MESA+ Meeting, 25 September 2017.

Multiscale Modelling of Agglomeration
Selective Laser Sintering

M.Y.Shaheen[1], T.Weinhart[1], W.W.Wits[2], A.R.Thornton[1], S.Luding[1]
[1] Multiscale Mechanics, MESA+, Engineering Technology, University of Twente.
[2] Design, Production & Management, Engineering Technology, University of Twente.

MESA+ INSTITUTE FOR NANOTECHNOLOGY

Introduction

Additive manufacturing (AM) is part of the 4th industrial revolution. Optimising the process will allow engineers to realise previously impossible designs, expanding the realm of possible application. The trends in industry towards AM and 3D printing have motivated our interest to simulate such processes.
One AM method is Selective Laser Sintering (SLS), in which objects are produced by depositing successive layers of powder particles (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 and many other.

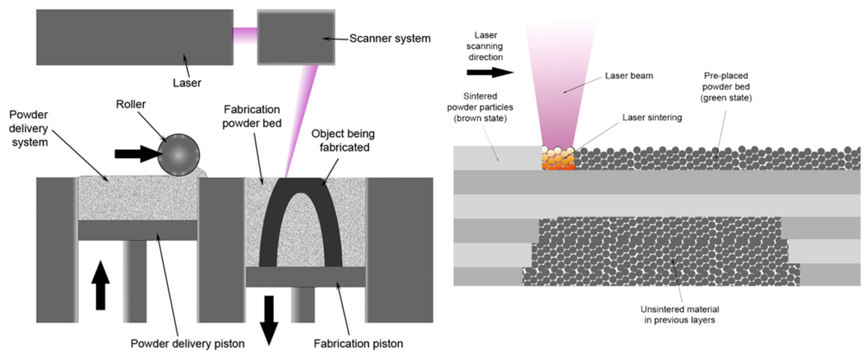

Figure 1: Schematic of SLS process (source: wikipedia.org)

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, pharmaceutics,...etc. We will first apply this model to the selective laser sintering process.
- Research approach:
  - Temperature dynamics.
  - Coupling between the individual scales.

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 (including rapid temperature changes).
- Transition micro- to mesoscale variables: calibration by experiments.
- Mesoscale: particles do not represent single particle but ensembles.
- Transition from meso- to macro-variables: 'coarse-graining'.
- Predict and optimise processes with macro-modelling.

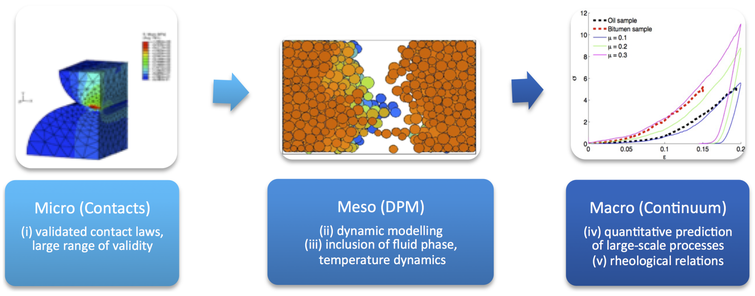

Figure 2: Schematic overview of the new two-stage approach

Sub-processes

- Powder deposition methods: slider, roller, rake,...etc.
- The use of virgin powder vs used powder.
- Powder particles distribution.
- Process parameters effect on product quality (temperature, orientation,...etc).

Experiments

- In-house experiments will be conducted to take into account the rapid surface melting and sintering process in SLS.
  - Sintratec kit, see Fig.3, is used for the experimental trials.
  - Initial control parameters: laser speed, chamber temperature, surface temperature, layer thickness, number of primeters, perimeter offset, hatch offset, and hatch spacing.
- Industrial validation and case-study experiments of the method are conducted in collaboration with other organizations and institutes.

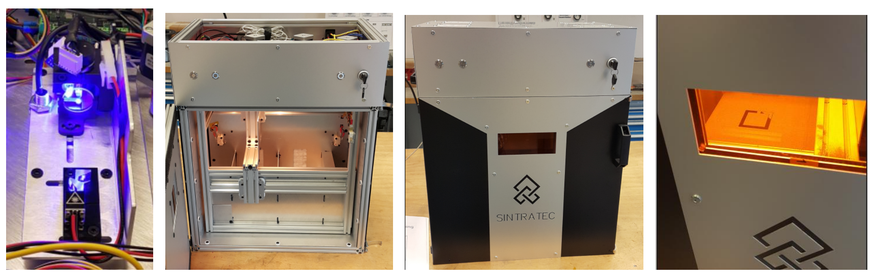

Figure 3: Sintratec kit

RESULTS

Preliminary work:
Contact model for sintering[1-2]

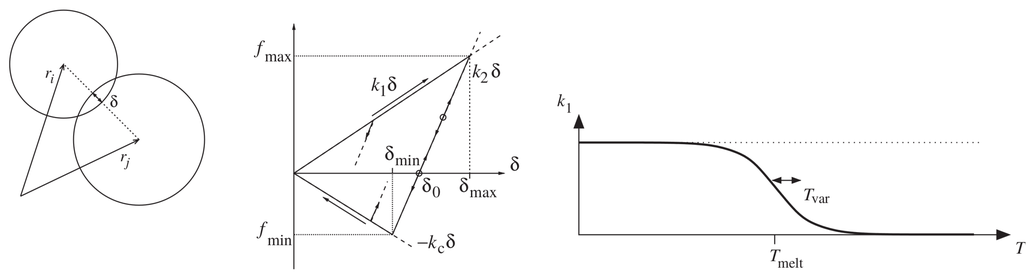

Figure 4: left: two-particle contact with overlap δ. middle: contact model for the normal (repulsive) contact force as a function of the overlap. right: schematic plot of the stiffness k_1 as a function of the temperature.

Deposition method[3]

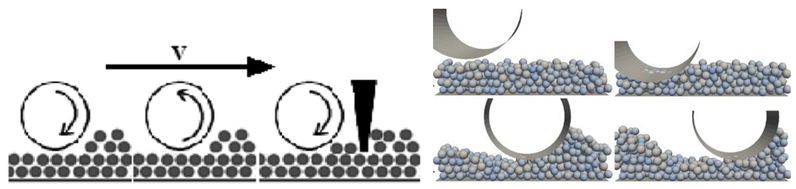

Figure 5: left: different compactions methods: forward rotating roller, counter rotating roller, and a forward rotating roller with a blade in front of it. right: simulation results of uniform powder distribution in combination with a counter rotating roller.

Heat disspation[4]

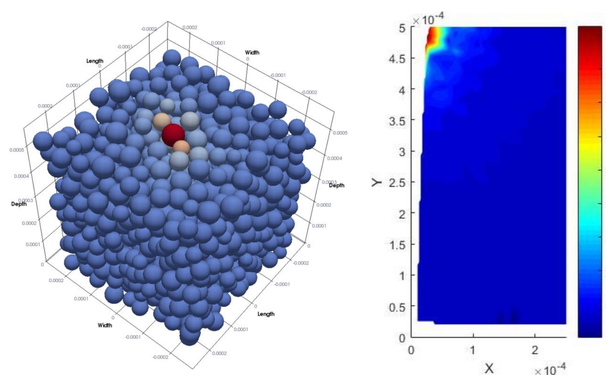

Figure 6: left: simualtion of heat dissipation in powder bed. right: plot of the temperature distribution in a 500*500*500 μm powder bed after 0.5 seconds of heating.

References

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

msm

UNIVERSITY OF TWENTE.