SUCCESS STORY 3014

Developed multiple scan and build strategies to achieve advances in productivity and end part quality.

Multi-Laser Power Bed Fusion Process Achieves 47% Reduction in Build Speed

Image of laser powder bed fusion with two lasers during printing (note effluent from each melt pool).

PROBLEM

Metal laser powder bed fusion (LPBF) systems with multiple lasers offer increased productivity over single laser systems. Parts that are uneconomical to produce with LPBF using a single laser system can be made cost-competitive through the use of multiple lasers. While many manufacturers are offering commercially available equipment with two and four lasers, there is a gap in understanding potential material defects arising from the use of multiple laser systems. To accelerate the industrialization of these multiple laser systems, it is critical to understand the material property implications resulting from these defects.

OBJECTIVE

The objective of this effort was to understand the metallurgical defects in multiple laser LPBF systems and apply nondestructive evaluation (NDE) methods to identify potential defects in service. The goal was to deliver a test artifact, technical data package, and new standard as the foundation for end users to confidently implement higher productivity metal additive manufacturing (AM) equipment. The project sought to accelerate the introduction of multiple lasers for demanding applications.

AMERICA MAKES TECHNOLOGY DEVELOPMENT ROADMAP

This project aligns to: MATERIAL

ASTM PROCESS CATEGORY: Powder Bed Fusion

EQUIPMENT: Concept Laser M2

MATERIAL: IN 718

TECHNICAL APPROACH

A test artifact was designed to examine material defects caused by the use of multiple lasers. Defects included porosity due to overlap of laser paths, lack of fusion porosity from lack of laser overlap in the stitching region, additional spatter from multiple melt pools, and varying surface roughness due to variance in calibration. The artifact was also designed to examine tolerance issues in the overlap of the individual lasers, as well as other factors affected by the use of multiple lasers. Melt pool monitoring was used to screen defects and micro-computed tomography (CT) to characterize these defects, identifying porosity and other microstructural features in the test artifacts. Using a Concept Laser M2 LPBF machine with two 400W lasers, Proto Precision Manufacturing Solutions printed the test artifact out of Inconel 718, an alloy of strong interest to the aerospace industry for AM.

ACCOMPLISHMENTS

The manufacture of INC718 via multiple lasers in the powder bed fusion process was successfully investigated. It was found that laser calibration and alignment play a significant factor in the end part quality of the multi-laser powder bed fusion (MLPBF) process. To address these issues, new methods and a set of standardized test artifacts were developed to assess laser calibration, alignment, and metallurgical quality of the stitched regions. These new methods are being incorporated into new standardization efforts that are now underway.

Through the investigation, multiple scan and build strategies were developed to have the best balance of productivity and end part quality. Additionally, it was found that for a representative component, a 47% build time decrease was achieved by the addition of a second laser to the build. This added productivity was accomplished while producing material that after heat treatment had comparable or better density, hardness, tensile strength, and high cycle fatigue properties than the nominal material properties.

PROJECT END DATE

August 2019

DELIVERABLES

- Test artifact designed to characterize metallurgical defects in LPBF built parts using multiple lasers
- Technical data package including quantitative image analysis of metallurgical defects using in-situ thermal imaging and micro-CT
- Final report detailing material and process parameters used during the project and outlining all results from each task
- Draft standard for identifying and controlling metallurgical defects in LPBF with multiple lasers

FUNDING

$387K total project budget
($250K public funding/$137K private funding)

PROJECT PARTICIPANTS

Project Principal:
The Ohio State University

Other Project Participants:
Proto Precision Additive Manufacturing Solutions
GE Additive

Public Participants:
U.S. Department of Defense
National Science Foundation
U.S. Department of Energy