standard, MSFC-STD-3716, to aid in the development of standard practices for L-PBF processes. This standard and its companion specification[2], MSFC-SPEC-3717, will now provide a consistent framework for the development, production, and evaluation of additively manufactured parts for spaceflight applications. The standard contains requirements addressing material property development, part classification, part process control, part inspection, and acceptance. The companion specification provides requirements for qualification of L-PBF metallurgical processes, equipment process control, and personnel training. Engineers from the three active human spaceflight programs have used the MSFC standard as a guideline for implementation of AM parts, assuring partners establish reliable AM processes and meet the intent of all NASA standards in materials, fracture control, nondestructive evaluation, and propulsion structures.

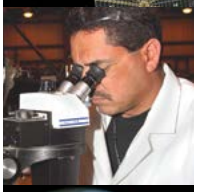
Path Forward to an AM Standard

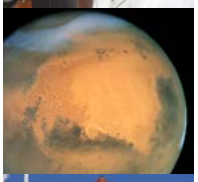
In addition to human spaceflight, standards for appropriate application of AM to other NASA missions such as science and aeronautics require consideration. Full embrace of AM technologies requires standardization beyond the Powder Bed Fusion process. A planned Agency standard applicable to all NASA programs and most AM technologies is currently being explored. Proper standardization is the key to enabling the innovative promise of AM, while ensuring safe, functional, and reliable AM parts.

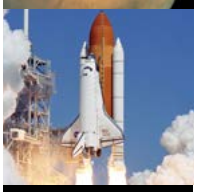
References

1. MSFC-STD-3716 “Standard for Additively Manufactured Spaceflight Hardware by Laser Powder Bed Fusion in Metals,” October, 18, 2017.

2. MSFC-SPEC-3717, “Specification for Control and Qualification of Laser Powder Bed Fusion Metallurgical Processes,” October 18, 2017.







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