Particle-based simulations of powder spreading and melt pool dynamics in laser powder bed fusion

Claas Bierwisch*

* Fraunhofer IWM
Wöhlerstraße 11, 79108 Freiburg, Germany
e-mail: claas.bierwisch@iwm.fraunhofer.de, web page: http://www.simpartix.com/

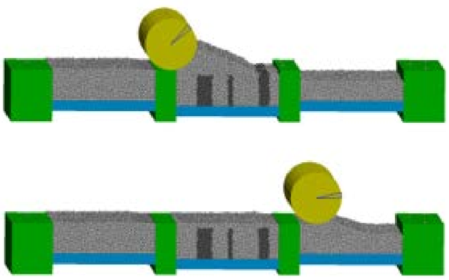
ABSTRACT

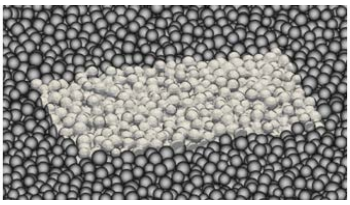
In laser powder bed fusion (L-PBF) a roller or a blade is used to apply a preferably uniform powder layer in the process chamber. Then, a laser locally introduces heat into the bed to melt the powder and thereby create the final shape in the current layer. At the moment, no established simulation tool chain exists for L-PBF. The availability of a continuous process simulation would yet be useful in view of the complexity of the process in order to (i) deepen the understanding, (ii) accelerate the product development cycle and (iii) increase the quality of the manufactured components.

Particle-based numerical methods enable certain relevant process simulations for L-PBF. These include discrete element method (DEM) simulations of powder spreading to obtain packing densities which influence the dynamics of the melting process. Smoothed particle hydrodynamics (SPH) simulations of melting and resolidification yield porosities, surface properties and temperature profiles. The latter can then be transferred to microstructure simulations determining the component strength.

A simulation example is shown in the figure below. A loose powder packing obtained by a DEM spreading simulation with a counter-rotating roller (a) provides the initial condition of the L-PBF simulation (b). The melting and resolidification is then modelled using an SPH approach taking into account the interaction with the laser as well as melt pool dynamics including gravity, viscosity, thermal diffusion, surface tension, Marangoni currents, radiation and vaporization pressure (c).

The present study focuses on the modeling of different material and process parameters and their respective influence on the process result in terms of porosity and surface roughness. Relevant dimensionless numbers based on material and process parameters are highlighted. The formation of non-trivial surface patterns is discussed and compared with similar experimental findings.


a)


b)

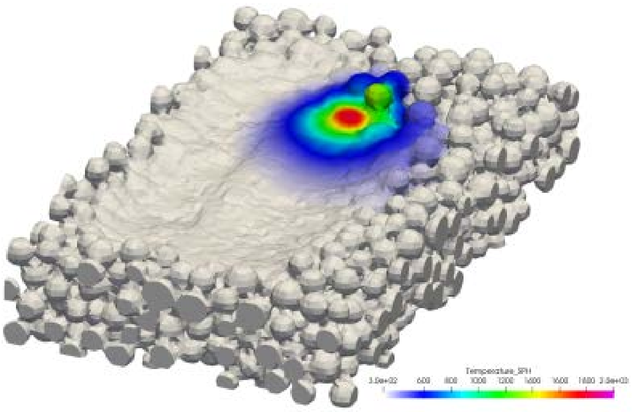

c)

Figure: a) DEM simulation of powder spreading process. b) Particle distribution after spreading simulation; shown in light gray is the area used for the subsequent melting simulation. c) SPH simulation of L-PBF with color-coded temperature profile.