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Lebensmittelverfahrenstechnik

Spray-Drying of Pastes with ACLR-Nozzle for Process Intensification

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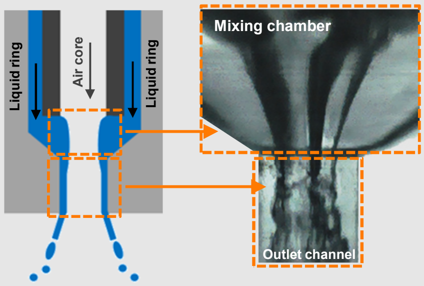
Spray drying

Liquid Feed
- ↑ Solid content
- ↑ Viscosity

Capacity/Efficiency
- ↑ Drying ✓
- ↓ Atomizing ⃠

Air-Core-Liquid-Ring (ACLR) atomizer:
- ✓ can handle highly viscous feeds
- ✓ requires minimum air flow and pressure
- ⃠ can suffer from unstable internal flow conditions



Schematic and photo of the annular flow inside of the ACLR nozzle

Properties of the liquid feed
Operating conditions
Nozzle geometry
Spray performance

Process-function of the ACLR-nozzle = Fluid mechanics

- **Droplet composition** → high impact on drying kinetics and particle morphology, and therefore on final powder properties
- **Single droplet drying setups** can be used to mimic the convective spray-drying process

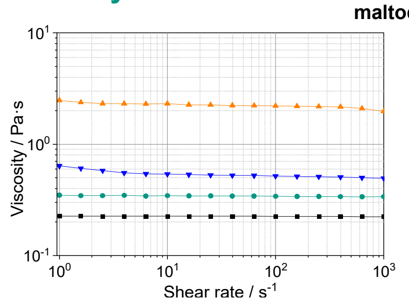
Project schedule

Project year	1				2				3			
Quarter	I	II	III	IV	I	II	III	IV	I	II	III	IV
WP 1: Atomization with the ACLR nozzle (CFD and validation)	X	X	X	X	X	X						
WP 2: Impact of composition and morphology on drying kinetics			X	X	X	X	X	X				
WP 3: Industrial applicability of the ACLR nozzle for spray-drying									X	X	X	X

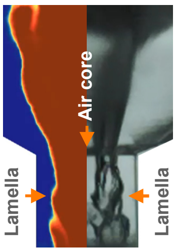
Current stage (between Year 1, Quarter III and IV)

Model system

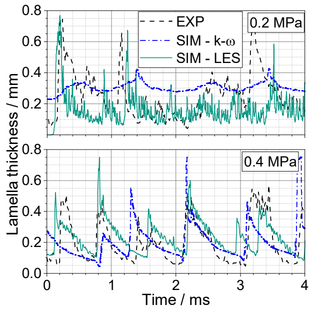
Aqueous solutions of maltodextrin (DE 8.8):

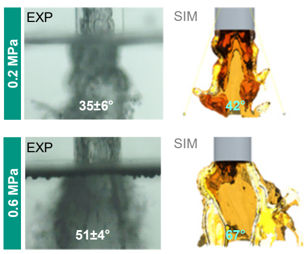


WP 1: Modelling the ACLR atomizer



- The multiphase flow was represented using the Volume-of-Fluid (VOF) method.
- The turbulence was resolved using Large Eddy Simulation (LES): $Re_{Gas} \sim 10^5$; $Re_{Liq} \sim 10^3$.
- The air is modelled as an ideal gas (Ma ~ 0.7), while the liquid is assumed to be Newtonian.
- Model succesfully recreates the unstable internal annular flow.
- So far validated with viscosities up to 140 mPa·s.
- Lamella thickness as main validation parameter → it defines droplet size.





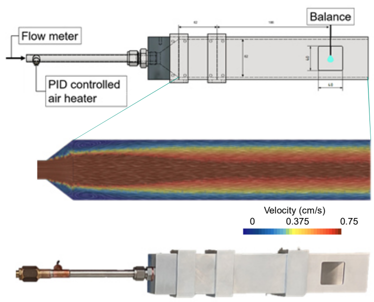
- The model can also recreate the formation of the spray cone
- Spray angle is used to validate the SIM and to monitor spray stability

Outlook

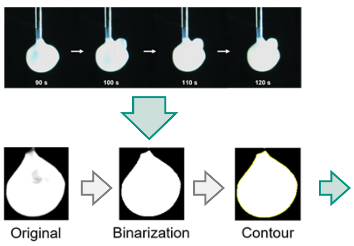
- Introduce non-Newtonian rheological model to evaluate flow stability and operational requirements with higher viscosities
- Experimentally validate the highest viscosity that can be feasibly atomized while maintaining average lamella thickness.

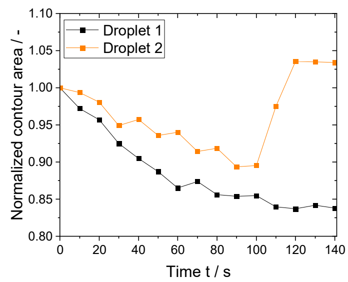
WP 2: Drying kinetics in a single droplet setup

- Conceptualization and design of the drying chamber.
- CFD based optimization of the flow pattern in the drying chamber to ensure an even and reproducible air flow.
- T_{Air} = 20 – 250 °C
- v_{Air} = <0.5 m/s
- Balance deviation = 0.01 mg
- Single droplet drying setup allows for direct observation of the drying kinetics and morphology development during drying.



Contour analysis is used to track droplet size:





Outlook

- Optimize the droplet generation by analyzing the best combination of used filament and droplet generation method
- Improve tracking of the drying kinetics
- Incorporate a sessile droplet setup to effectively use the perks of each respective drying setup