W COMOTION
Your Innovation Partner

Closed-loop High-fidelity Simulation Integrating Finite Element Modeling with Feedback Controls in Additive Manufacturing

This technology offers a first instance closed-loop simulation framework to quickly survey a parameter space by comparing feedback control results with experimental and analytical solutions. This computational architecture can be beneficial with costly and time-consuming experiments.

What is the Problem?

A high-precision additive manufacturing process, powder bed fusion has enabled unmatched agile manufacturing of a wide range of products from engine components to medical implants. Additive manufacturing has enabled unprecedented fabrication of complex parts from polymeric and metallic powder materials. However, broader adoption of the technology remains challenged by insufficient reliability and in-process variations. These variations are induced by, for example, uncertain laser-material interactions, environmental vibrations, powder recycling, imperfect interactions of mechanical components, and complex thermal histories of materials. Although finite element models and feedback controls have been identified key for predicting and engineering part qualities in powder bed fusion, existing results in each realm are developed in separate computational architectures due to their different time scales, meaning it can take hours or days to simulate the sintering of even a few layers with powder bed fusion.

What is the Solution?

The solution is a first instance closed-loop simulation framework by integrating high-fidelity finite element modeling with feedback controls originally developed for general mechatronics systems. By utilizing the output signals (e.g., melt pool width) retrieved from the finite element model to directly update the control signals (e.g., laser power) sent to the model, the proposed closed-loop framework enables testing the limits of advanced controls in powder bed fusion and surveying the parameter space fully to generate more predictable part qualities. Along the course of formulating the framework, the finite element analysis is verified by comparing its results with experimental and analytical solutions, and then used to understand the melt-pool evolution induced by the in-layer thermomechanical interactions.

What Differentiates it from Solutions Available Today?

Technology ID
BDP 8710

Category
Hardware/Machine Vision
Selection of Available Technologies

Authors
Xu Chen

Learn more

Current research employs finite element modeling and feedback controls to understand the energy deposition mechanisms and to regulate the in-process variations in powder bed fusion and other additive manufacturing technologies, however this analysis is time consuming. The benefits of this technology are the ability to quickly survey the parameter space fully to generate more predictable part qualities, and quickly design controllers and update parameters for novel materials and printer settings. These benefits are more prominent when the experiments are costly and time-consuming.

Patent Information:

US20220414297A1

References

1. Dan Wang, Xu Chen(44978) , https://asmedigitalcollection.asme.org/dynamicsystems/article-abstract/143/2/021006/1086765/Closed-Loop-High-Fidelity-Simulation-Integrating?redirectedFrom=fulltext, J. Dyn. Sys., Meas., Control