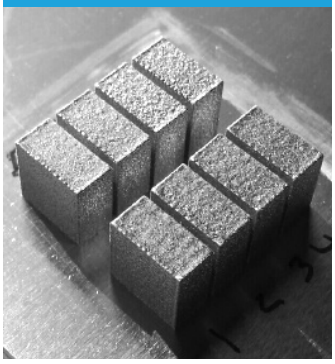
SUCCESS STORY

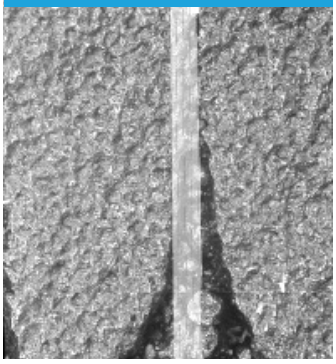
Developing Measurement Science to Support High-Priority Metrology and Standards Required in Additive Manufacturing (AM)

Ensuring Quality Parts are Produced and Certified

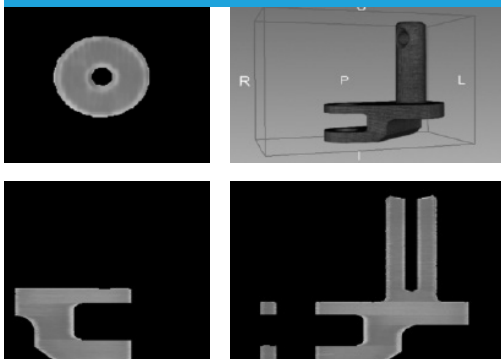
In-process Sensing & Monitoring



Non-destructive Evaluation Methods



Layerwise Certification Standards



A variety of challenges related to measurement sciences limits the adoption of additive manufacturing for many industries that require qualified parts.

PROBLEM

Additive manufacturing (AM) presents a variety of measurement science challenges which limit the broad application of AM for performance-critical parts. Current commercial laser powder bed fusion (LPBF) machines operate in an "open loop" manner, with little or no real-time monitoring of the process to ensure quality requirements are consistently achieved.

OBJECTIVE

The objective of this project was to address metallic material systems and manufacturing processes in three high priority thrust areas to:

- Develop, integrate, and validate a robust, informative in-situ process monitoring capability to ensure part quality
- Develop and validate a non-destructive evaluation (NDE) standard to establish quality certification methods well suited to AM
- Create a 3D Quality Certificate (3DQC) for each manufactured part using run-time process monitoring data indexed to part geometry

These thrust areas would help ensure that quality parts are produced and certified for use in end products across multiple manufacturing industries.

TECHNICAL APPROACH

The measurement science challenges were divided into three focused research tracks:

In-Process Sensing and Monitoring

Led by EWI, this research team evaluated, developed, and integrated a variety of thermal, visual, and acoustic sensing techniques on an LPBF platform. Evaluation techniques included variable part quality conditions and industrial printing systems.

NDE Methods

The team led by Concurrent Technologies Corporation (CTC) focused on maturing flaw seeding techniques within test specimens and establishing accurate and reliable NDE size limitations for detecting the seeded flaws.

Layerwise Certification Standards for AM

The research team led by the University of Louisville used thermal monitoring of each layer during a part build and compared it to a layer-by-layer quality certification template created from the STL file for the component. This produced a Layerwise Quality Certification standard that can be used for the AM industry.

AMERICA MAKES TECHNOLOGY DEVELOPMENT ROADMAP

This project aligns to:

VALUE CHAIN

ASTM PROCESS CATEGORY:
Powder Bed Fusion

EQUIPMENT:
Laser Powder Bed Fusion (LPBF) Machines

MATERIAL:
CoCr
17-4 PH
Ti-6Al-4V

ACCOMPLISHMENTS

The combined efforts from each of the three tracks of this project have led to broader applications of AM for performance-critical components through qualification and certification standards, post-build inspection and verification, and through deployment of novel in-situ sensors and techniques that can be adapted to any industrial AM process.

Specific accomplishments include:

- An open architecture sensor test bed for LPBF was designed and fabricated with the ability to control defect generation and detection
- The following sensors were successfully integrated and tested in the LPBF test bed:
    - High Speed Thermal Imager
    - Photodetector
    - Spectrometer
    - Infrared-Based Thermal Imager
    - Visible Range Machine Vision Imager
    - Laser-Based Profilometer
    - Airborne Acoustic Microphone
- The following advanced sensing techniques were tested:
    - Fringe Projection
    - Surface Acoustic Waves
    - Machine Vision Defect Algorithms
    - Visual Light Pool Imaging
- An NDE baseline showing limits for a variety of materials produced with LPBF technology was established. Other materials and processes can leverage this baseline.
- A 3D Quality Certificate template was created.

A case of flaw-containing NDE test specimens (including CoCr, 17-4 PH, and Ti-6Al-4V) from this project is available for continued research by America Makes members.

PROJECT END DATE

August 2016

DELIVERABLES

- Sensors Test Bed Characteristics of LPBF
- Sensors Capable of Detecting Geometric and Volumetric Defects
- Sensor Integration into Test Bed and Testing
- Sensor and Measurement Strategy Capable of 90% Defect Detection
- Integrated Sensor for Collecting Live Data on Commercial System
- Final Project Report
- Semi Annual Project Reports
- NDE Standards
- Computational Methods for 3DQC

All downloadable deliverables are available to members of America Makes via the Digital Storefront.

FUNDING

$5.0M total project budget
This project was funded by NIST under Award Number 70NANB13H192.

PROJECT PARTICIPANTS

Project Participants:
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Concurrent Technologies Corporation
University of Louisville

Public Participants:
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National Institute of Standards and Technology

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