DEM powder spreading and SPH powder melting models for additive manufacturing process simulations

Claas Bierwisch*

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

ABSTRACT

Additive manufacturing processes currently penetrate both science and industry. These methods provide specific advantages including the customization and complexity of the produced components. Additively manufactured components are already utilized in complex systems such as airplanes but their overall reliability has not yet proved satisfactory.

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. However, particle-based numerical methods enable process simulations for L-PBF. These include DEM simulations of powder spreading to obtain packing densities which influence the dynamics of the melting process. SPH simulations of melting and resolidification yield porosities, surface properties and temperature profiles. The latter can 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 provides the initial condition of the L-PBF simulation. 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 surface tension, Marangoni currents and vaporization pressure.

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.

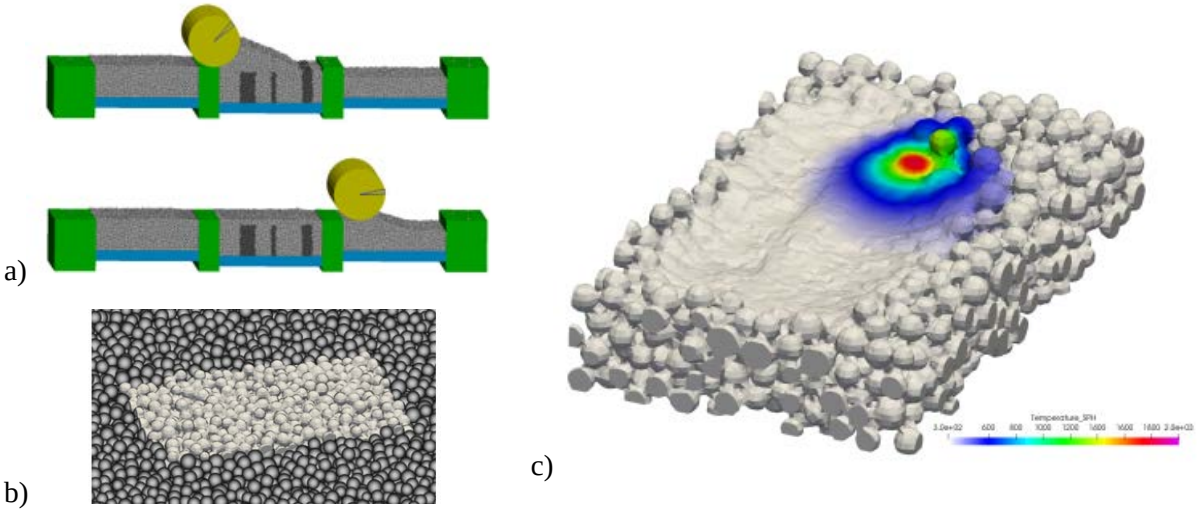

Figure: a) DEM simulation of powder spreading process. b) Particle distribution after spreading simulation; shown in light gray is the area used for the subsequent melting simulation. c) SPH simulation of laser powder bed fusion with color-coded temperature profile.