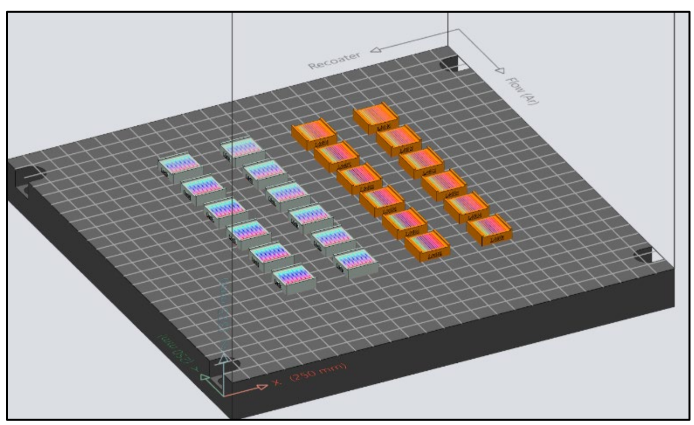
Master Thesis Project

A study of melt pool dynamics and microstructure evolution of Laser Powder Bed Fusion processed Inconel 718 alloy using single track experiments

Background

Laser Powder Bed Fusion (L-PBF) is one of the most established metal Additive Manufacturing (AM) techniques and is suited for production of functional components for aerospace, space, and automotive applications. Quality assurance of L-PBF parts is critical for applications with strict requirements on the mechanical performances. For a given material and L-PBF machine system, an appropriate window of key processing parameters needs to be identified through experimental optimization, and in some cases with aids of numerical simulations. Meanwhile, the microstructure of a L-PBF processed material is significantly different from its conventionally made counterpart. The intensive local heating by the focused laser beam introduces large thermal gradients, thus creating a highly non-equilibrium microstructure through rapid solidification. The remelting of previous layers gives rise to epitaxial grain growth along the build direction. Different experimental and numerical approaches were developed to establish relationships between the process, the microstructure, and the mechanical properties of L-PBF processed materials. Single track experiments, developed at an early stage since the technology emerged, provide useful information regarding melt pool dynamics, microstructure evolution and defect formation. For instance, examination of the molten track morphology helps to understand how melt pool dynamics are changed by the laser processing parameters, and microstructural characterization of the cross sections of single tracks helps to understand how grains are orientated with respect to the laser scan direction and thermal gradient.

Description of the thesis work



Most of the thesis work will be dedicated to the characterization of single tracks printed with varied laser processing parameters, i.e., laser power, scan speed, hatch distance, and layer thickness, through optical microscopy and Scanning Electron Microscopy (SEM). The student will develop methodologies for evaluating the melt pool stability and link the observed trends in experiments to existing theories, i.e. Rayleigh instability, Marangoni flow, evaporation, etc. The printing process is also monitored by state-of-the-art online monitoring systems where thermal radiation from the single-track specimens during the L-PBF process can be extracted to help analyzing the results. At a later stage, the student will down-select a few samples out of the extensive sample matrix for in-depth microstructural characterizations using advanced techniques such as Electron-Backscattered Diffraction (EBSD) mapping.

Organization

The thesis will be performed at the Department of Industrial and Materials Science, which is hosting the competence centre "*Centre for additive manufacturing – metal (CAM^2)*" that involves a broad network of national and international companies.

Extent and time plan

30 hp master thesis project, starting (flexible) in Sep 2021/January 2022 and should finish by May 2022.

Qualifications

Interest and curiosity in the subject, good understanding of material science and additive manufacturing, basic skills in image analysis as well as good analytical skills.

Supervisors and examiners:

Supervisors: Dr.Zhuoer Chen, Chalmers: zhuoer.chen@chalmers.se

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