Inline CT-Analysis of the Melting Area during Fused Filament Fabrication

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In the 21st century, 3D printing has become a mainstream process for prototyping and low-volume production. Fused Filament Fabrication (FFF) is the most commonly used process for 3D printing plastics. A plastic filament is melted in a nozzle and a component is built up layer by layer. As with all manufacturing processes, there is an interest in continuously optimizing and improving the FFF process. One approach is based on process simulation, which provides a better understanding of the process. Subsequently, it is always necessary to validate the simulation models with the real process. This validation has only been possible to a limited extent in the case of FFF. In this work, a method is presented that allows a non-destructive investigation of the melt behavior during the printing process. For this purpose, a 3D printer nozzle with an extruder was integrated into an X-ray computed tomography system. Thus, a computed tomography (CT) scan can be performed during the extrusion process. By using highly absorbent tungsten filaments, sufficient contrast can be created between the metal nozzle and the plastic filament to allow analysis of the melt behavior. This setup makes it possible to distinguish between the solid filament area and the melt area, as well as to determine the contact between the filament and the die wall. In this way, simulations can be validated and nozzle geometries can be improved.