Modeling Fluidized Beds and Pneumatic Conveying of Solids with Aspen Plus V8

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Product Management, AspenTech

Solids Process Modeling Webinar
September 24, 2013

Hosted by:
Jennifer Dyment and Ron Beck,
Product Marketing, AspenTech
Ongoing Series of Technical Webinars
Engineering webinars for education and best practices

RECENT WEBINARS:

- Modeling Solids Dryers and Granulators with Aspen Plus V8 (Technical) – April 2013

UPCOMING WEBINARS OF INTEREST:

- Model Plate Fin Exchangers in Aspen HYSYS Simulators featuring Petrofac – October 8th 2013
aspenONE Engineering
Best-in-class engineering solutions in an integrated workflow
Agenda

- Introduction
- Fluidized Bed
  - Circulating Fluidized Bed Demo
- Pneumatic Conveying
  - Dilute Phase Conveying Demo
  - Dense Phase Conveying Demo
- Questions & Discussion
Why is Modeling Solids Important?

Specialty & Agricultural Chemical Process
Fertilizers, ChlorAlkali, pTA, Silicones

- Fluid Raw Material
- Reactions (liquid/gas)
- Separation (liquid/gas)
- Crystallization (liquid/solid)
- Drying (solids/gas)
- Solid Product

Extractive Industry Process
Coal, Oil Sands, Cement, Phosphates, Alumina

- Mineral Raw Material
- Grinding (solids)
- Classifying (fluid/solid)
- Reactions (fluid/solid)
- Separation (solids/liquid/gas)
- Fluid Products
Modeling Processes with Solids
Traditional Approach

- Two Models
- Manual Data Transfer
- Inconsistent Properties
- Local Optimization

Aspen Plus Urea Synthesis Model

SolidSim Urea Granulation Model
AspenTech and SolidSim
Bringing Our Strengths Together

- Physical Properties
- Reactions & Electrolytes
- Fluid Unit Operations
- Integrated Workflows
- Worldwide Support
- University Program
- Solids Process Modeling
- Solids Characterization
- Solids Unit Operations
- Deep Expertise
- Relationship with universities researching solids technology

SolidSim functionality is completely integrated in Aspen Plus V8.2
May 2013 release
Aspen Plus V8 - Optimizing Processes with Solids and Fluids Made Easy

- Sample Templates
- Online Training
- Economics for Solids
- Visualize PSD
- Visualize Separation Curves
- Optimize Entire Process
- Comprehensive Solids Model Library
Aspen Plus provides a comprehensive model library for the unit operations of particle technology.

<table>
<thead>
<tr>
<th></th>
<th>Crystallizer</th>
<th>Crusher</th>
<th>Screen</th>
<th>Dryer</th>
<th>Granulator</th>
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<td><strong>SolidSim</strong></td>
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**Design Philosophy:**
One unit operation model can represent many different types of equipment at various levels of fidelity from conceptual→detailed.
Aspen Plus Solids Modeling - Solids Handling Operations

<table>
<thead>
<tr>
<th></th>
<th>Gas Cyclone</th>
<th>Scrubber</th>
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The updated models use *state-of-the-art* correlations and methods to ensure accurate sizing and design.
Aspen Plus Solids Modeling - Solids Handling Operations

Total of 38 models from SolidSim have been integrated into Aspen Plus
Aspen Plus Solids Modeling - Description of Disperse Solids

- Aspen Plus allows for detailed description of disperse solids
  - Different particle types (sub streams)
  - Each particle type is described by
    - Distributed Properties
      - Composition
      - Particle size
    - Scalar values per particle type (sub stream)
      - Moisture content(s)

Moisture content as impact on heat capacity, density and settling velocity of the particles
Self Guided Examples

- Get up to speed easily by using 12 New Self Guided Examples
  - Consist of example files and detailed step-by-step slides
  - Included in the Support Center (http://support.aspentech.com) and accessible via aspenONE Exchange

Search “Solids”, “Granulation”, “Dryers” etc.

Filter By:
- Process
- Model Features
- Components
- Component Form...
- Reaction Type
- Run Class
- Unit Operation Type
- Physical Properties
- Column Reboiler T...

Sort by date

Examples:
- How do I estimate model parameters in Aspen Plus...
- How do I model the pneumatic conveying...
- How do I model a circulating fluidized bed...
- How do I model a fluidized bed agglomerator in...
- How do I model a batch dryer in Aspen Plus?
- How do I model a multichamber fluidized bed...
- How do I model and optimize a belt dryer...
- How do I set up multiple particle types...
- How do I set up a Particle Size Distribution (PSD)...
- How do I model crushing/milling and classification...
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Why Model a Fluidized Bed?

- **Problem:** Loss of fines, unknown particle size distributions or flow rates, high operating costs

- **Benefits:**
  - Gain a better understanding of particle size distributions and flow rates throughout process
  - Minimize loss of fines due to optimal designed gas-solid separation sections
  - Reduce operating costs due to optimal gas and solids flow rates
Fluidized Bed Model in Aspen Plus V8.2

- Aspen Plus Fluidized Bed Model
  - describes bubbling or circulating fluidized bed
    - fluid mechanics (one-dimensional)
    - entrainment of particles
    - solids and vapor in thermodynamic equilibrium
  - considers
    - particle size and density / terminal velocity
    - geometry of the vessel
    - additional gas supply
    - impact of heat exchangers on bed temperature and fluid mechanics
  - provides different options/correlations to determine
    - minimum fluidization velocity
    - transport disengagement height
    - entrainment of solids from the bed
    - distributor pressure drop (porous plate / bubble caps)
Fluidization in Aspen Plus - Model Short Description

- Model of the fluidized bed considers
  - Bottom zone (dense bed)
    - High solids concentration
    - Fluid mechanics according to Werther and Wein
      - Considers growth and splitting of bubbles
  - Freeboard
    - Comparable low solids concentration
    - Fluid mechanics according to Kunii and Levenspiel

- User defines bed inventory by specifying the pressure drop or the solids hold-up
  - Height of the bottom zone and the freeboard can be determined
  - Bubble related profiles (e.g. bubble diameter, bubble rise velocity etc.) as well as interstitial gas velocity, pressure, and solids volume concentration profiles can be calculated
  - By using selected entrainment correlation, the solids mass flow and PSD at the outlets can be calculated
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Circulating Fluidized Bed Example

- The following example will demonstrate how a fluidized bed process can be simulated and optimized with Aspen Plus
  - Simulation of a fluidized bed with external gas-solid separation and recycle of entrained material
  - Optimization study to decrease energy demand
Circulating Fluidized Bed Example – Review Results

- With the optimized flow rate it is possible to decrease
  - the pressure drop by ~12%
  - the volume flow by ~9%

→ Decrease in energy for the primary blower by ~20%
Fluidized Bed - Summary

- Aspen Plus can be used to model bubbling or circulating fluidized beds with subsequent gas/solid separation.

- Modeling fluidized beds helps to:
  - Gain a better understanding of particle size distributions and flow rates throughout process.
  - Minimize loss of fines due to optimal designed gas-solid separation sections.
  - Reduce operating costs due to optimal gas and solids flow rates.

20% decrease in energy for the primary blower in the example case.
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Why Model Pneumatic Conveying?

- **Problem:** Plugging of the conveying line, attrition or breakage of conveyed material, high operating costs

- **Benefits:**
  - Reduce risk of plugging due to optimized design
  - Minimize attrition and breakage due to minimized gas and solids velocities
  - Reduce operating costs due to minimized pressure drop
Depending on the solids loading there are two major solids conveying types that have to be distinguished:

- **Dilute phase conveying**
  - Solids loading up to 30 kg solid per kg gas
  - Lower pressure drop compared to all other conveying types
  - Highest material velocity and therefore the highest tendency to abrasion
  - Material conveyed in the gas stream

- **Dense phase conveying**
  - Solids loading up to 150 kg solid per kg gas
  - Medium pressure drop
  - Low material velocities
  - Material is conveyed in dunes/slugs
Solids Conveying - Dilute Phase Conveying Model

- Model predicts the pressure drop of a lean phase conveying system
  - Pressure drop of the solids according to Muschelknautz or Siegel
  - Horizontal, vertical and inclining pipelines can be considered
  - Pressure drop due to initial acceleration of solids can be considered
  - Pressure drop due to elbows can be considered (pipe)
  - Plugging limit is calculated
Solids Conveying - Dense Phase Conveying Model

- Model predicts the pressure drop of a low-velocity slug flow conveying system
  - Model is based on the method proposed by Wypych and Yi to predict the pressure drop in horizontal pipelines
  - In vertical sections, a pressure drop to lift the solid mass has to be added
  - Pressure drop due to elbows can be considered (pipe) by use of an equivalent length
  - Slug velocity and total length of slugs is calculated
Modeling Solids Conveying with Aspen Plus V8.2

- Conveying lines can be operated in pressure or vacuum/suction mode:

  **Pressure mode**

  ![Pressure Mode Diagram]

  **Vacuum/suction mode**

  ![Vacuum/suction Mode Diagram]

- The Aspen Plus Pipe & Pipeline model allows you to simulate:
  - Dilute phase and dense phase conveying
  - Pressure and vacuum conveying
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Dilute Phase Conveying - Pipe Example / Pressure Conveying

- Modeling and optimization of a dilute phase conveying line
  - Base case:
    - Total pressure drop of the conveying line is ~ 25 mbar
  - Task:
    - Decrease the pressure drop of the conveying line
  - Constraints
    - Ensure that no plugging of the conveying line will occur (approach to saltation velocity > 5 m/s)

live demo
Process Optimization – Review Results

- With the optimized flow rate it is possible to decrease
  - the pressure drop by ~23%
  - the volume flow by ~14%
  \[ \text{Decrease in energy for the blower by over } \sim 34\% \]

### Base Case

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The following example will demonstrate how a vacuum operated dense phase conveying line can be simulated by using the pipeline model

- Use of characteristic curve of blower to determine gas volume flow
Pneumatic Conveying - Summary

- Aspen Plus can be used to model dense and dilute phase conveying in pressure and vacuum mode.
- Modeling pneumatic conveying helps to:
  - Reduce risk of plugging due to optimized design.
  - Minimize attrition and breakage due to minimized gas and solids velocities.
  - Reduce operating costs due to minimized pressure drop.

34% decrease in energy for the primary blower in the example case.
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What Next?

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    - ASIA/PACIFIC and INDIA: +65-6395-3900
  - Or email us at [esales@aspentech.com](mailto:esales@aspentech.com)

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  - Jen Dyment [jennifer.dyment@aspentech.com](mailto:jennifer.dyment@aspentech.com)
Get Started with Solids Modeling in Aspen Plus

Learning Resources are Available

- Computer Based Training: Getting Started with Solid Modeling in Aspen Plus V8
- Videos also available at: [www.youtube.com/user/aspentechnologyinc](http://www.youtube.com/user/aspentechnologyinc)
- Demos available in aspenONE Exchange and the Support Center (support.aspentech.com)
Want More Help?

Consider a training class from AspenTech

http://training.aspentech.com
Aspen Plus: Solids Modeling Training

Solids Modeling Using Aspen Plus (EAP2911)

September 27, 2013 – Virtual-Americas
October 15, 2013 – Frankfurt, Germany
October 25, 2013 – Houston, TX
October 30, 2013, 2013 – Reading, UK

http://support.aspentech.com/supportpublictrain/CourseInfo.asp?course=EAP2911

• Become proficient in modeling processes containing solids handling equipment
• Determine optimal process conditions for new or existing solids processes
• Support troubleshooting and de-bottlenecking of solids processes
• Gain the practical skills and knowledge to begin modeling new and existing solids processes
Questions