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AMMTO & IEDO JOINT PEER REVIEW

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Filament Extension Atomization for High Solids Loading in Energy Efficient Spray Drying Systems | IEDO

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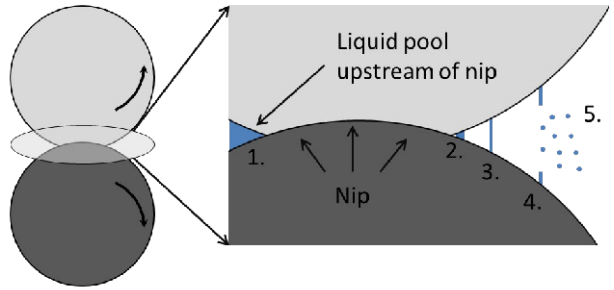
Project Overview

- Filament Extension Atomization (FEA) reduces energy load on industrial spray dryers by reducing amount of water needed to be evaporated
- **IEDO goal addressed: Food and Beverage – "Improve energy efficiency by advancing the electrification of process heating, evaporation, and pasteurization processes"**
- Spray drying is responsible for ~2billion lbs of product / year and the least efficient part of the drying process
- Existing spray technologies only allow lower solids concentrations – driving high energy usage in spray dryers
- FEA opens up process window by enabling spraying of ultra high solids solutions, 40% increase over state of the art – **up to 80% solids by mass**
- **FEA** enables:
  - **40% reduction in energy per kg of product**
  - 3.5X increase in output
  - Up to **50% reduction in CO_2 emissions**
  - 1.5M tons of CO_2 savings / year if widely adopted
- Significant impact to food & beverage, with potential for impacts across chemical, pharmaceutical and other powder production processes
  - **Reduces costs by 40-70%** through reduced energy & better capital utilization
  - Reduces carbon intensity
  - Enables smaller spray dryers

ADVANTAGES OF FILAMENT EXTENSION ATOMIZATION (FEA)

Solids Loading	▲ up to 80%
Powder Production Rate	▲ up to 3.5X
Cost Reduction	▼ 40-70%
Energy Savings	▼ 40%+
Carbon Intensity	▼ 50%+
Total Carbon Reduction	▼ 1.5M tons/year
NO_x Reductions	▼ 40%



Project Outline

Innovation: Filament Extension Atomization for High Solids Loading in Energy Efficient Spray Drying Systems

Project Lead: Palo Alto Research Center (PARC)

Project Partners: Utah State University, Darigold, Leprino, Tetrapak

Timeline: September 2020 - March 2024; ~66% complete

Budget: $3,749,817 Total - $750,000 Cost Share (just finished budget period 2)

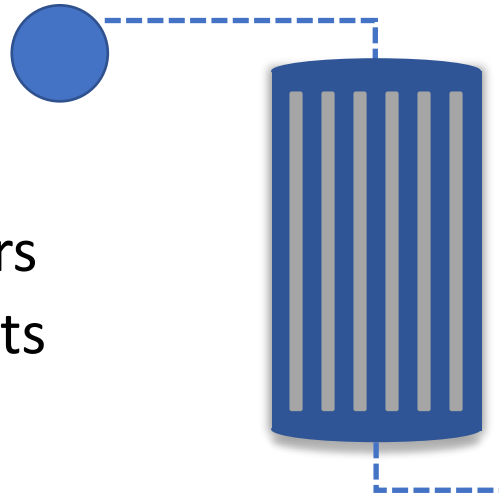
	FY20 Costs	FY21 Costs	FY22 Costs	FY23 Costs (Q1)	Total Planned Funding
DOE Funded	$177,580	$604,613	$899,749	$229,472	$2,999,817
Project Cost Share	$34,202	$161,346	$224,938	$57,368	$750,000

End Project Goal: Demonstrate FEA can be scaled to meet industrial needs by showing FEA total output of 7.5 L/min in 3 unit array, dried powder from 70% solids whey protein products with powder quality equal to powder from industry standard solids loading.

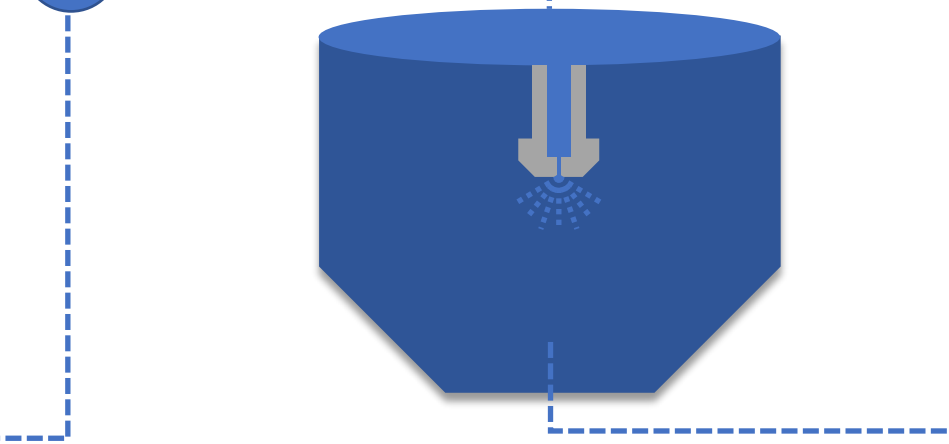
Background & Strategic Approach

- In the food production industry
  - Milk powders
  - Protein powders
  - Colors
  - Fruit and vegetable powders
  - Synthetic / alternative meats
- Spray drying consumes an estimated 20% of all industrial energy
- ~2 billion pounds of whey products annually

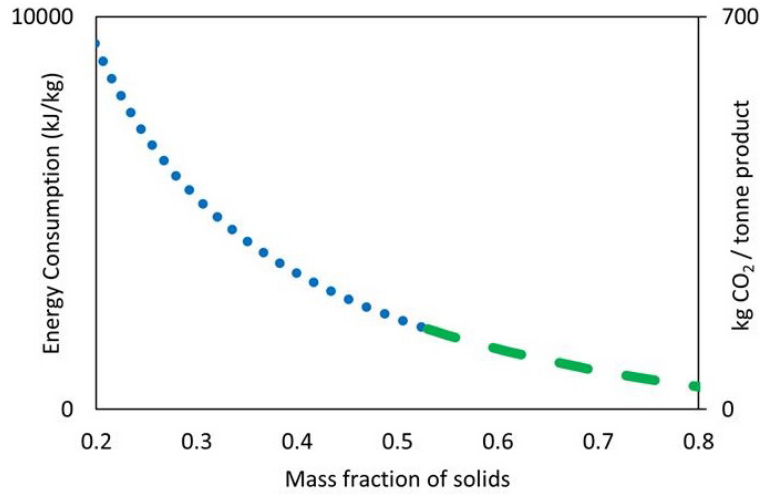
Falling film evaporator or membrane separation concentrates slurries to 20-50% wt.



Slurry is atomized and subjected to hot dry air to form powders of 50-200µm



Energy consumption driven by mass fraction of solids



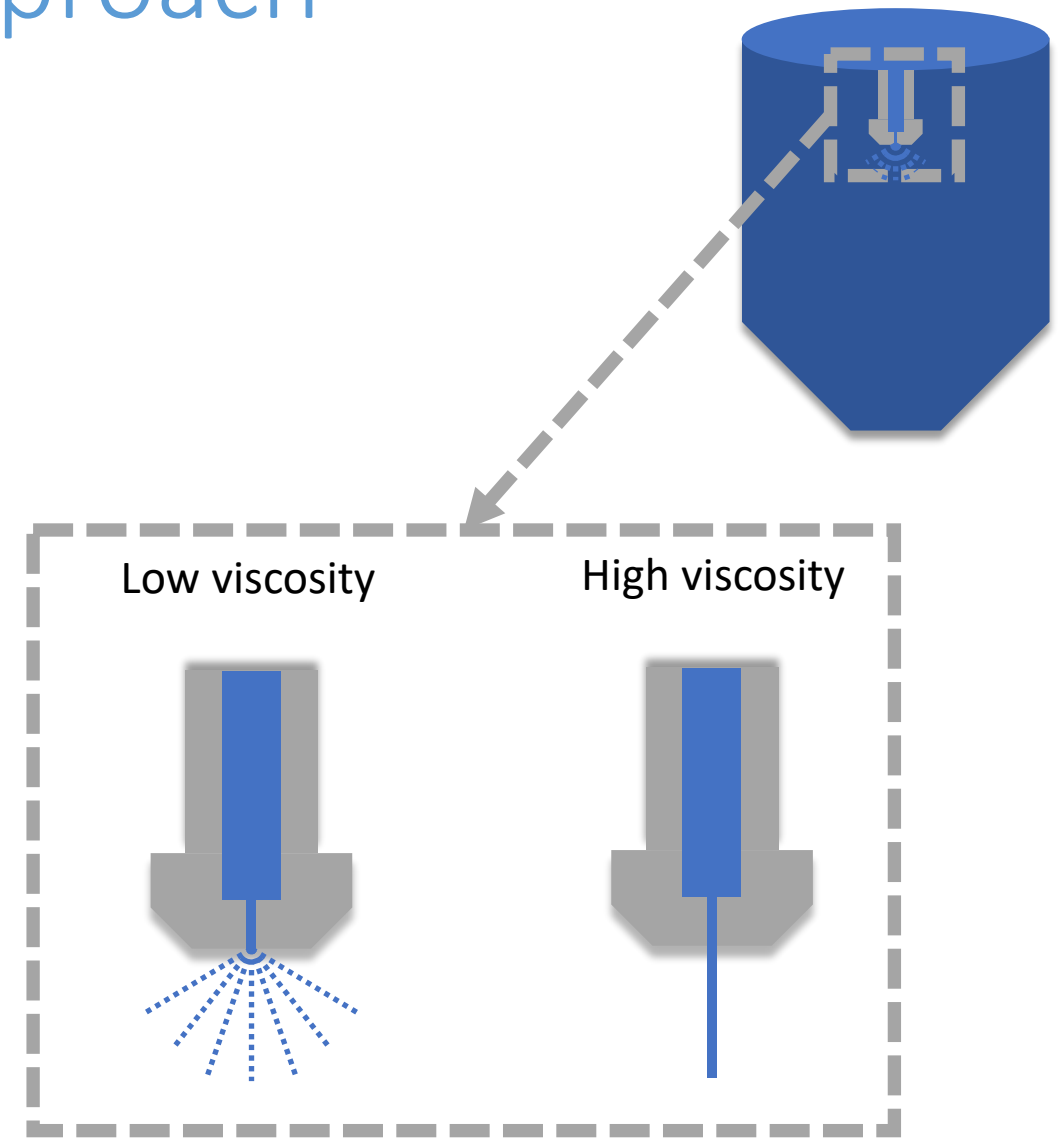
Mujumdar, A. S., 2014, Handbook of Industrial Drying, CRC Press.
Cheng et al. E3S Web of Conferences 53, 01031 (2018)

Background & Strategic Approach

- High cost driven by the latent heat of water
- Unable to increase solids content in feed slurry
- Slurry concentration dictated by **viscosity limitations of spray nozzles**
  - Sweet Dry whey ~50% wt.
  - Whey protein concentrate ~30% wt.
  - Micellar casein concentrate ~20% wt.

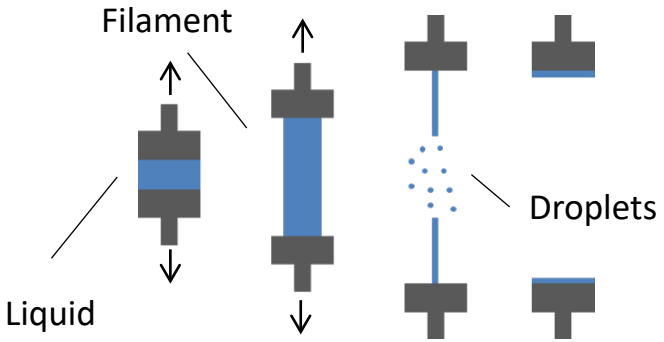
Lactose-driven viscosity

Protein-driven viscosity

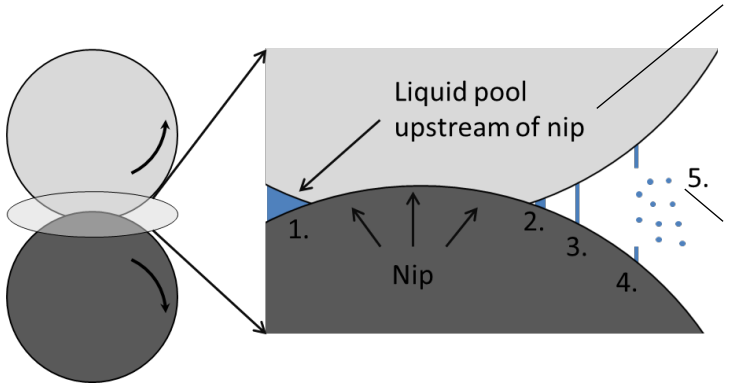


Background & Strategic Approach - FEA

Single filament break-up

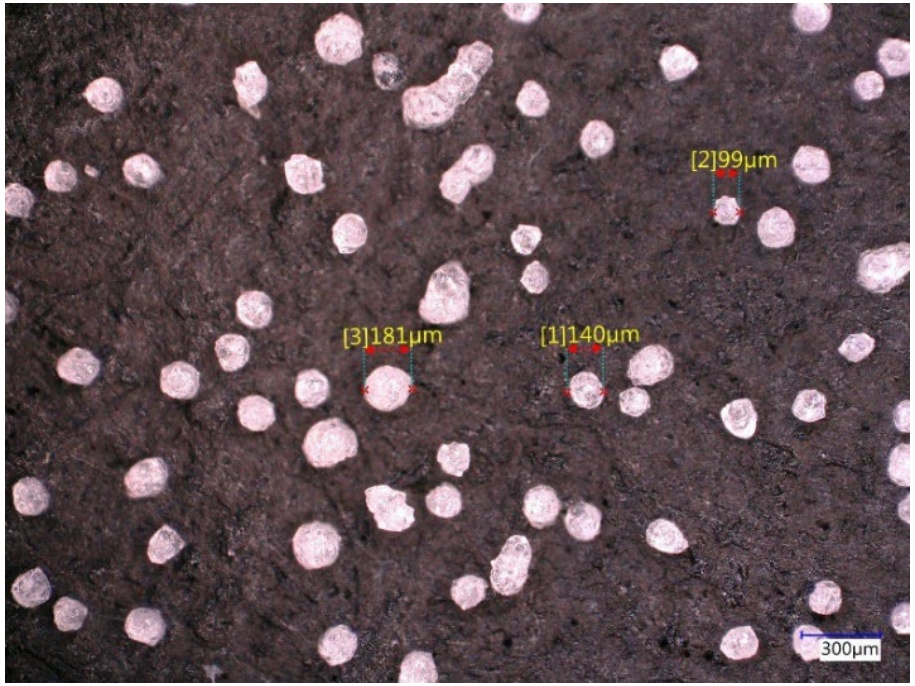


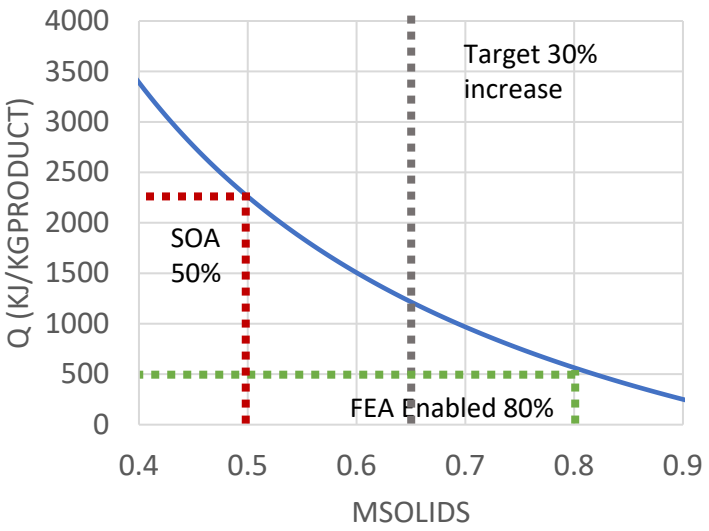
Multiple filament break-up

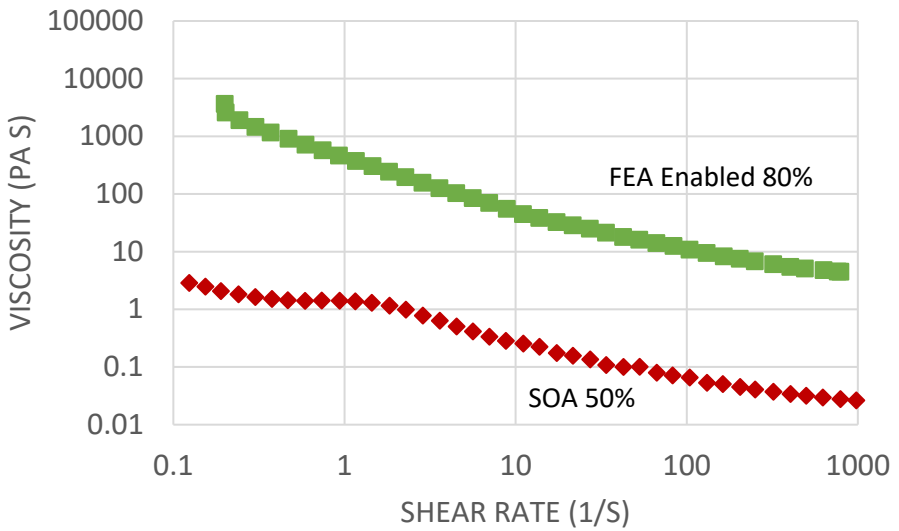


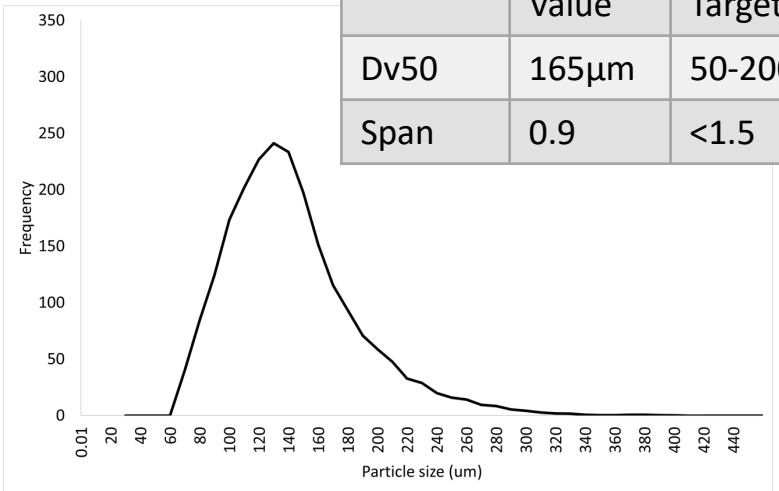
1 wt% PEO in Water-Glycerol

Results and Achievements – Spraying Dry Whey



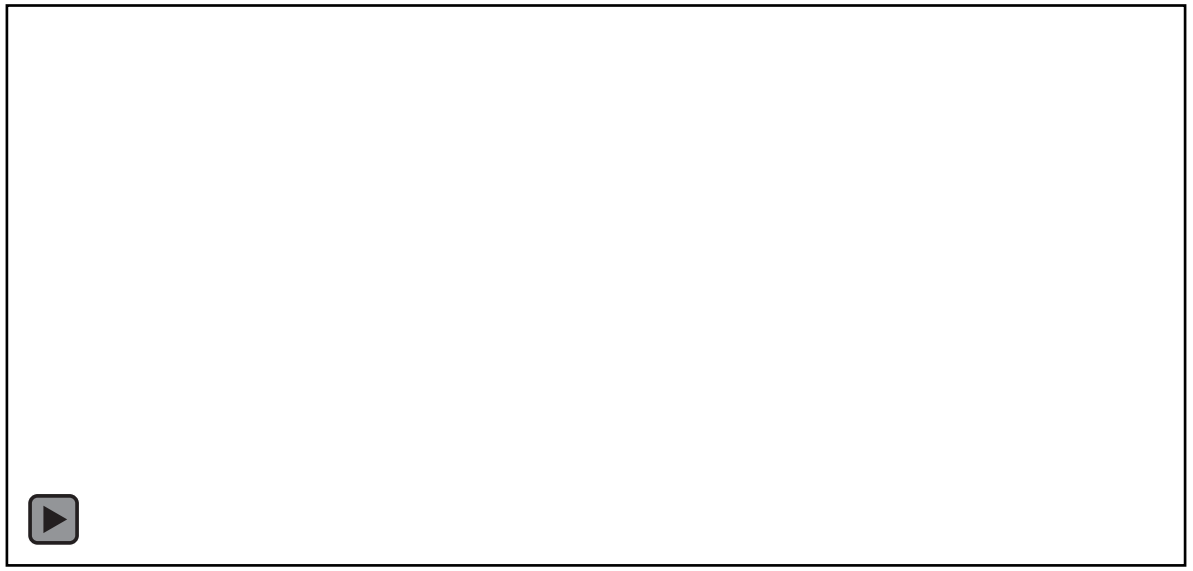


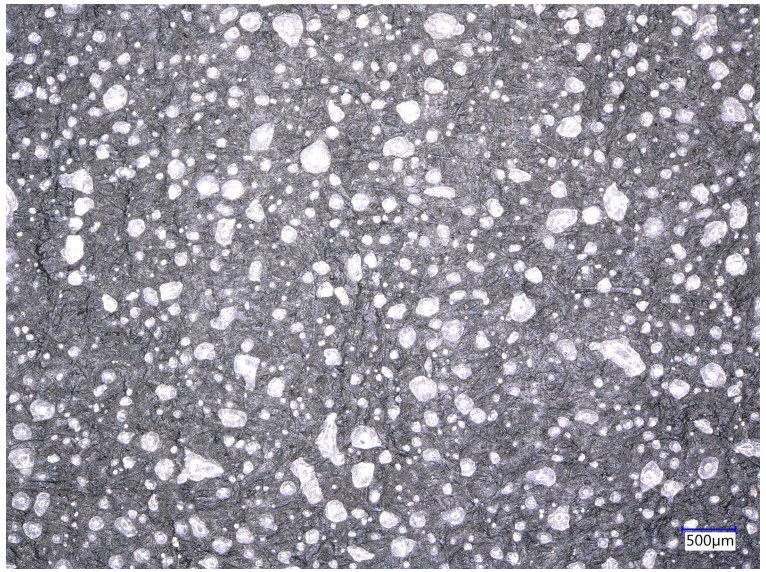


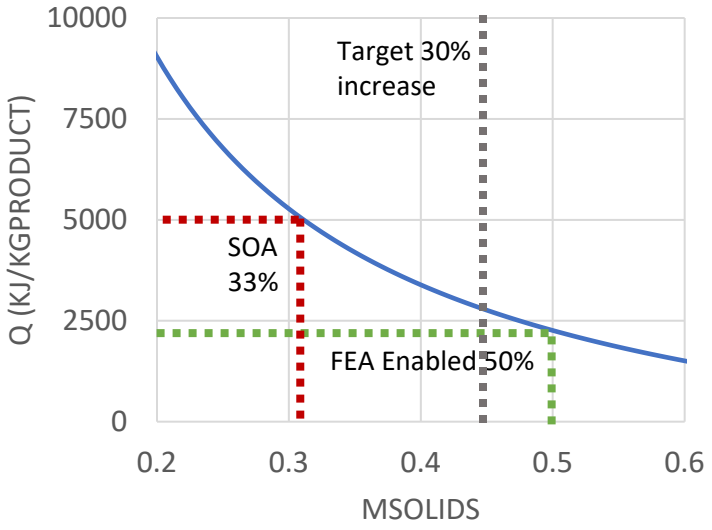


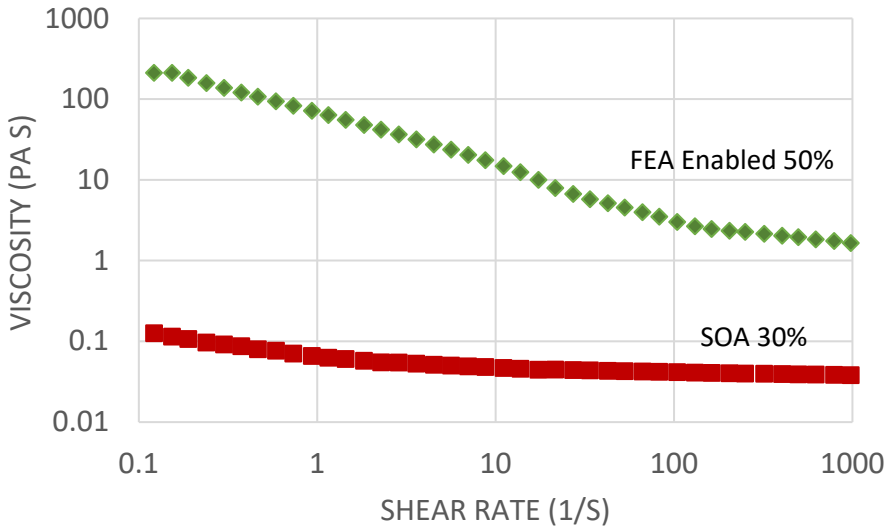
	Value	Target
Dv50	165µm	50-200
Span	0.9	<1.5

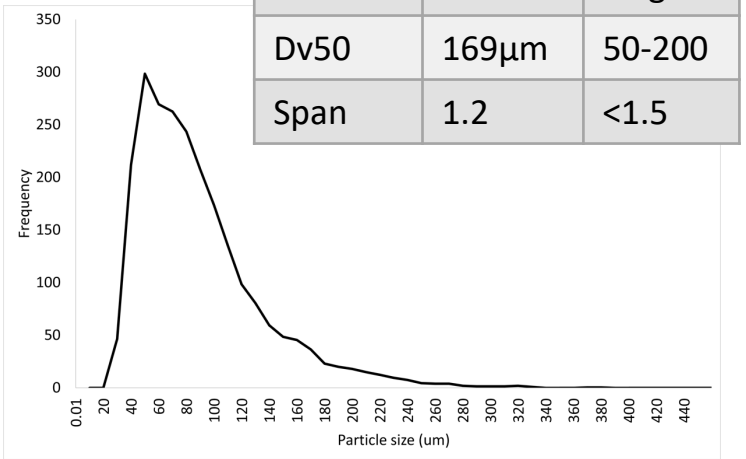
Results and Achievements – Spraying WPC-80







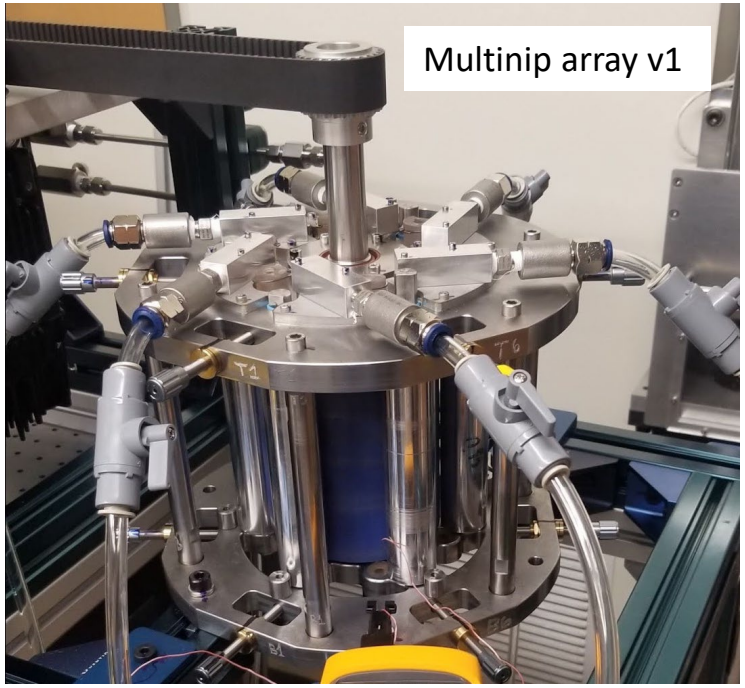


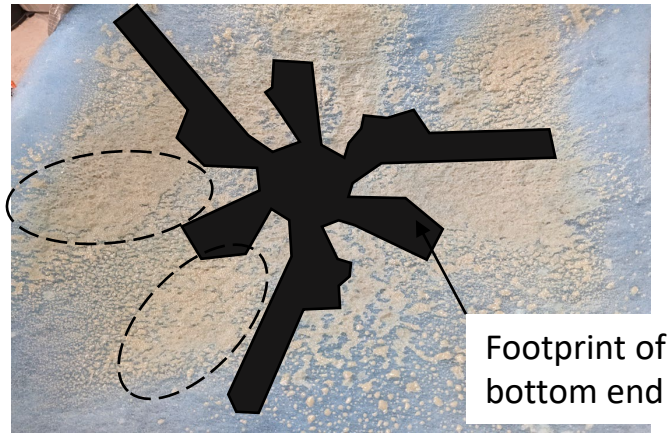


	Value	Target
Dv50	169µm	50-200
Span	1.2	<1.5

Results and Achievements

- Multinip array commissioned in 2022
- System has 6 total nips, controlled by a single motor
- Spray is harvested downward or outward into spray dryer
- Achievements
  - 72 hours of runtime (target 72)
  - Sprayed 4.7 L/min of whey product (target 2.5)
  - Harvested at 2.5 L/min of whey product (target 2.5)





Future Work, Technology Transfer, & Impact

Future Work:

- Next budget period is focused on further scaling spray system and integration with dryer
- Spray system: Further scale to 7.5 L/min of spray output
- Drying: Integrate FEA system with 10L/hour water removal spray dryer from Tetrapak
- Evaluate powder properties, assess cleanability of system, finalize technoeconomic analysis

Technology Transfer:

- Next steps would be to create larger scale demonstrations with FEA
- Needs to be integrated with upstream water removal
- Commercialization would be either through licensing, joint venture, or PARC spinout. Options currently being evaluated.

Impact:

- FEA will improve spray drying energy intensity by 40%, cut carbon emissions by 50% and increase output by 3.5X for production of whey products in the food and beverage sector

Questions?

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