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Melting and Solidification for Powder Based Additive Manufacturing Using Optimal Transportation Meshfree Method

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Selective Laser Melting (SLM) is an additive manufacturing (AM) process, where a powder bed is partially melted. Layer by layer, complex three dimensional geometries including overhangs can be produced, because non-melted powder acts as support structure.

Up to date the multiple interacting physical phenomena are not yet fully understood. This is why the material and process development mainly relies on experimental studies that are time and cost intensive. Novel simulation tools such as meshless methods offer the potential to gain a deeper understanding of the process - structure - property interaction. This can help to find optimal process parameters and to individualize AM manufactured parts by locally altering material properties.

Using conventional FEM methods, extremely large deformations of the mesh lead to ill-shaped elements and per consequence to degenerate computations. Meshfree methods eliminate the mesh dependency by employing a more flexible formulation to relate a point of integration to its neighboring nodal points. This requires flexible shape functions that depend on the nodal positions only [1].

The Optimal Transportation Meshfree (OTM) Method is a meshless method based on the weak formulation of the differential equations and can be downscaled to the Finite Element Method. It accounts for a broad variety of materials ranging from solids to fluids [2] including thermo-mechanical behavior.

This flexibility makes the OTM an optimal tool to simulate the melting of powder particles and the motion of the melt flow. An approach to account for the phase transition and the fusion of particles using OTM will be presented. Furthermore, the behavior of the metal during solidification is assessed. Releasing the induced residual stresses can yield undesired deformations and destroy AM parts.

References

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