An Air Coupled Ultrasonic Array Scanning System for In-situ Monitoring and Feedback Control of Additive Manufacturing

Dr. Dan Xiang [1], Dr. Arnab Gupta[1], Dr. Honam Yum[1] , Dr. Tim Osborn[2]
[1]X-wave Innovations, Inc., Gaithersburg, MD
[2]University of Dayton Research Institute, Dayton, OH

X-WAVE INNOVATIONS, INC.
Make state-of-the-art obsolete

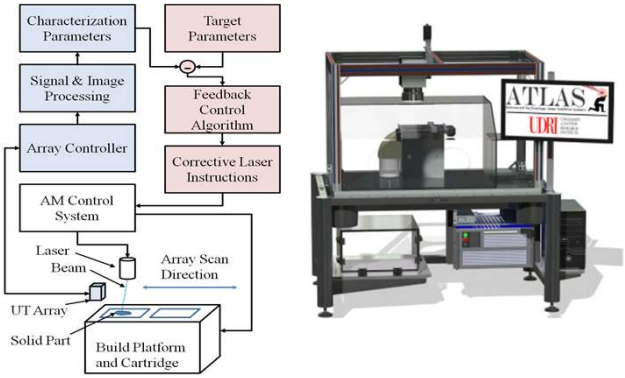
UDRI

Introduction

Additive manufacturing (AM) is a next generation method of production to be adopted by the Oil and Gas (O&G) exploration/extraction industry. AM is particularly useful in its ability to enable rapid development of tough metal (as well as other materials) components with strength approaching that of parts formed by traditional manufacturing techniques. Currently the majority of AM processes, however, are plagued by a lack of online process control. In this SBIR effort, X-wave Innovations, Inc. (XII) and the University of Dayton Research Institute (UDRI) are developing an Air Coupled Ultrasonic Array Scanning (ACUAS) system for in-situ monitoring and feedback control of AM processes.

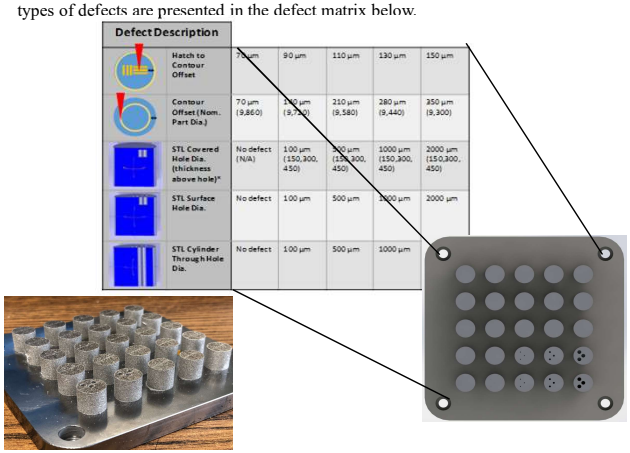
System Configuration

A schematic overview of the major components of ACUAS enabled AM system and a picture of the AM testbed are presented as below.



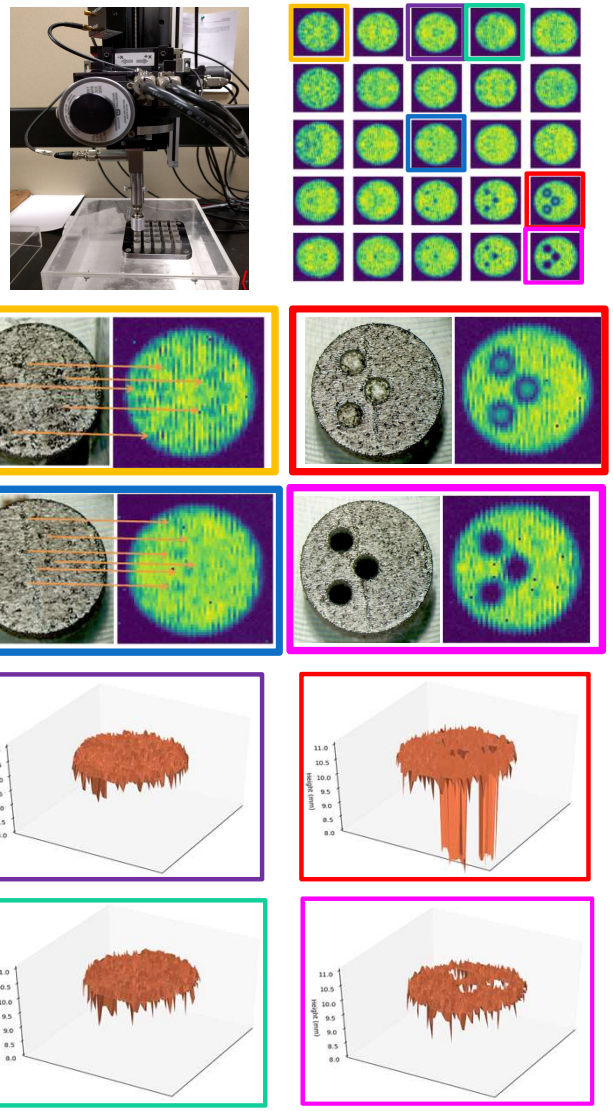
AM Specimen Fabrication

An AM specimen containing 25 cylindrical posts with different processing parameters has been fabricated. Some posts have designed defects, while others don't. A summary of the specimen posts processed with different parameters and different types of defects are presented in the defect matrix below.



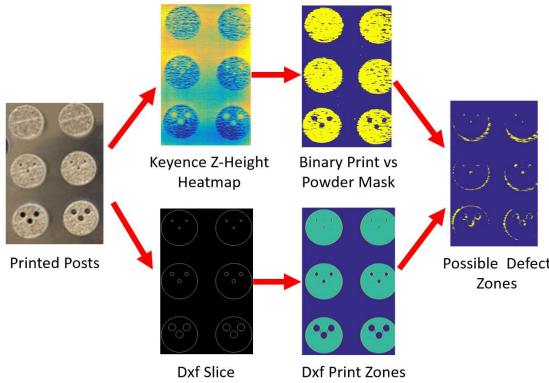
Air Coupled Ultrasonic Scanning

Air coupled ultrasonic scanning has been performed on the fabricated AM specimen. Various data analysis methods have been applied to the collected waveforms to extract the defect information. Some of the analysis results are shown below.



Feedback Control Framework

For defect detection and feedback control purposes, it was determined that the first step is to determine anomalies outside the print regions. To this end, a method was developed for generating a binary Print vs. Powder mask. Next, a dxf slice of the build layer was imported into the profilometer scan coordinate system. The dxf slice was compared to the binary print vs. powder mask to determine zones where an identified print region lied outside of the dxf part zones. These zones would then be flagged as possible defect zones. The preliminary feedback control process is shown as a schematic below.



Summary

We are developing an Air Coupled Ultrasonic Array Scanning (ACUAS) system for in-situ monitoring and feedback control of AM processes. We fabricated an AM specimen containing 25 cylindrical posts with different processing parameters and different types of defects. We conducted experiments on the fabricated AM specimen using air coupled ultrasonic scanning, and conducted data analysis to the collected ultrasonic testing data to extract the defect information in the specimen. We also performed preliminary design work regarding the feedback control framework.

Acknowledgement/Funding Agency

SBIR Phase I contract #DE-SC0017805
"An Air Coupled Ultrasonic Array Scanning System for In-Situ Monitoring and Feedback Control of Additive Manufacturing"
PI: Dan Xiang, X-wave Innovations, Inc.