Printing of High Strength Aluminum Alloys via Laser Powder Bed Fusion Additive Manufacturing

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Introduction

Laser Powder Bed Fusion (LPBF) is an additive manufacturing (AM) process that utilizes fine metal powder to build parts layer by layer. Process parameters such as laser power and scan speed are the major influencing factors on overall build quality and mechanical properties. Aluminum Alloy 6061 is a commonly used structural material in aerospace and automotive industries. Defects formed during printing, such as cracks and pores, impede its application via AM. As limited research has been performed on Al6061 fabricated with LPBF, in this study, a wide range of process parameters were systematically studied to produce defect free parts, with the final goal to establish the process-structural-property relationship for Al6061 in LPBF.

Methodology

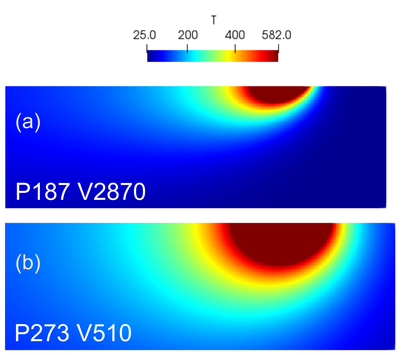

Figure 1: Melt pool simulation of **(a)** 187W and 2870 mm/s and **(b)** 273W and 510 mm/s

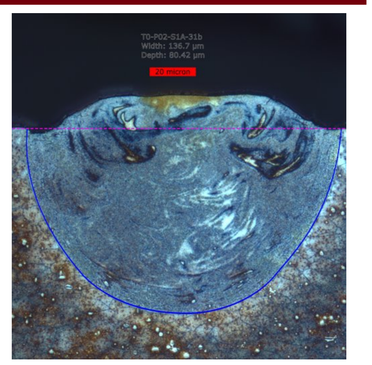

Figure 2: Cross section view of a melt pool imaged with an optical microscope

- A bead-on-plate sample was printed with 42 lines varying from 79.5W to 1000W of laser power and scan speeds from 8.5mm/s to 2995.2 mm/s
- Bead-on-powder plate with identical laser and speed parameters was printed
- Optical imaging of the plates to measure melt pool width, depth, and surface topography were conducted
- Plates were cut, potted, and polished to reveal melt pool size and microstructure via Scanning Electron Microscopy (SEM)
- Parameters varying from 96.4W to 393.9W and speeds of 201.8 mm/s to 2830.6 mm/s were used for cubic samples with varying hatch spacing

Results and Discussion

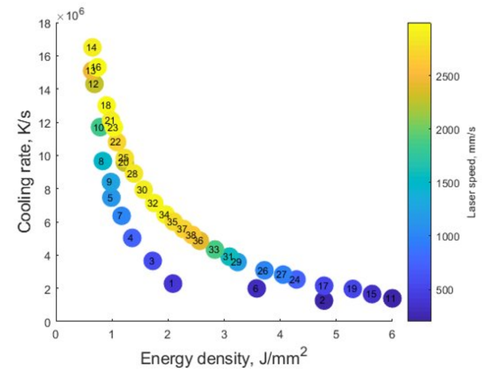

Figure 3: Energy density vs. cooling rate vs. laser speed of 42 parameters

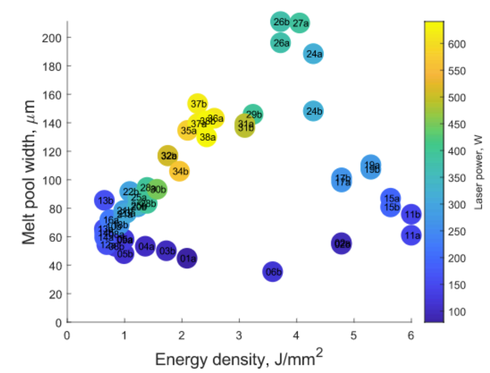

Figure 4: Energy density vs. melt pool width vs. power of 42 parameters

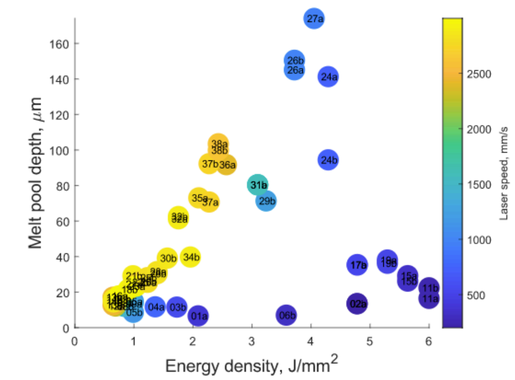

Figure 5: Energy density vs. melt pool depth vs. power of 42 parameters

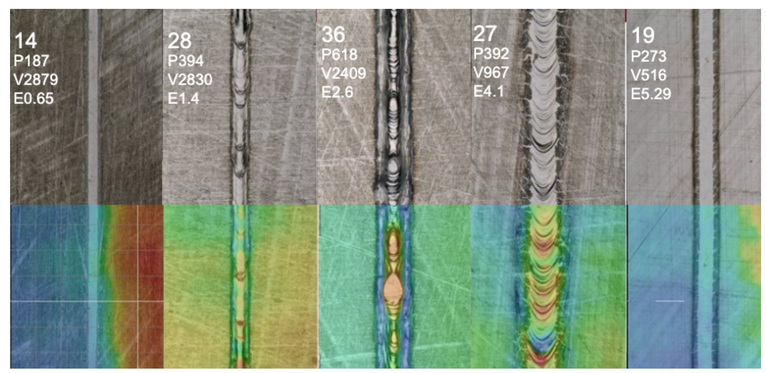

Figure 6: Varying line morphologies for bead-on-plate samples and corresponding height maps

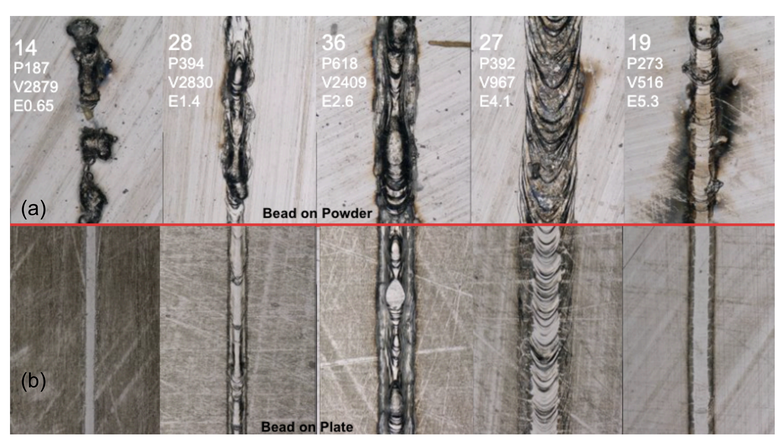

Figure 7: Comparison of **(a)** bead-on-plate and **(b)** bead-on-powder melt pools

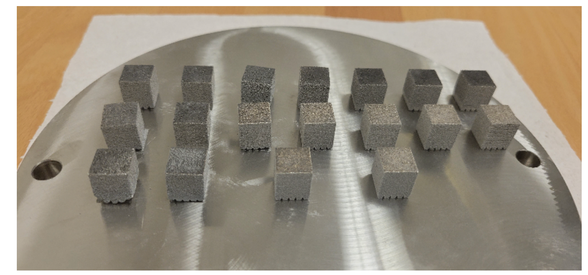

Figure 8: Cube samples for 7 varying power, speed, and hatch spacing

Figure 9: Enlarged view of cubic sample 21-h150

Conclusions

- High laser power lines produced trench shaped morphology with larger width, up to 153μm as well as deeper melt pools, as much as 110μm below the surface
- Lower laser power lines lead to shallow melt pools or even no melting
- Bead-on-powder lines resulted in melt pools and morphologies comparable to the bead-on-plate
- Cubic samples were successfully printed from low to moderately high laser powers

Acknowledgement

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