Multiscale Modelling of Selective Laser Sintering

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Introduction

Additive manufacturing (AM) is part of the 4th industrial revolution. One AM method is Selective Laser Sintering (SLS), in which objects are produced by depositing successive layers of powder (plastic, metal, ceramics, or glass), and sintering parts by selectively scanning the powder bed with a laser, as shown in Fig.1. The technology is used in various fields, e.g. industrial design, automotive, biotech, aerospace ... etc. Optimising the process will allow engineers to realise previously impossible designs, expanding the realm of possible applications.

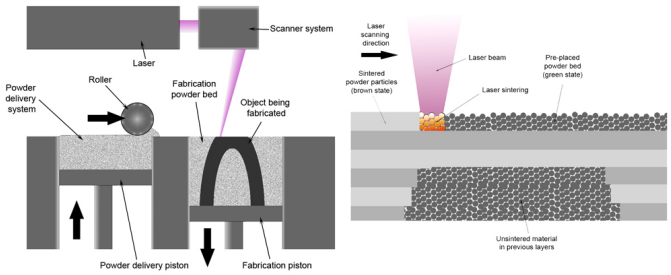

Figure 1: Schematic of SLS process (source: wikipedia.org)

Aims and Challenges

The aim of this study is to develop a multiscale model of powder agglomeration that will allow us to predict bulk processes in additive manufacturing (selective laser sintering process). Research challange is to capture temperature and rate-dependence of the sintering process

Approach

A novel two-scale approach (micro-meso and meso-macro) is used to couple the different scales, shown in Fig.2:

- Microscale contact model for rapid sintering.
- Micro- to meso-variables: calibration by experiments.
- Mesoscale: particles represent ensembles.
- Meso- to macro-variables: 'coarse-graining'.
- Predict and optimise processes with macro-modelling.

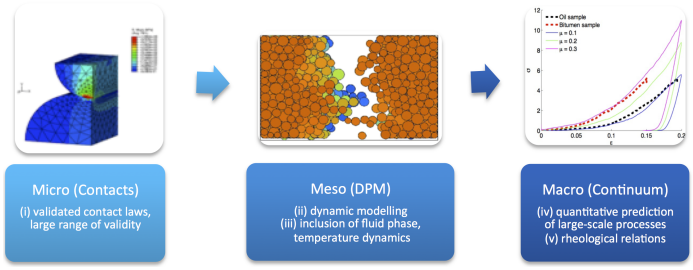

Figure 2: Schematic overview of the new two-stage approach

Experiments

In-house experiments will be conducted to take into account the rapid surface melting and sintering process in SLS. Sintratec kit, Fig.3, is used for the experimental trials.
Industrial validation and case-study experiments of the method are conducted in collaboration with external organizations and institutes.

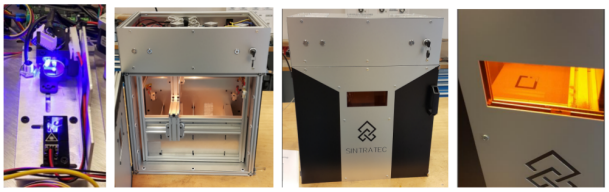

Figure 3: In-house SLS set-up

Results

Preliminary work:

Contact model for sintering[1][2]

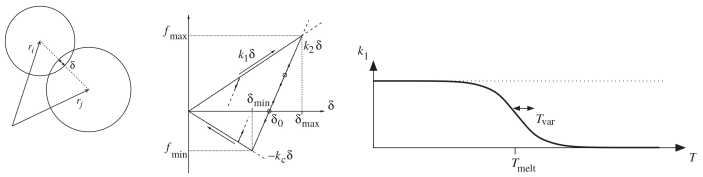

Figure 4: Left: two-particle contact. Middle: contact model for the normal contact force. Right: schematic plot of k_1 as a function of T.

Deposition method[3]

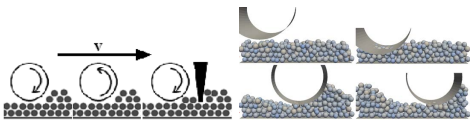

Figure 5: Left: different compactions methods. Right: simulation results of uniform powder distribution in combination with a counter rotating roller.

Heat disspation[4]

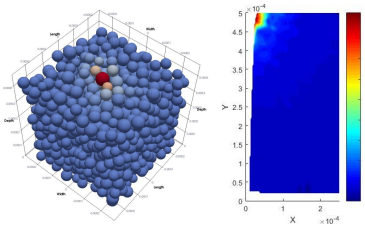

Figure 6: Left: simualtion of heat dissipation in powder bed. Right: temperature distribution in a 500*500*500 μm powder bed after 0.5 seconds of heating.

References

[1] S. Luding et al, J Mech Phy Solids 53(2), 455-491, 2005.
[2] Fuchs et al, EPJ Web Conf. 140 (2017) 13012.
[3] R. Asad, D.S. ten Broek, Internal research, UT, 2016.
[4] R.E. Rusticus, J.H. Zaaijer, Internal research, UT, 2016.