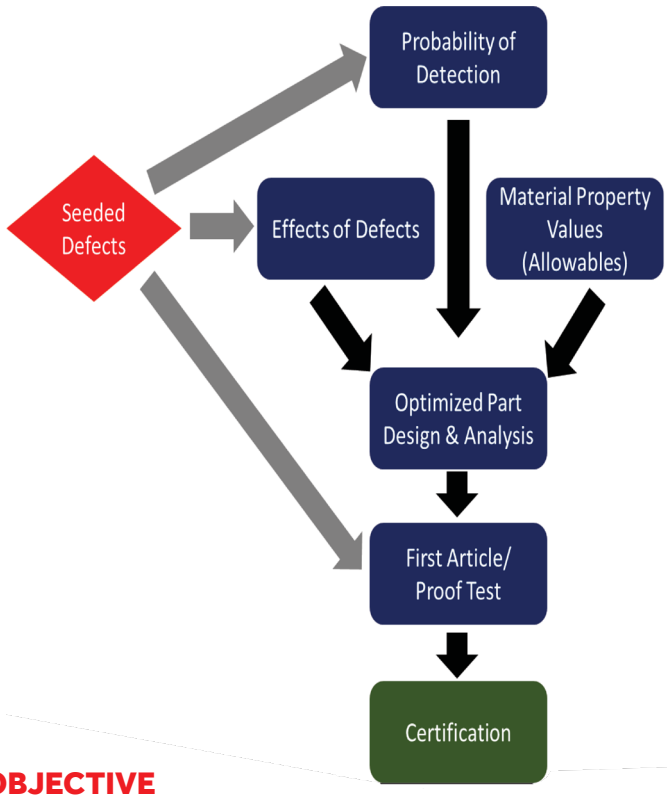
PROJECT SUMMARY 3026.003

Advanced Tools for Rapid Qualification (ATRQ) Surrogate Damage Generation for LPBF Defects with Nickel Alloy IN718

The ability to seed representative surrogate defects into otherwise nominal material can provide fundamental understanding of processing defects with LPBF and help advance additive process qualification and part certification.



PROBLEM

Laser powder bed fusion (LPBF) additive manufacturing (AM) has shown significant promise in creating complex component geometries manufactured with a number of useful metallic alloys. Understanding the mechanical performance of these components, however, still lags behind traditional processing methods, especially in fatigue and fracture. The mechanical performance debits are due to defects that are generated during the course of processing, which often exhibit a highly correlated nature due to the inherently linear and planar nature of the LPBF process. Understanding the formation of material/processing anomalies in LPBF and their effect on performance is critical to advancing analysis and model-based qualification methods.

OBJECTIVE

The objective of this program is to quantify the impact of defects in LPBF with controlled and systematic evaluation of material performance as a function of defect characteristics in nickel alloy IN718. Specifically, the program seeks to develop an understanding of the mechanisms that trigger defect types commonly observed in LPBF; a processing approach for intentionally generating surrogate defects; targeted CT inspection, metallography, and fatigue testing responses of these surrogate defects for comparison to naturally occurring defects; a component scale demonstration of the methodology; and an initial implementation of a software tool for generating build files for controlling defect type, size and location.

AMERICA MAKES TECHNOLOGY DEVELOPMENT ROADMAP

This project aligns to:

PROCESS

ASTM PROCESS CATEGORY: Powder Bed Fusion

EQUIPMENT: GE Concept Laser M2

MATERIAL: Nickel Alloy IN718

TECHNICAL APPROACH

In order to develop this fundamental understanding for processing defects with LPBF, it is necessary to generate representative defects in a controlled manner to enable quantitative studies of the mechanical property debits and probability of detection (PoD) of authentic LPBF defects. The technical approach and methodology include over a dozen LPBF build iterations in IN718, model-informed analysis of local processing conditions, in-situ process monitoring, post build computed tomography (CT), mechanical testing (fatigue), and user developed LPBF fusion machine control. Combining process modeling with in-situ monitoring accelerates determination of the key process parameters needed to control the formation and severity of typically observed LPBF defect types. CT and mechanical testing are being used to verify the presence of morphologically representative defects, as well as benchmark their mechanical performance debits relative to legacy data. Ohio State University (OSU) has demonstrated its ability to control numerous key processing parameters to achieve desired material response (high density) in the ongoing America Makes project #3014. The scope of this program acts as a continuation to elicit the opposite result in otherwise quality material. To ensure transition to America Makes and the DoD supply chain, OSU is partnering with a local small business AM supplier, Proto Precision Additive, and large aerospace and defense OEM/ Propulsion Supplier Rolls-Royce and Lockheed Martin.

PROJECT START DATE

May 2019

PROJECT END DATE

August 2021

EXPECTED DELIVERABLES

- Build travelers for all IN718 builds to include: build geometry files, build parameter files, slice files, environment log information, post-build heat treatment schedule(s)
- In-situ monitoring data for all IN718 builds
- CT and RT data for all inspected IN718 specimens
- Uniaxial tension and fatigue test data for all tested IN718 specimens
- Metallography and fractography images for select IN718 specimens
- Physical LPBF printed IN718 specimens
- Executable software stack for generating surrogate defects
- Final report and all technical update presentations
- Transition plan document

FUNDING

$1.37M total project budget
($968K public funding/$403K private funding)

PROJECT PARTICIPANTS

Project Principal:
Ohio State University

Other Project Participants:
Ohio State
Rolls Royce
Proto Precision Manufacturing
Lockheed Martin
Blue Quartz

Public Participants:
U.S. Department of Defense

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