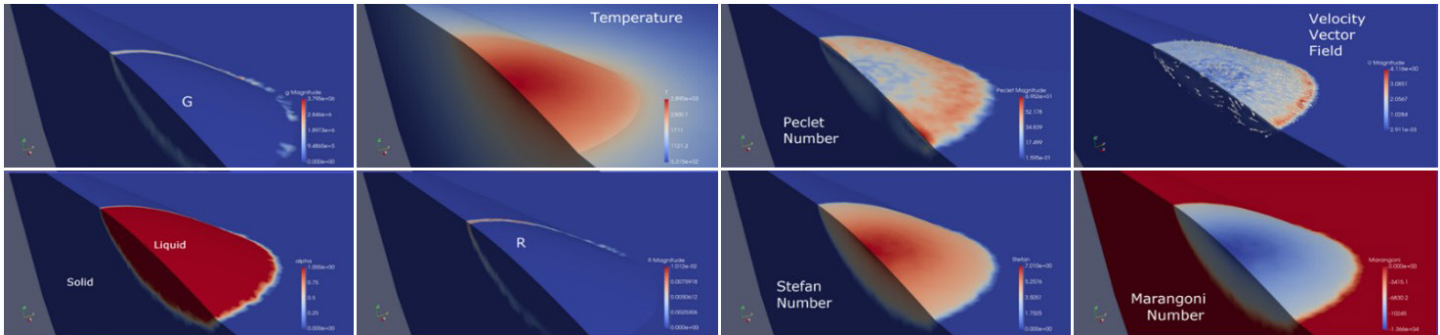**SUCCESS STORY**

*Developing a Ti-6Al-4V Knowledge Base Using LENS®
Directed Energy Deposition process (DED)*

Reduce Barriers to Using Ti-6Al-4V for AM

Simulations of melt-pool physics performed using the ICME suite of software, Additive Manufacturing Parameter Predictor (AMP²)

PROBLEM

Optomec's Laser Engineered Net Shaping (LENS®) additive manufacturing (AM) process is governed by a large number of process parameters (e.g., power, wavelength, spot size, energy flux distribution, scanning velocity, powder feed rate, substrate preheat, etc.). Various combinations of these parameters are being used today to produce AM components. There is currently no process parameter database, or knowledge base, to assist in obtaining defect-free AM deposition of Ti-6Al-4V utilizing the LENS powder bed directed energy deposition (DED) process. A knowledge base for Ti-6Al-4V would allow a process engineer to select from a matrix of vetted process parameter combinations which would minimize and potentially eliminate the trial and error approach to AM part process development.

OBJECTIVE

The objective of this project was to develop a Ti-6Al-4V knowledge base in collaboration with Optomec, Applied Optimization, and the Pennsylvania State University – Applied Research Lab (ARL), offering a matrix of vetted process parameter combinations and best practices for LENS. This knowledge base would facilitate the production of defect-free LENS deposits.

TECHNICAL APPROACH

Applied Optimization collaborated with the ARL to leverage prior work performed on LENS systems at the ARL and used that information as a basis for simulations, which led to the improved understanding of bead profile measurements and refined focus on repair-related configurations.

The team conducted multiple AM builds of Ti-6Al-4V to develop known parameters that yielded optimal results and then captured those results in an AM knowledge base. In order to populate and complete the knowledge base, the team worked together to:

- Define process parameter ranges
- Simulate deposition with varied parameters under single-line, multi-line, and multi-layer conditions
- Validate deposition experimentally via designed experiments under single-line, multi-line, and multi-layer conditions
- Repeat as required to refine the correlation

AMERICA MAKES TECHNOLOGY DEVELOPMENT ROADMAP

This project aligns to:

MATERIAL

ASTM PROCESS CATEGORY:
Directed Energy Deposition

EQUIPMENT:
LENS®

MATERIAL:
Ti-6Al-4V

ACCOMPLISHMENTS

The knowledge base developed by the team for Ti-6Al-4V can be offered as a LENS system accessory package, expanding the use of LENS and other AM technologies for part build and repair applications.

Best practice recommendations related to parameter calibration, measurement, and correlation were developed and shared with other process and database development efforts.

A series of training sessions with Industrial Engineering Student Workforce & Educational Outreach Interns were held at America Makes. These sessions focused on setting up, running, and post-processing data from ParaGen simulations, which is the numerical simulation software that was used for this project. Applied Optimization also trained students on the use of ParaGen at its facility in Dayton, Ohio.

This project greatly benefited from collaboration with the America Makes "AM Laser Powder Feed - Reborn" project, which provided critical laser-based process parameters related to laser spot size measurement, laser power measurement, powder spot focus standoff, and powder spot size measurement. This data was used as input to the melt pool physics simulation.

LENS® (Laser Engineered Net Shaping) is a registered trademark of Sandia National Labs.

PROJECT END DATE
March 2017

DELIVERABLES

- Deliver knowledge base data for Ti-6Al-4V
- Predictive results for a range of vetted LENS repair process parameters:
  - Multiple thickness substrates
  - Various edge conditions
- Characterization of key process variables that are critical to process development and control:
  - Laser spot size
  - Focal point
  - Powder feed rate
- Best practice recommendations related to variable parameter definitions for the LENS process
- Series of training modules, covering utilization areas of the LENS technology

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

FUNDING
$431K total project budget
($212K public funding/$219K private funding)

PROJECT PARTICIPANTS
Project Principal:
Optomec Inc.

Other Project Participants:
Applied Optimization Inc.
Pennsylvania State University –
Applied Research Lab (ARL)

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

4023 Development of Knowledge Base of Deposition Parameters for Ti-6Al-4V Process

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