SUCCESS STORY 5518.001

Powder bed fusion used to print test parts on an ATLAS printer

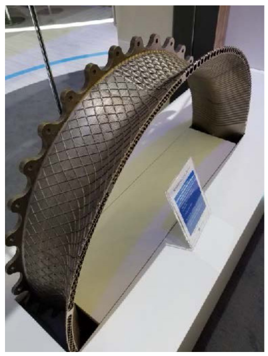
Development of high productivity parameter used to reduce part build time by 43%

Key Machine Features

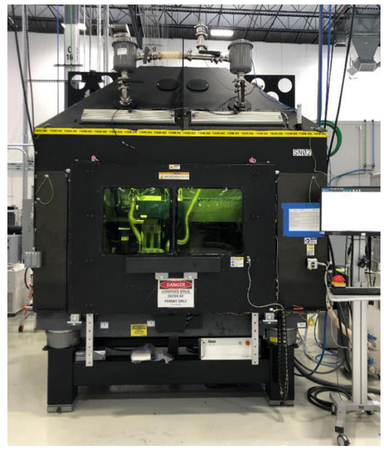
- Build envelope: 1,000mm x 900mm x 300mm
- Machine exterior: ~7' x 8' x 10'
- Gantry based architecture
- 1kW laser
- 3D scanner translates with laser
- Discrete dosing
- Optimal air flow over the print area

ATLAS Machine Experience

- 900+ days of print time
- 200+ build jobs



Rocket Nozzle Tech Demo; High Speed Parameter



ATLAS Machine

GE Additive's ATLAS laser powder bed fusion platform enables rapid design-build-test cycles to produce larger jointless designs required for applications.

PROBLEM

Metal laser powder bed fusion (LPBF) is beneficial to key aerospace and defense industries by enabling geometric designs otherwise impossible to achieve with traditional manufacturing methodologies. While capable of building complex thin walls and internal passages, LPBF is limited by relatively small build volumes, so aerospace and defense suppliers require part joining to fabricate a final component. These joining operations involve additional manufacturing steps—including tooling, post-processing, and inspections as well as the associated development and validation of those processes—resulting in increased cost, weight, part defects, and lead times.

OBJECTIVE

The goal of the project was to attain a 90%-part count reduction for a powerhead propulsion system critical to both scramjets and space launch vehicles. This addressed the needs of the Department of Defense (DoD) and the National Aeronautics and Space Administration (NASA) to enhance supply chains through part consolidation, efficiency, and heightened performance. The powerhead for the project was composed of over 1,000 parts to run a hot gas manifold, main injector, heat exchanger, and pre-burners. This project demonstrated how GE's proprietary ATLAS LPBF large build platform technology (1,000 x 900 x 300mm) reduced the part count to 11.

AMERICA MAKES TECHNOLOGY DEVELOPMENT ROADMAP

This project aligns to:

MATERIAL

ASTM PROCESS CATEGORY
Powder Bed Fusion

EQUIPMENT
ATLAS Machine

MATERIAL
Inconel 718 Alloy

TECHNICAL APPROACH

GE, Aerojet Rocketdyne, and NASA Marshall Space Flight Center collaborated to develop qualification data requisite of manufacturing a powerhead for liquid fueled scramjet and rocket systems, using GE Additive's proprietary LPBF ATLAS technology. This team was positioned with engine programs and a wide array of product applications for weld joint removal including RS-25 engines. This gave the team the opportunity to work closely with GE on the innovative large format machine (ATLAS) and the premier materials team at NASA.

GE executed experiments to evaluate metallurgical and flow properties compared to the parts produced on other commercial LPBF machines, establishing new design approaches, new part orientations, and parameter settings.

Aerojet Rocketdyne defined material property and feature size resolution requirements while NASA performed the corresponding testing and evaluation. GE built test specimens while NASA evaluated the ATLAS-produced parts.

The tasking approach for successful output was a four-phase approach with Phase I encompassing the build envelop evaluation with high laser power, Phase II developing the stitching through three design of experiments and a final optimized stitching verification, Phase III addressing downward surface development and heat transfer coefficient (HTC), and Phase IV providing a full-scale component build.

ACCOMPLISHMENTS

Prior to beginning large-scale printing, testing, and analysis, it was extremely important for the team to develop a repeatable build setup, test specimen geometry, and method for evaluation. The specimens were designed to knock off the build plate to eliminate the need for a machining operation for build plate removal and thus reduced the turn time between build and collection of results. The first build served to establish a baseline by assessing variation in build plate location and orientation to gas flow, all with the same baseline high productivity parameter. The findings of this study showed a roughly 5-15% improvement in surface finish over the baseline parameter. General trends showed that a reduction in the overall energy density of the downside contour improved surface roughness. A heat exchanger was selected as a demonstration piece and was printed successfully on an ATLAS machine utilizing the high productivity parameter validated early in the project and the downward surface parameter developed. The high productivity parameter reduced the heat exchanger part build time from 54 to 31 days (43% improvement).

PROJECT END DATE

October 2022

EXPECTED DELIVERABLES

- Build geometry to characterize full build volume
- Surface finish, geometry conformance, and variation for build volume
- Tensile, high cycle fatigue, and metallography data from full build volume characterization
- Analysis of HCF stitch debit using 800W process
- Baseline (<300W) full build volume materials data vs. 800W
- Report of stitching optimization efforts
- Build geometry to characterize heat transfer performance
- Report of surface finish optimization to achieve heat transfer performance
- Dimensional analysis from full size component build
- Tensile and metallography data from full size component build coupons
- Data management plan

FUNDING

$1.1M total project budget

PROJECT PARTICIPANTS

Project Principal:
GE Additive

Other Project Participants:
NASA MSFC (Marshal Space Flight Center)
Aerojet Rocketdyne
Auburn University

Public Participants:
U.S. Department of Defense