Chair of Metal Forming and Casting
TUM School of Engineering and Design
Technical University of Munich

“Incremental Casting”: Support Material and Close-Loop Control of Layer Height for Direct Metal Printing with Aluminium

Final Report

Motivation

“Incremental casting,” also known as Molten Metal Jetting (MMJ), is an additive manufacturing process in which a material is melted and ejected droplet-by-droplet onto a build platform to produce a component. The process operates without powder raw materials, which offers significant advantages in terms of workplace safety. To fully realize the potential of MMJ, support structures are necessary, which require costly post-processing. Furthermore, inaccuracies in droplet generation lead to deviations in component geometry, which in turn necessitates post-processing.

Approach

The goal of the first project phase was to develop water-soluble salt support structures and to integrate an automatic geometry deviation compensation. The subsequent project continuation involved the development of support structures in which salt functions solely as a releasing layer, the establishment of a calibration process for determining optimal initial process parameters, and the investigation of components with deliberately varied droplet sizes. A dual print head was developed for the simultaneous processing of aluminum and salt, and test specimens were produced and analyzed to investigate the aluminum-salt interface and to characterize the mechanical properties.

Results and Outlook

Figure 1 shows an aluminum component fabricated using a monolithic salt support structure.

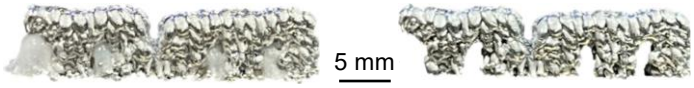

Figure 1: Left: TUM logo made of aluminum with a monolithic salt support structure. Right: The same component after the support structure has been removed (doi: 10.26153/tsw/51024).

During the investigation of the aluminum-salt interface, no significant effects of the salt on the aluminum surface were observed. An automated simulation environment was set up to numerically investigate the processing of the two materials. The developed in situ measurement system enables the determination of the local layer height of the components in the MMJ and, together with the implemented control algorithm, the adjustment of the droplet size during printing as well as the implementation of the calibration process to identify optimal initial process parameters. The conducted tensile tests indicate advantages of the release-layer support structures over monolithic salt support structures, as well as an influence of the build material droplet size on the mechanical properties of the components.

Publications

- https://doi.org/10.1007/s11740-021-01055-1
- https://doi.org/10.3390/ma14154072
- https://doi.org/10.1115/IMECE2021-70279
- https://doi.org/10.26153/tsw/51024
- https://doi.org/10.1115/IMECE2023-112380

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Partnerships

TUM Institute of Micro Technology and Medical Device Technology (Prof. Lueth)