Master thesis project Spring/Fall 2023: Experimental investigation of the statistical nature of the melt pool size in Laser Powder Bed Fusion

Background and scientific objective

Laser Powder Bed Fusion (LPBF) is a layer by layer additive manufacturing technique used to produce near net-shape metal parts. During the process, a thin layer of metal powder is deposited on a so-called build plate. A focused laser beam is then used to locally melt and fuse the powder according to a predefined scan path. After one layer is completed, the procedure is repeated until the 3D part is created. The LPBF process inherently allows for the direct production of complex metal parts making it a potent process to be applied within the context of topology optimized and highly customized parts. This leads to a widespread application of LPBF in the aerospace, automotive, defence, tool making, and medical industry [1,2,3].

Despite the previous mentioned advantages of the process, LPBF produced parts generally suffer from a lack of repeatability, forcing industry to apply resource-demanding qualification processes or to avoid the use of LPBF altogether. Within the scope of your Master thesis project, you will experimentally explore the variability of the melt pool size as a function of the two most dominant processing parameters (the laser power P; and the laser velocity V) as well as evaluating the influence of the initial temperature (T) on the process response.

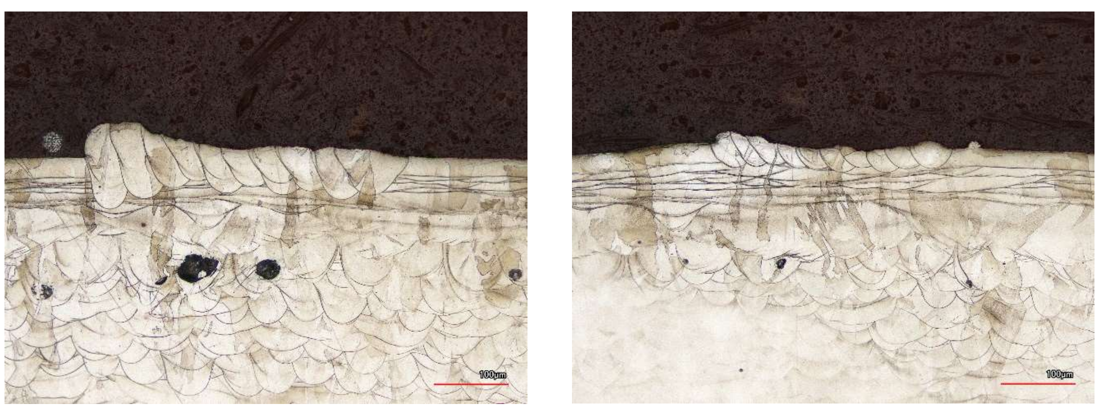

Figure 1 Post-mortem melt pool cross-sections of multiple laser-tracks om 316L stainless steel.

To that end, different LPBF parts need to printed using an in-house developed LPBF device. Post-mortem cross-sections (as illustrated in Figure 1) will be used to establish the relation between input factors (P, V, T) on the responses (melt pool width and melt pool depth). Additionally, in-situ dual wavelength thermal imaging is utilized to capture the effect of input factors on the resulting melt pool length. The aim of your work is to establish a relation between the input factors and the mean value of the responses. Moreover, the standard deviation should be mapped in respect to the input factors. Lastly, an empirical model able to estimate the impact of power, velocity, and initial temperature is to be established following a Design of Experiments approach. The primary material to be investigated is 316L stainless steel.

Work packages

- Literature review
- Design of Experiments
- Experimental work
  - Sample printing using an LPBF device
  - Sample preparation (metallography: embedding, polishing, etching)
  - Optical microscopy
  - In-situ thermal imaging
- Data analysis/postprocessing
- Writing of a scientific report

What you are going to learn/apply

- In-depth understanding of the LPBF process
- Operating an in-house developed LPBF device
- Preparation of metallic samples for microscopy
- Fundamentals of thermal imaging
- Fundamentals of Design of Experiments

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