Optimizing the Post-Processing of Additively Manufactured Parts

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Introduction

Greenville Advanced Manufacturing Works uses additive manufacturing for complex components
Process development on current processes for UTSR

GOAL: Determine efficacy of and improvements to post-processing techniques of additively manufactured parts

Fluorescent Penetrant Inspection

Setting up a Fluorescent Penetrant Inspection (FPI) booth was one of the firsts tasks I was given
Required Signoff from multiple parties, needed:
• Readiness for production use
• Engineering safety controls in place
• Instructions written for operation
Water splash guard installed, and a GFCI outlet for blacklight

Creation of Quality Indicators

Performing FPI on additively manufactured (AM) parts is difficult because of the rough surface of as printed parts
The goal of this project was to understand cost/cycle of surface treatments to enable FPI of AM parts
Coupons were designed in Siemens NX and then printed to mimic AM parts
Surface treatments or media blasting were used to decrease surface roughness
325 Ra was normal for as built panels, whereas 200 Ra was the roughness for panels after surface treatment

Post-Build Heat Treatment

A computational and experimental study

Post-processing of AM superalloys often involves heat treatment to get optimal properties
Goal of this project was to create a model to describe the precipitation of γ’ in IN-738
The intent was to use cellular automata to model the diffusion of elements in the as-printed components
Simulations were run against experiments to determine if they model reality
Differential Scanning Calorimetry was used to determine phase transformation temperatures, especially after thermal exposure
Thermo-Calc was used to determine what phases could be expected
DSC curves show transformations around 575°C, matching up with Thermo-Calc
Scanning Electron Microscopy performed to examine phases present in samples heat-treated at 575°C
Thermo-Calc Scheil solidification predictions show that the first phase to appear is γ, followed by a BCC phase, then finally γ’
This implies a very small amount of γ’ in the as solidified structure

Build Time Estimation

A build time estimator was programmed in python using sci-kit learn’s multiple linear regression function
Inputs:
• Constant:
• Variables:
  • Machine,
  • Build Volume
  • material,
  • Surface Area
  • parameter set
  • Z-Height
  • Multiple linear regression used to predict build time in hours
  • R² Value reported to be 0.99

Powder Capsule Redesign

This project was one that needed to be done to improve the builds that the team was performing. The powder capsule is used to document what the state of the powder was for a build, so that analysis does not need to be performed every time. This is done by building a 3D wall around the powder, such that the powder has no egress from the structure. This allows the history of the powder used to build the part to be easily saved and catalogued for later analysis.

Conclusions

There were multiple conclusions from this variety of projects
3D printing very small features is difficult
We understand that there are a few different events taking place during the heat treatment that bear more scrutiny
Transformations at 575°C and 1065°C may be of interest for heat treatment – perhaps bounds for the heat treatment process
From Thermo-Calc, A large amount of γ’ and other TCP phases are expected to appear at equilibrium
However, this is often hard to determine as kinetics of these phases are very slow

References