NextManufacturing
Carnegie Mellon University

Wednesday, May 2, 2018
11:00 am-12:00 pm

Scott Hall 6142

In-Situ Melt Pool Monitoring Methodologies for the Laser Powder Bed Fusion Process

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ABSTRACT

The Laser Powder Bed Fusion (L-PBF) process generates extremely high thermal gradients, fast fluid flows, and significant evaporation of material. The dynamic nature of the process requires monitoring on short enough length and time scales to detect potential flaws in-situ. These constraints lend themselves to visible light high speed cameras due to their relatively high performance and low price. This work shows that a commercial high speed camera and high magnification lens are capable of viewing melt pool dynamics in and around Ti-6Al-4V (Ti64) melt pools at up to 20 kHz. The effect of the plume on measured melt pool dimensions is shown and thermal gradients at the edge of a raster are measured. Also, total melt pool emission (including from the plume) is shown to correlate to melt pool cross-sectional area across changes to power, velocity, and substrate temperature. As will be discussed, the explicit detection of the melt pool boundary can be difficult under certain conditions. For the purposes of flaw (e.g. keyholing porosity and balling) detection this issue is circumvented through the use of Computer Vision techniques to directly describe Inconel 718 (In718) melt pool morphology – including the vapor plume and spatter particles. Melt pool morphologies are then observed across processing space and studied using unsupervised Machine Learning techniques and linked to flaws observed ex-situ. Finally, supervised Machine Learning techniques are then used to classify melt pools observed in-situ. Such classification of melt pools based on identified flaw formation signatures enables the study of melt pool morphologies during fusion of non-bulk geometries such as overhangs and contour regions.

BIOGRAPHY

Dr. Brian Fisher received his BS in Mechanical Engineering from Brown University in 2010, after which he spent four years working as a design engineer for a renewable energy company before starting his PhD under the direction of Professor Jack Beuth in 2014. His research interests lie in understanding the physical mechanisms governing metal additive manufacturing and will be joining the United Technologies Research Center.

Dr. Luke Scime joined CMU in the fall of 2014 after receiving his BS in Mechanical Engineering from the University of Florida. During his time at CMU, Luke has focused on using machine learning and computer vision to analyze in-situ data from metal additive manufacturing processes. During his free time, Luke enjoys photography and volunteering for the FIRST robotics program. Luke will be joining Oak Ridge National Laboratory.