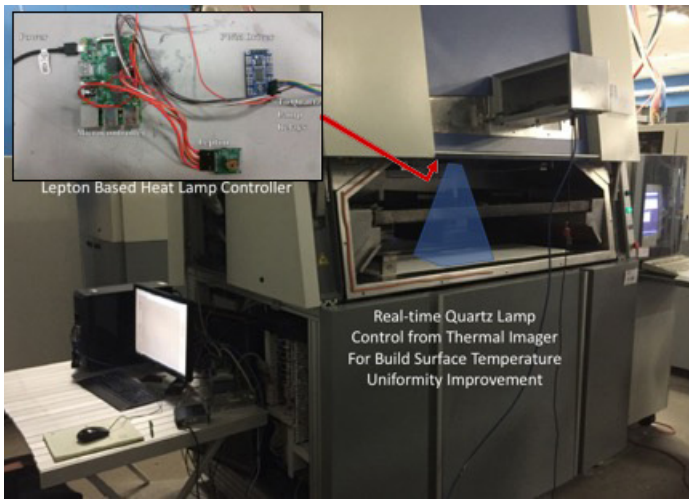
SUCCESS STORY

Advancing closed loop process control for powder bed fusion of thermoplastics

Improved part quality & performance predictability while reducing sensitivity to variations in build conditions



Sinterstation with FLIR A325 camera mounted to a modified machine door that incorporated a Zinc Selenide (ZnSe) window.

PROBLEM

Current commercial powder bed fusion (PBF) machines operate primarily in a scripted open loop control manner, with the operator setting a desired temperature for the build surface and indicating what material is loaded. Though all selective laser sintering (SLS) machines have a closed loop control on the powder feed and build surfaces based on point measurements with a pyrometer, they are vulnerable to changes in the heat distribution from convective disturbance and changes in the heater properties over time.

OBJECTIVE

The objective of this project was to examine the potential of more comprehensive feedback control in PBF machines. The University of Texas at Austin (UT) teamed with Harvest Technologies, which later became part of Stratasys Direct Manufacturing (SDM) to address this potential by exploring modifications to a production 3D Systems Sinterstation 2500, incorporating feedback control in the powder pre-heat area, the build surface area, cooldown box, and laser power compensation areas.

TECHNICAL APPROACH

The approach of this project was based on careful measurements of the thermal history of the build material at three critical phases in the PBF process, controlling key process parameters based on these measurements, and producing desirable conditions even when variations or disturbances in the build process were present. This approach was driven by the knowledge that part quality in PBF is closely tied to the optimization of the thermal time history of the material being converted from powder feedstock to finished 3D object. By including feedback control in critical parts of this thermal history, required part properties were optimized and the processes could adapt to disturbances that existing open loop machines cannot compensate for. The feedback control target areas were the powder pre-heat area, the build surface area, cooldown box, and laser power compensation areas.

AMERICA MAKES TECHNOLOGY DEVELOPMENT ROADMAP

This project aligns to:

VALUE CHAIN

ASTM PROCESS CATEGORY: Powder Bed Fusion

EQUIPMENT: 3D Systems Sinterstation 2500

MATERIAL: Nylon 11

ACCOMPLISHMENTS

The project evaluated several options for in-situ thermally imaging the build surface, with the most viable being a custom adaptation developed around the new (at the time) FLIR LEPTON sensor. The team worked with a local startup (TAHI Company) to integrate the Lepton/feedback controller into the Sinterstation and successfully showed that improved temperature uniformity was achievable. Short builds showed promising results and provided confidence for Stratasys to continue testing and dialog with TAHI after the project was completed.

The team also discovered that enhancing feedback control in the feed bin areas was not effective in changing overall part properties because these properties are so dominated by the build surface activity. It is suspected that improved feed bin thermal uniformity is masked somewhat by the mixing action of the roller in the spreading process.

The team found that cooldown feedback control was not feasible due to the slow thermal response to piston/cylinder heater control due to the low thermal conductivity of the polymer part cake.

Investigation of the initial candidate sensor system (thermal imager through the observation window of the Sinterstation door) led to development of an in-situ laser power meter to allow evaluation of the effects of laser window contamination. The team conducted detailed laser window contamination assessment on multiple machines with SDM, and found that although nitrogen shielding of laser windows (a common practice) reduces the overall contamination rate, it can create a more nonuniform laser window contamination pattern.

PROJECT END DATE

August 2017

DELIVERABLES

- Demonstration and Associated Data Feedback Benefits and Limitations Represented on a Modified 3D Systems SLS Machine
- Demonstration and Associated Data Feedback Benefits and Limitations for Laser Power Compensation Due to Window Contamination
- Final Report (Closed Loop Control for Powder Bed Fusion for Thermoplastics)

FUNDING

$1.6M total project budget
($652K public funding/$960K private funding)

PROJECT PARTICIPANTS

Project Principal:
University of Texas - Austin

Other Project Participants:
Stratasys Inc.
Integra Inc.

Public Participants:
U.S. Department of Defense

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

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

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

ncdmm.org

AmericaMakes.us