Reducing Undesirable Powder Deposition

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Commonly affected processes and industries

- Atomisation / spray drying
  - Food / metal / ceramics / pharmaceutical powder industries

- Boilers & furnaces
  - Many industries

- Etc.
Negative impacts

- Product yield / capacity
- Browning & oxidation / powder combustion
- Energy ↔ $$$
- Plant shut-down & cleaning
- Heat recovery opportunities
Traditional methodology

Identify problems

Lab testing
  • Temperature & relative humidity (RH)

Sticky curve models

Dryer settings control

Process Improvement:
  • Cyclones
  • Fluidised beds
  • Insulation
  • Hammers
Optimal process control

Smart processing equipment design

Lab tests and model verification

Fundamental understanding mechanisms

In-plant observations

Experimental & theoretical equations

Computer Models

Research methodology

Optimal process control
In-plant observations

- Hatches located in same position, but on different cyclones
Lab tests – Impingement jet

- Air relative humidity (≈ Water activity)
- Air temperature (°C)
- Critical sticky region
- Non-critical sticky region
Impingement jet deposition morphologies

Increasing particle stickiness
Underlying mechanisms

Stickiness - adhesion
- Viscosity (T & RH)
- Glass transition temp.
- Surface tension
- Surface energy & wetting angles *(wall properties)*

Kinetics
- Mass *(size & shape)*
- Impact velocity
- Impact angle
- Air flow patterns
Experimental & theoretical equations

Deposition criteria:

\[ U_{ad} \geq \frac{\rho}{3k^2} d_p V_{n,i}^2 \]

Rebound calculation:

\[ V_{n,r} = \sqrt{R^2 V_{n,i}^2 - \frac{2U_{ad} A_c}{m}} \quad \text{and} \quad V_{\tan,r} = R V_{\tan,i} \]
Computational Fluid Dynamics (CFD) Computer models
Verification of airflow models

- Particle Image Velocimetry (PIV)

![Graph showing airflow visualization with CFD and PIV data. Legend indicates different velocity ranges with color coding.]

- Normalised Velocity ($V/V_{max}$):
  - $> 0.9$
  - $< 0.9$
  - $< 0.7$
  - $< 0.5$
  - $< 0.3$
  - $< 0.1$

Distance from jet centre (mm)

Distance from wall (mm)
Verification of models

- Experimental morphologies
Verification of models

- Experimental morphologies
Verification of models

- Experimental morphologies
Bend geometry
The next steps...

- Continue in-plant work & lab tests
- Improve computer model accuracy
- Verify results for complex geometry
- Apply models to industry
Summary

- Powder deposition is costly to industry
- Traditional control is simple, but not optimal
- Verified computer models can help minimise deposition problems
Normalised velocity magnitude (ms$^{-1}$)

- $> 0.9$
- $< 0.9$
- $< 0.7$
- $< 0.5$
- $< 0.3$
- $< 0.1$