Pulse Combustion Systems
Introduction

November, 2015
Topics

• Company Overview
• Technology Overview
  • Pulse Drying Basics
  • Comparison to Conventional Spray Dry
  • Advantages of Gas Dynamic Atomization and Rapid Drying
  • Patents
• Recent Successes
• Tech Time – Control System
Pulse Holdings LLC
dba Pulse Combustion Systems

- In Business Over 10 Years; Arizona LLC
- Over 200,000 hours of Pulse Dryer Ops
- Fifteen Units Sold; > 100 Truckloads Tolled
- 20,000 SF facility in Payson, AZ (Plant Tour)
  - Pilot Dryer for Product Development
  - P-1 Dryer for Scale-up Demo & Tolling
- Successful Demo’s on >200 products
- Superior Results all Product Categories
<table>
<thead>
<tr>
<th>Dryer Model</th>
<th>P-0.1</th>
<th>P-0.5</th>
<th>P-1</th>
<th>P-2</th>
<th>P-3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat Release BTU/hr</td>
<td>100,000</td>
<td>500,000</td>
<td>1MM</td>
<td>2MM</td>
<td>3MM</td>
</tr>
<tr>
<td>Evaporative Capacity, lb/hr</td>
<td>50</td>
<td>250</td>
<td>500</td>
<td>1000</td>
<td>1500</td>
</tr>
</tbody>
</table>
Technology Overview

• Pulse Combustor Basics
• Video – PCS Dryer in Action
• Atomizer Distinctives
• Implications & Advantages
• Patents
• Technical Info
Pulse Combustor Basics

1. Air is pumped into the combustor’s outer shell at low pressure.
2. The air flows through the patented unidirectional air diode, and
3. Enters a tuned combustion chamber.
4. Fuel is added to the combustion chamber and mixes with the air.
5. The fuel-air mixture is ignited by a pilot and explodes, creating hot air about 3 psi above combustion fan pressure.
6. The hot gases rush down the spray dryer's tailpipe toward the atomizer (#7). The air diode blocks upward flow from the combustion chamber. As the combustion chamber empties, the next charge of fuel and air enter. When they mix, the hot walls of the chamber cause ignition. The system runs at about 100 Hz.
8. Atmospheric Quench Air is blended in to achieve desired product contact temperature.

9. The atomizer releases the liquid into the gas stream, and dynamically controls atomization, drying and particle trajectory.

10. The atomized liquid enters a conventional tall-form drying chamber. The powder is retrieved using standard collection equipment, such as cyclones and baghouses.
PCS Pilot **Dryer** in Operation
## Major Distinction From Conventional Spray Drying Is Atomization Process

<table>
<thead>
<tr>
<th></th>
<th>Conventional Spray Dryer</th>
<th>PCS Pulse Dryer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feed Pressure</td>
<td>High</td>
<td>Very Low</td>
</tr>
<tr>
<td>Feed Viscosity</td>
<td>Low</td>
<td>Low to Very High</td>
</tr>
<tr>
<td>Type of Atomization</td>
<td>Mechanical Shear</td>
<td>Gas Dynamic</td>
</tr>
<tr>
<td>Delta T (Typical)</td>
<td>200F – 400F (?)</td>
<td>400F – 700F</td>
</tr>
<tr>
<td>Drying Time</td>
<td>30 sec</td>
<td>0.5 sec</td>
</tr>
<tr>
<td>Drying Source &amp; Atomization Source</td>
<td>Separate</td>
<td>Co-located</td>
</tr>
</tbody>
</table>
Shear-Free Spray Drying Makes a High Quality Powder

Gas Dynamic Atomization:

A Slow, Low-Pressure Feed Introduced into a Pulsating Hot Gas Stream Prevents Delicate Bonds from Bursting.

No Mechanical Shear.

1200°F

Feed Pipe / Atomizer
Higher Heat Transfer = Less Degradation

Direct Dryer Solids Exposure Comparison

- **Pulse**: Avg = .5 sec
- **Flash**: Avg = 3 sec
- **Conventional Spray**: Avg = 20 sec

Residence Time (seconds): 0, 1, 5, 30, 60
Spray Chamber Temperature Zones

Spray

Pulse
Competitive Advantages of Pulse Combustion Dryers

• **Powder Quality/Characteristics**
  - Very Short Residence Time = Less Degradation
  - No Mechanical Shear
  - Excellent Surface Characteristics
  - Freeze Dry Quality

• **Operating and Maintenance Costs**
  - High $\Delta T = $ Lower Utility Costs
  - Ability to Handle Higher Solids in Feed = Even Lower Utility Costs
  - Low Pressure System Reduces Maintenance Costs by up to 90%
  - Advanced Control System is less labor intensive

• **Initial Dryer Acquisition Costs**
  - Competitive Pricing
  - Modular Construction Reduces Installation Time and Cost
Patent Overview

• Utility
  • Inlet Air Diode
  • Particle Size Control

• Process – Pulse Drying of:
  • Condensed Distiller’s Solubles
  • Beneficial Live Viruses

• Filed; In Process:
  • Pulse Drying of Egg Whites
Recent Demonstration/Operation Successes

• Algal Slurries (3 projects)
• Egg Whites, Yellows, Whole – Proteins & Lipids
• Microencapsulations (Tolling for 3 Companies)
• Plant Proteins
• Crystallized Acid Whey
• Dairy, Non-Dairy Creamers
• Minerals, Metals (Incl. Lithium Battery Powders)
• Polymers, Chemicals
• Nutriceuticals (Humic, Extracts)
Postscript - Tech Time: Control System

• PCS Dryer is PC Controlled; Runs Self; Collects Data
• DaqFactory Software, Off the Shelf Components
• Honeywell Flame Safety
• User may customize

• Slides Following:
  • System Overview Screenshot
  • HMI Data
Thank you

Contact us via
www.pulsedry.com