National Aeronautics and Space Administration

NASA

TECHNOLOGY SOLUTION

Information Technology and Software

Additive Manufacturing Model-based Process Metrics (AM-PM)

Computational tool to model and evaluate additively manufactured parts

Additive manufacturing enables unrivaled design freedom and flexible fabrication of components from a wide range of materials including metals, composites, polymers, and ceramics. The near net shape parts are made by processes like sequential melting or layer-by-layer material deposition with a complex set of processing variables. The sequential nature of the process means that every step can impact the next and thus, tools to evaluate that risk before and during manufacturing are necessary.

Inventors at the NASA Langley Research Center have developed a novel method to model and ingest point-wise process data to evaluate an additive manufacturing build and its file for issues by highlighting potential anomalies or other areas where the build may have issues with fusion of the material. The technique was originally developed for use in tandem with powder bed fusion additive manufacturing for aerospace parts and is capable of being used on consumer grade computers.

BENEFITS

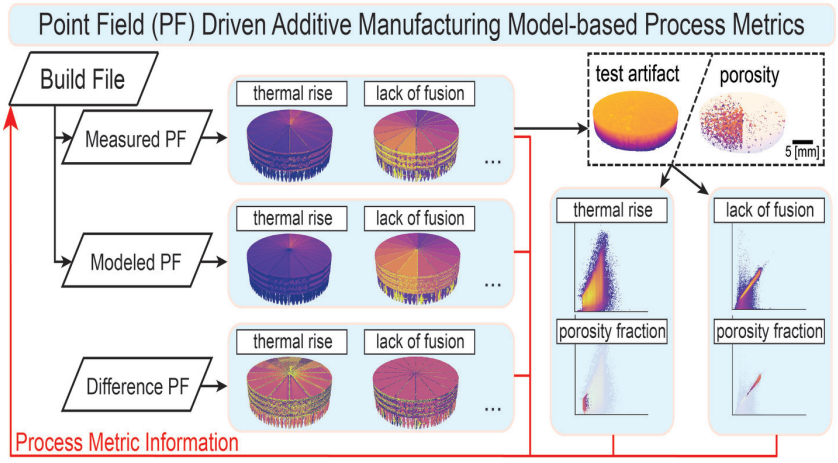
- Computationally efficient: Calculations are performed with track-wise precision though a build in minutes, at least 10x faster than other in-use modeling approaches.
- Multiple use-cases: AM-PM can be employed before, during, and after an additive manufacturing process to ensure build correctness.
- Possible time and cost saving: Evaluating build instructions for potential issues before manufacturing can reduce risk, cost, time to market for additively manufactured parts.
- Accessible: The AM-PM modeling technique can be run on a consumer-grade computer, and runs off of the build file or process points as recorded-only material property inputs.
- At a relevant size scale: The method models additive manufacturing processes on the mesoscale (between part-scale and cubic microns).

THE TECHNOLOGY

Modeling additive manufacturing processes can be difficult due to the scale difference between the active processing point (e.g., a sub-millimeter melt pool) and the part itself. Typically, the tools used to model these processes are either too computationally intensive (due to high physical fidelity or inefficient computations) or are focused solely on either the microscale (e.g., microstructure) or macroscale (e.g., cracks). These pitfalls make the tools unsuitable for fast and efficient evaluations of additive manufacturing build files and parts.

Failures in parts made by laser powder bed fusion (L-PBF) often come when there is a lack of fusion or overheating of the metal powder that causes areas of high porosity. AM-PM uses a point field-based method to model L-PBF process conditions from either the build instructions (pre-build) or in situ measurements (during the build). The AM-PM modeling technique has been tested in several builds including a Ti-6Al-4V test article that was divided into 16 parts, each with different build conditions. With AM-PM, calculations are performed faster than similar methods and the technique can be generalized to other additive manufacturing processes.

The AM-PM method is at technology readiness level (TRL) 6 (system/subsystem model or prototype demonstration in a relevant environment) and is available for patent licensing.



Point Field Driven Additive Manufacturing Model-based Process Metrics

APPLICATIONS

The technology has several potential applications:

- Additive manufacturing: build correctness modeling before, during, and after manufacturing for any additive manufacturing process.
- Additive manufacturing: rapid development of build strategies customized to each part geometry and sub-geometries.

PUBLICATIONS

Patent Pending

The Additive Manufacturing Moment Measure - A Parallel Computation Technique for Determining Build Variance in the Laser Powder Bed Fusion Process. May 10, 2022. Materials Research Society (MRS) 2022 Spring Meeting. Conference presentation.

The Additive Manufacturing Moment Measure (AM3) Approach to Predictions of Solid Cooling Rate and Time Above Melt. August 17, 2022. Additive Manufacturing Benchmarks (AM-Bench) 2022. Conference presentation.

Hocker, Samuel J. A., Brodan M. Richter, Joseph N. Zalameda, Peter W. Spaeth, Andrew R. Kitahara, and Edward H. Glaessgen. “Additive Manufacturing Model-Based Process Metrics: Reduced Order Modeling of the Laser Powder Bed Fusion Process.” Conference presentation presented at the 2022 Materials Science & Technology Conference, Pittsburg, PA, October 12, 2022. https://www.matscitech.org/MST22.

Hocker, Samuel J.A., Brodan Richter, Peter W. Spaeth, Andrew R. Kitahara, Joseph N. Zalameda, and Edward H. Glaessgen. “A Point Field Driven Approach to Process Metrics Based on Laser Powder Bed Fusion Additive Manufacturing Models and In-Situ Process Monitoring.” Journal of Materials Research (2023).

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