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Geometry dependent microstructures in powder bed fusion of metals

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Additive Manufacturing, especially powder bed fusion of metal using a laser beam (PBF-LB/M) has become an important alternative to traditional subtractive manufacturing technologies due to the geometric freedom offered. In addition to the geometric freedom, researchers and industrial end user envision the usage of tailored microstructures and thus tailored mechanical properties. Meaning mechanical properties can be created as needed in different sections of one single part. Microstructural evolution itself is highly dependent on cooling rates and temperature gradients. Since PBF-LB/M creates parts layer by layer and weld track by weld track, the adjustment of local cooling rates and temperature gradients, within a certain processing windows, and thus part properties is theoretically possible. In order to fully exploit the possibility of tailored microstructures it is therefore of utmost importance to fully understand the thermal behavior of the process. While the possibility to be able to build chosen microstructures in certain areas of a part is often seen as a feature, the local change in microstructure due to a change in the thermal field due to a changing geometry can just as often seen as a bug.

Since the formation of microstructure depends on local temperature gradient and solidification rate, simulations must be able to predict both quantities to reflect experimental results. We use thermomechanical simulations on the part scale and thermofluidic simulations on the powder scale to show the influence of geometry on the temperature gradient and solidification rate. Being able to predict these quantities the user can actively decide between feature and bug.