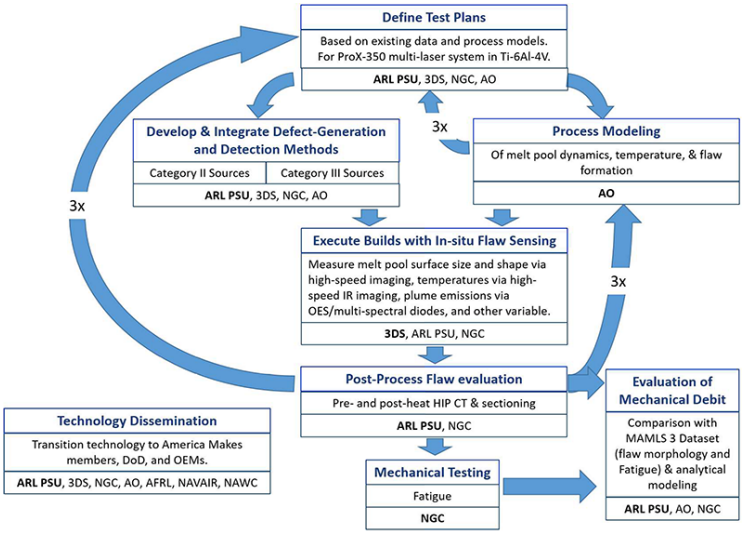
PROJECT SUMMARY 3026.001

Advanced Tools for Rapid Qualification (ATRQ) Surrogate Damage Generation for LPBF Defects with Titanium Alloy Ti-6Al-4V

Project flowchart indicating tasks for project completion and assigned team members.



PROBLEM

It is well established that flaws, such as lack-of-fusion or spherical porosity, occur during powder bed fusion additive manufacturing (PBFAM). Depending on their morphology and location, flaws can negatively affect build and part quality. Equally problematic is the lack of guidelines establishing limits on the size, morphology, or location of flaws or verified strategies to estimate the mechanical properties debit incurred due to the presence of flaws. The failure to establish accepted models or relationships between flaw characteristics and mechanical properties, to define nondestructive evaluation (NDE) guidelines, to quantify the reliability of sensing methods, and to implement rapid certification/qualification strategies for PBFAM is partly due to the current, limited ability to reproduce flaws, representative of natural ones, in a controlled fashion.

OBJECTIVE

The objectives of this work are to develop methods for repeatable generation of morphologies representative of natural defects during laser PBFAM of Ti-6Al-4V, to demonstrate similarity of these surrogate defects to naturally occurring ones, and to compare the material debits incurred by surrogate and natural defects. In particular, the proposed work seeks to develop methods, based on build plan and process perturbations, for the formation of surrogate defects with known morphologies at a specific location, representative of naturally-occurring flaws; model and predict interactions leading to flaw formation; refine methods to characterize, both in-situ and via NDE, natural and surrogate defects and demonstrate similarity between both; and establish, quantify, and model relationships between defect characteristics (e.g. morphology, location) and failure under fatigue loading.

AMERICA MAKES TECHNOLOGY DEVELOPMENT ROADMAP

This project aligns to: PROCESS

ASTM PROCESS CATEGORY: Powder Bed Fusion

EQUIPMENT: 3D Systems ProX-320

MATERIAL: Titanium Alloy Ti-6Al-4V

TECHNICAL APPROACH

The project team includes The Pennsylvania State University Advanced Research Laboratory (Penn State), 3D Systems, Applied Optimization, and Northrop Grumman. A test plan is being developed to characterize controlled flaws in the PBFAM process. Process modeling of the experimental plan is being performed by Applied Optimization. Penn State is leading the development of in-process anomaly generation methods and in-situ monitoring of flaw generation during sample builds. Test samples are being printed using a 3D Systems ProX-320 machine with the developed in-situ monitoring capabilities added. The resultant test samples are then characterized, tested, and analyzed to establish an extensive dataset containing in-process sensor signatures, computed tomography (CT), and metallographic data for identified defect types and morphologies. Resultant hardware, software, and data are being transitioned to America Makes and Department of Defense at the conclusion of the effort.

PROJECT START/END DATE

May 2019 - August 2021

EXPECTED DELIVERABLES

- Validated methods along with hardware and software tools for repeatable generation of surrogate defects
- Modeling software for prediction of defect formation and resulting mechanical performance
- An extensive dataset containing in-process sensor signatures, CT, and metallographic data for identified defect types and morphologies
- Fatigue testing data on at least between 25-100 specimens with intentionally-introduced surrogate

FUNDING

$1.37M total project budget
($968K public funding/$404K private funding)

PROJECT PARTICIPANTS

Project Principal:
Pennsylvania State University Applied Research Laboratory

Other Project Participants:
3D Systems
Applied Optimization
Northrop Grumman

Public Participants:
U.S. Department of Defense

NCDMM Blairsville
Headquarters
486 Cornell Road
Blairsville, PA 15717
Phone: (724) 539-8811
NCDMM.org

NCDMM Chambersburg
Letterkenny Offices
4755 Innovation Way
Chambersburg, PA 17201
Phone: (717) 553-0068

NCDMM Youngstown
America Makes Offices
236 West Boardman Street
Youngstown, OH 44503
Phone: (330) 622-4299
AmericaMakes.us

NCDMM Huntsville
7027 Old Madison Pike, NW
Suite 108
Huntsville, AL 35806
Phone: (256) 929-6299