PROJECT SUMMARY 5516.001

Acceleration of Large-Scale Additive Manufacturing (ALSAM)

GE Additive M2 Series 5 Laser Powder Bed Fusion Printer

PROBLEM

The adoption of additive manufacturing (AM) in research environments is limited due to the closed machine architecture of most systems which hinders the development and integration of new technologies into commercial platforms. For example, selective laser melting (SLM) of large parts requires multiple lasers for cost-effective production, but multi-laser strategies are not yet fully developed. Integrating multi-lasers on a commercial system is challenging because of the residual stresses of the layer-by-layer additive process caused by rapid heating and cooling, steep temperature gradients, re-melting, and solidification of underlying layers.

OBJECTIVE

The goal of the project is to deliver a GE Additive M2 Series 5 Laser Powder Bed Fusion (LPBF) system to America Makes/Air Force Research Laboratory (AFRL). This machine contains an open architecture and allows for the rapid integration of new ideas and technologies into the platform. The machine also has several new technology capabilities to demonstrate the open architecture: follow-me mode, multi-spectral sensing, and beam shaping. The M2 Series 5 system includes two 1 kW fiber lasers and a chiller upgrade, as well as fast scanning mirrors and in-situ beam alignment features.

AMERICA MAKES TECHNOLOGY DEVELOPMENT ROADMAP

This project aligns to:

PROCESS

ASTM PROCESS CATEGORY
Powder Bed Fusion

EQUIPMENT
GE Additive M2 Series 5

MATERIAL
Ti-6Al-4V

TECHNICAL APPROACH

The project team includes the Additive Manufacturing Laboratory at GE Research Corporation, the Applied Research Laboratory at the Pennsylvania State University (Penn State), and GE Additive. After a critical design review of the machine and the expected open-architecture modifications, the team is incorporating the existing ALSAM software package (developed in Project 3024.001) into the M2 Series 5 system. This final effort is following months of preliminary research and development of the ALSAM software package. These earlier development efforts included the installation of the ALSAM software package on a GE Additive M2 Series 4 system at GE Research.

GE Research is building four fast scanning mirror (FSM) systems to replace the beam-bending mirrors on the M2 Series 4 system. The FSM systems provide the small angle motion needed to shape the beam. Effective beam shaping also requires more laser power to achieve an optimal power density. The current 400-W IPG fiber lasers are being replaced with 1000-W IPG lasers. An in-situ multi-beam alignment approach is being developed using a down-beam sensor developed by Penn State. The dynamic beam shaping capability in the ALSAM system is being demonstrated on the titanium alloy, Ti-6Al-4V.

The performance and acceptance of these system improvements are functionally tested, and calibration routines are demonstrated. Multi-laser control analysis and verification include single track parameters, hatch and overlap parameters, feature-based compensation, and evaluation of the follow-me mode. The new laser system and fast-scanning mirror setup are validated according to calibration criteria defined by the team and using a testing methodology that includes the use of burn paper patterns which verify positional accuracy and wobble pattern acceptance.

Upon machine arrival at AFRL, a Site Acceptance Test (SAT) was performed by GE Additive. This test validates the machine capabilities as a standard Concept Laser 5 LPBF machine. Once the specific ALSAM software and hardware is added to the machine, its capabilities as an ALSAM machine will be validated by performing Designs of Experiment #1 and #2 which were initially performed at GE Research using the Concept Laser Series 4 machine.

PROJECT START DATE

December 2020

EXPECTED END DATE

April 2023

EXPECTED DELIVERABLES

- Upgrade laser power to 1,000 watts per laser
- Enable high frequency and accuracy beam modulation and shaping
- Provide in-situ calibration of the laser system
- Upgrade to GE Additive M2 Series 5 LPBF system
- Final report

FUNDING

$2,051,854 total project budget
($1,851,854 public funding/$200,000 private funding)

PROJECT PARTICIPANTS

Project Principal:
General Electric Research Corporation

Project Participants:
General Electric Additive
Penn State University Applied Research Laboratory

Public Participant:
U.S. Department of Defense