Reducing energy consumption in spray drying by monodisperse droplet generation

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What is Drying?

- 2.5 MJ for each kg of evaporated water
- Assuming 100% efficiency & no falling-rates
- Conventional dryers efficiency 20-50%
- 10-25% of industrial energy consumption
- Usually final step – product quality issues
What is spray drying?

- Liquid feed atomized
- Mixes with hot air
- Evaporation Occurs
- Constant-rate, falling-rate
- Dry powder collected
- Fines recycled
- Spent air disposed or
- Recycled/Heat-exchanged
Spray drying applications
Reducing energy consumption

- Better atomization
- Match heat & load needs
- Better insulation
- Heat recovery
  - Mass exchange
  - Heat exchange
Challenges of Current Atomizers

Wide droplet size distributions
Largest drops dictate drying conditions
Non-uniform product treatment
Increased thermal degradation
Loss of valuable water
Production of fines
Fire & explosion risks

Mass of water evaporated

Density function

Conventional
Piezo
Over-dried
Monodisperse droplet generation

AC + DC Pressure

Time
Modelling equations

- Heat balances
- Mass balances
- Drying kinetics
- Travel dynamics

• Heat out = Heat in – drop heating – latent heat gain – dryer body heat loss

• Water loss (Droplets) = Water gain (Gas)

• CDC, Skimmed milk

• Force balance
### State variables & methodology

- **State variables**
  - Gas temperature
  - Droplet temperature
  - Droplet diameter
  - Droplet velocity
  - Droplet density
  - Droplet moisture
  - Gas humidity

- **Simulate mono- & “best” polydisperse system**
  - By changing drop freq.
  - at same mass flowrate
  - Calculate $T_{\text{Gin}}$ that satisfies $X_p=5\%$

- **For different critical X**
Results & Discussion
Conclusions & further work

(a) Inlet air temperature (°C)

% Energy savings

(b) % Energy savings vs. Droplet diameter ratio

Droplet diameter (μm)

y=0cm

y=40cm

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