Application and modeling of a lab scale Twin Screw Extruder for the continuous mixing of Li-Ion battery slurries

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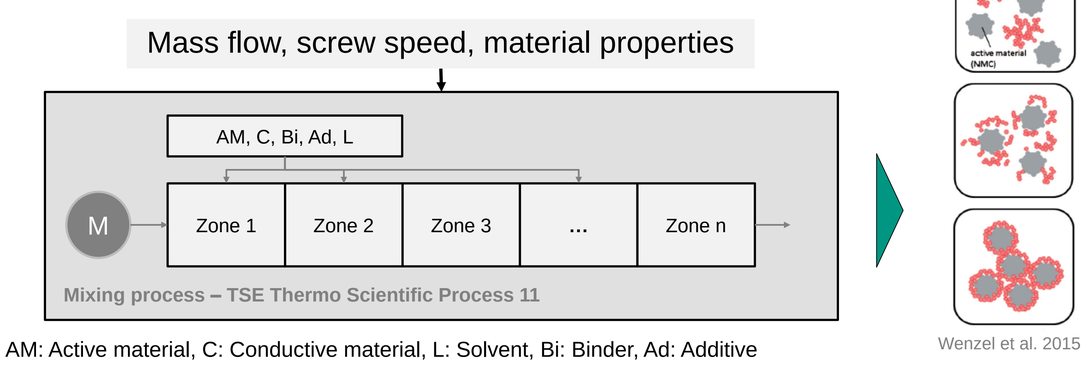
Motivation

- Towards **continuous** and **agile** production of battery slurry:
  - **Versatile** dosing of slurry components during mixing
  - **Variable** slurry production for **testing** purposes or **scale-up**
  - **Reduction** of waste material after ramp up
- **Adaptive control** of production rate, temperature, energy input and viscosity

Extrusion process

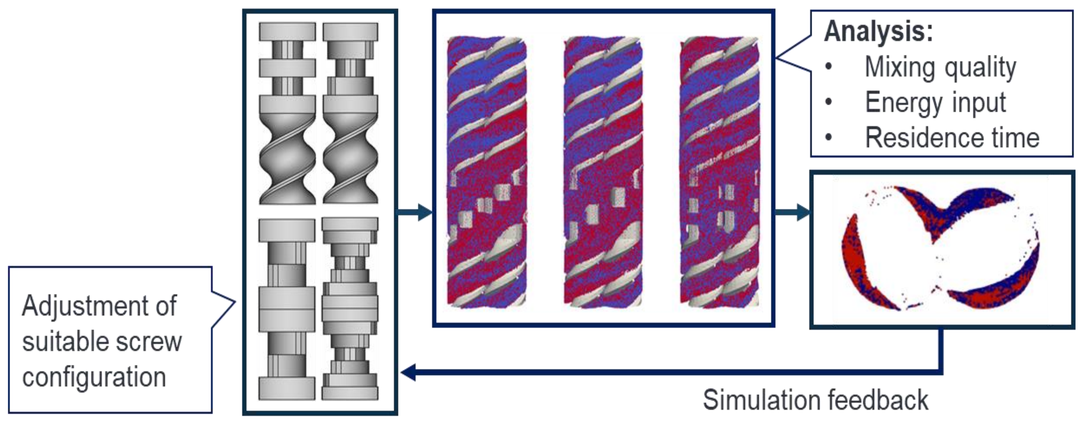


AM: Active material, C: Conductive material, L: Solvent, Bi: Binder, Ad: Additive

Wenzel et al. 2015

Digital Twin Approach

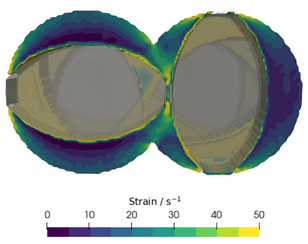
- **Simulation** based **i**nvestigation of material **strain** corresponding to various process parameter variations prior to experiments
- Evaluation of feeding, kneading and conveying **performance** through screw **segmentation**
- **Iterative approach** for adaptation of process parameters and screw design to quality requirements



Results

- **Simulation**
  - Analysis of the material flow behavior under experimental process parameters for efficiency evaluation
  - Smoothed particles hydrodynamics (SPH) provides detailed information of slurry screw interaction
  - 1D Modell enables optimization of screw configuration

Shear rate distribution
Single filled sections

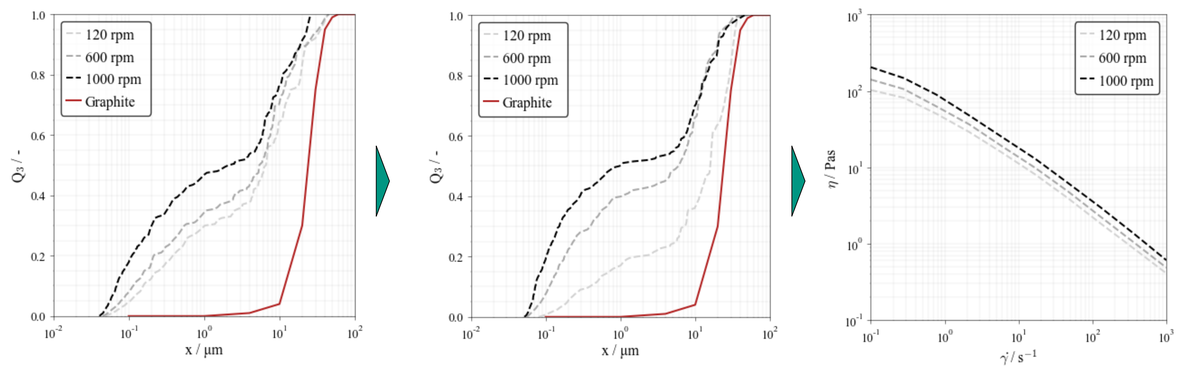


- **Experimental**
  - Analysis of the **effect of screw speed and flowrate** on slurry rheology, particle sizes (PSD) and homogeneity

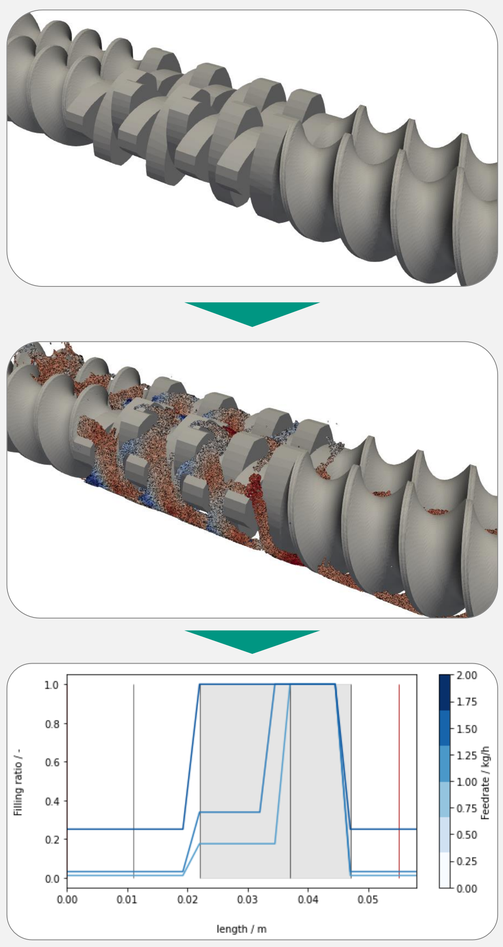
Reference Screw
Control over PSD ↓
Homogeneity ↓

Optimized Screw
Control over PSD ↑
Homogeneity ↑

Rheology
Anode slurry viscosity results



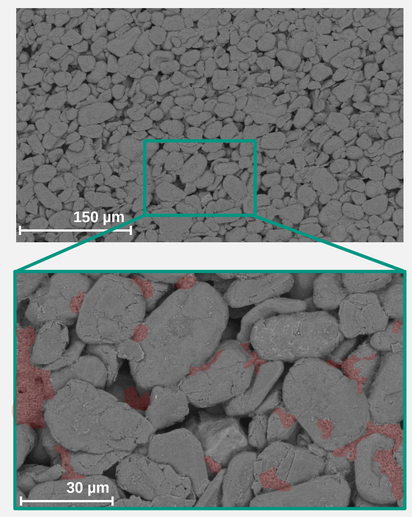
Digital Twin-Screw-Extruder (TSE)



Conclusion

- **Extrusion** process provides **continuous** slurry production
  - **Agile handling** of new recipes, slurry composition and material feasible
  - **Adaptive customization** of particle size distribution, homogeneity and stability due to variable screw design
- **Digital twin** as a key element for the **optimization** of the process
  - **Iterative modeling** supports the investigation of new screw configurations and process parameter → Waste reduction
  - Analysis of residence time, material distribution and strain feasible

Micro structures



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