DFGD
Process Equipment

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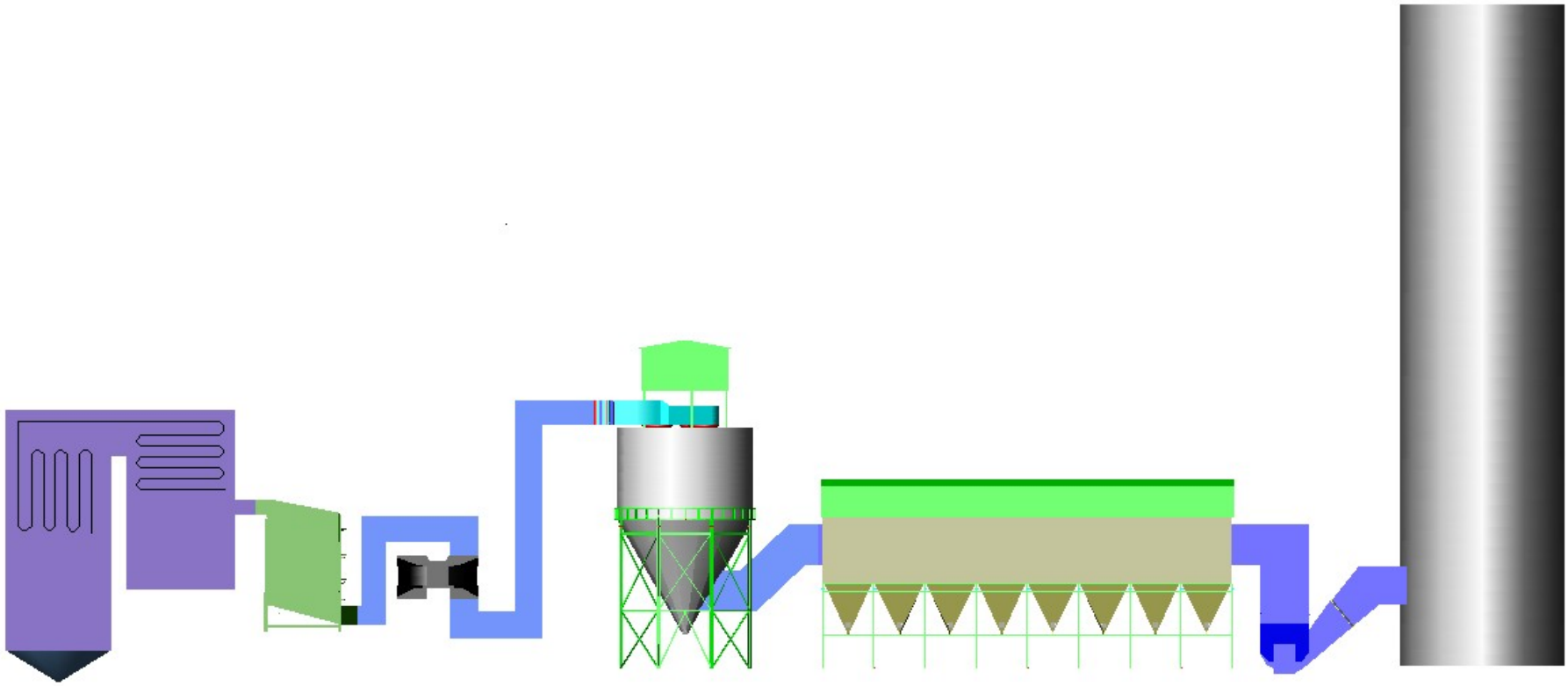
System Design

Typical DFGD Installation



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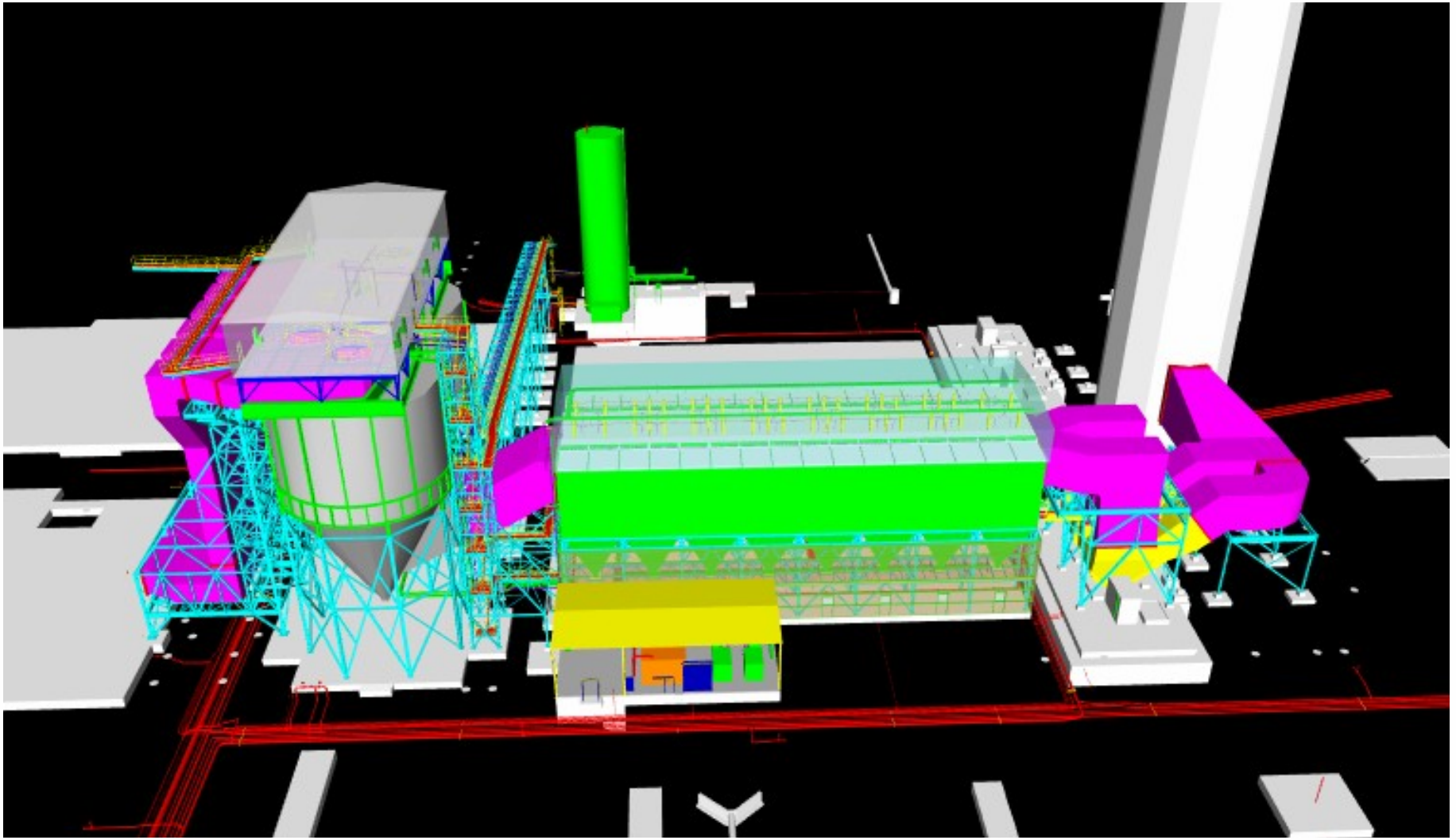
Typical DFGD Installation

Typical DFGD Installation



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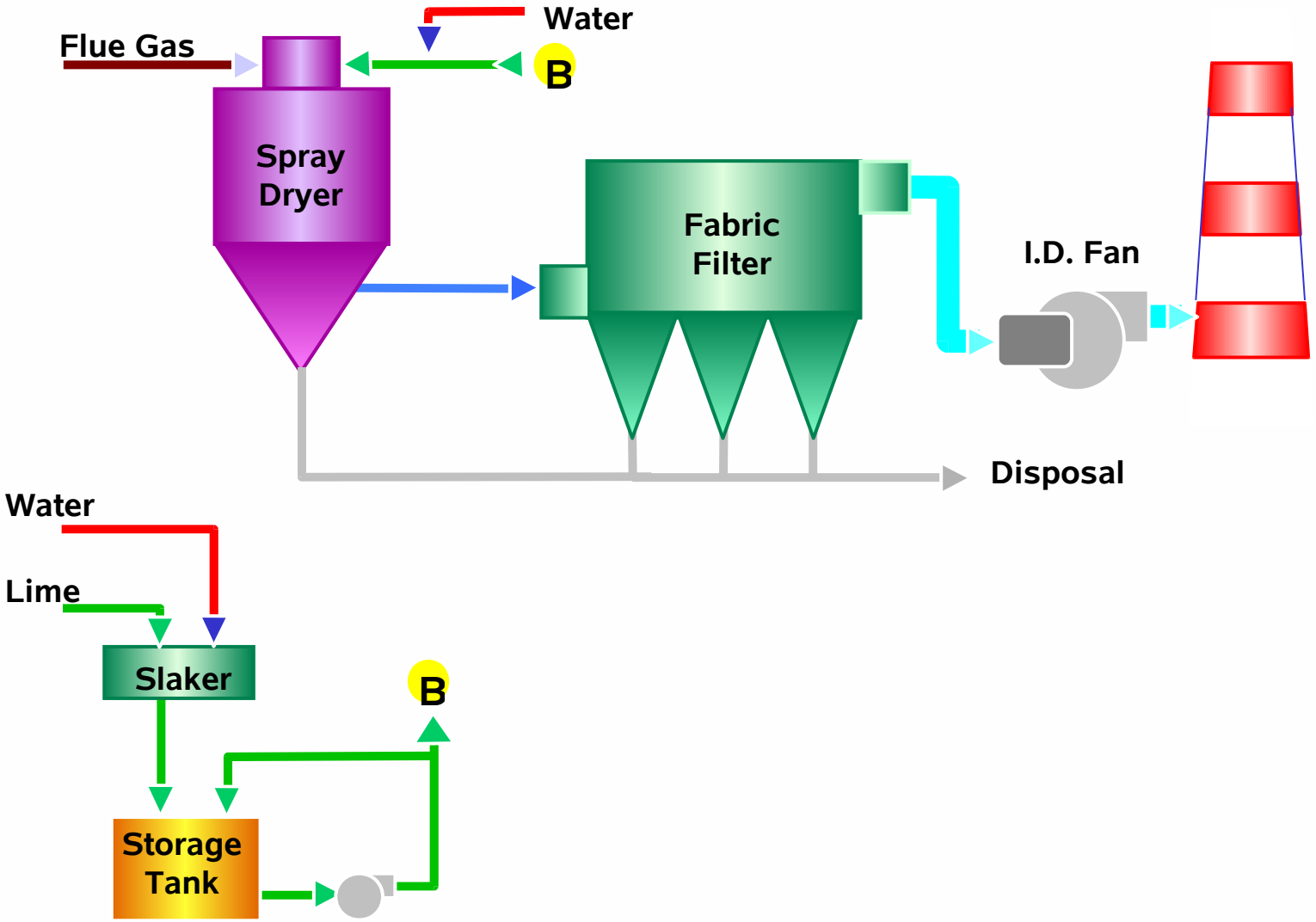
DFGD Process Flow Lime Only



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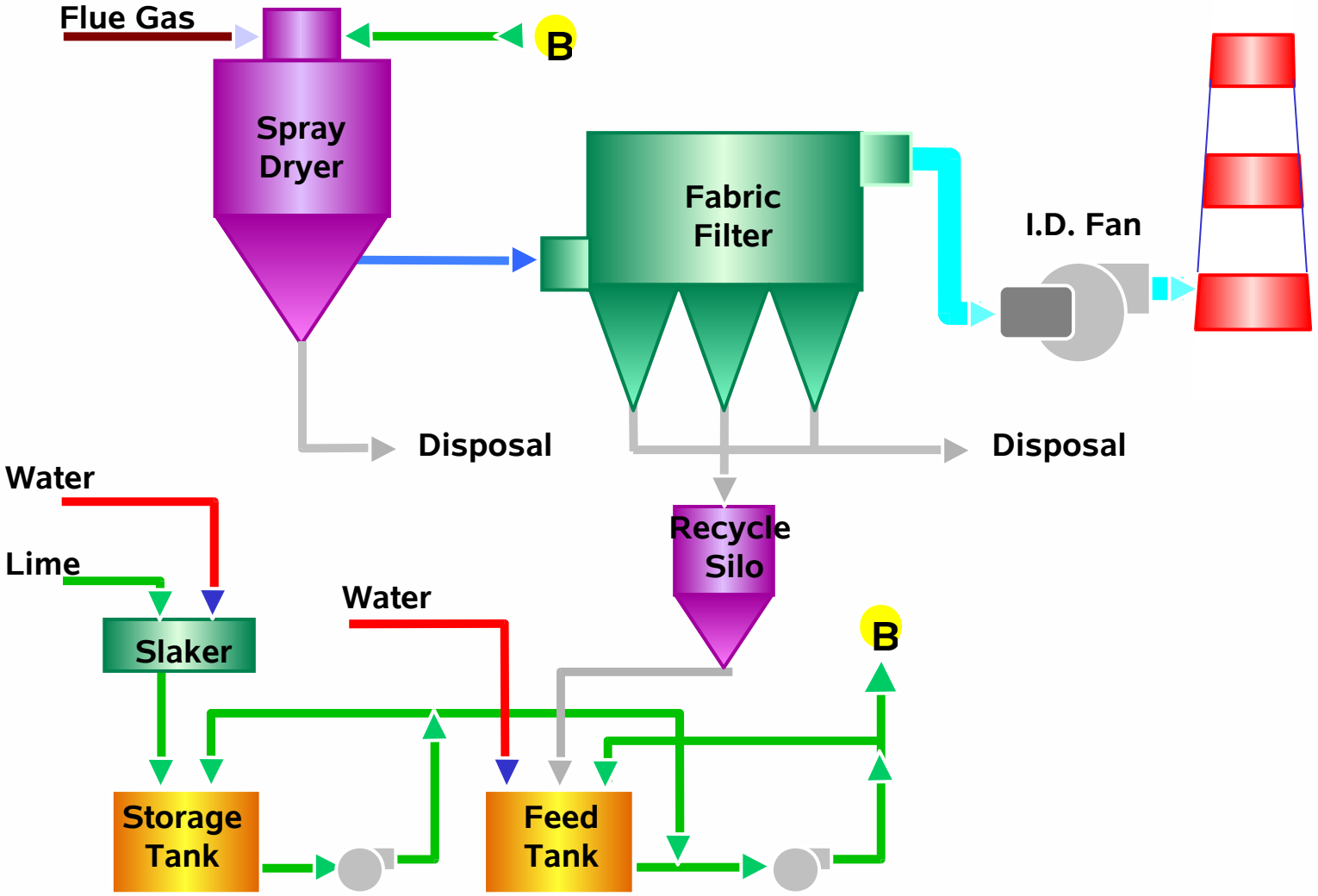
DFGD Process Flow Recycle



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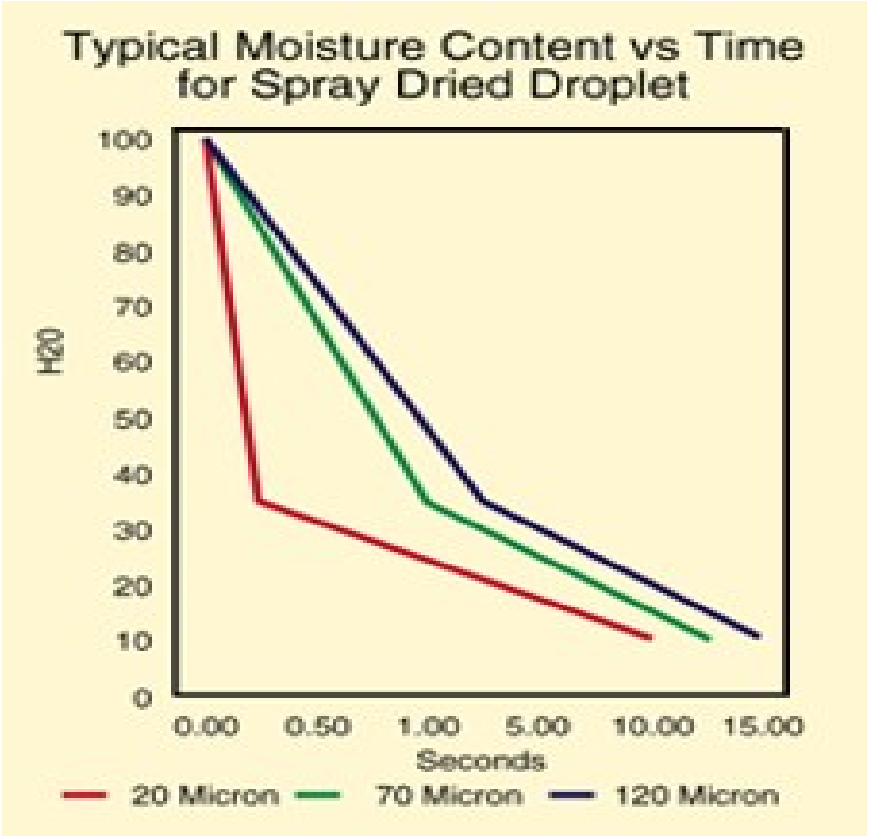
SDA Spray Cloud

Atomizing Key to the Process

- Fine Droplet Size
- Uniform Size Distribution
- Controlled Cloud Shape
- Optimum Gas/Liquid Mixing
- Stable and Controlled Temperatures



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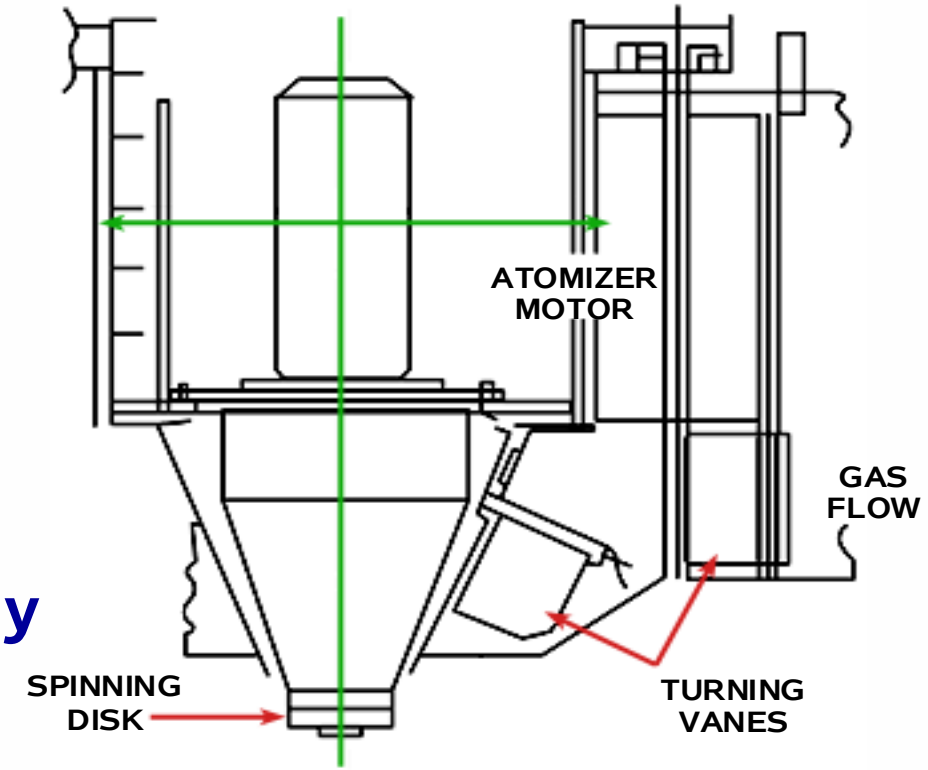
Rotary Atomizer

- **Inlet Gas Distributor and Atomizer**
  - Disk Rotates 8,000 to 13,000 rpm
  - <50 Micron Droplets Created by Centrifugal and Shear Forces
  - Each Atomizer Unit Operates Independently



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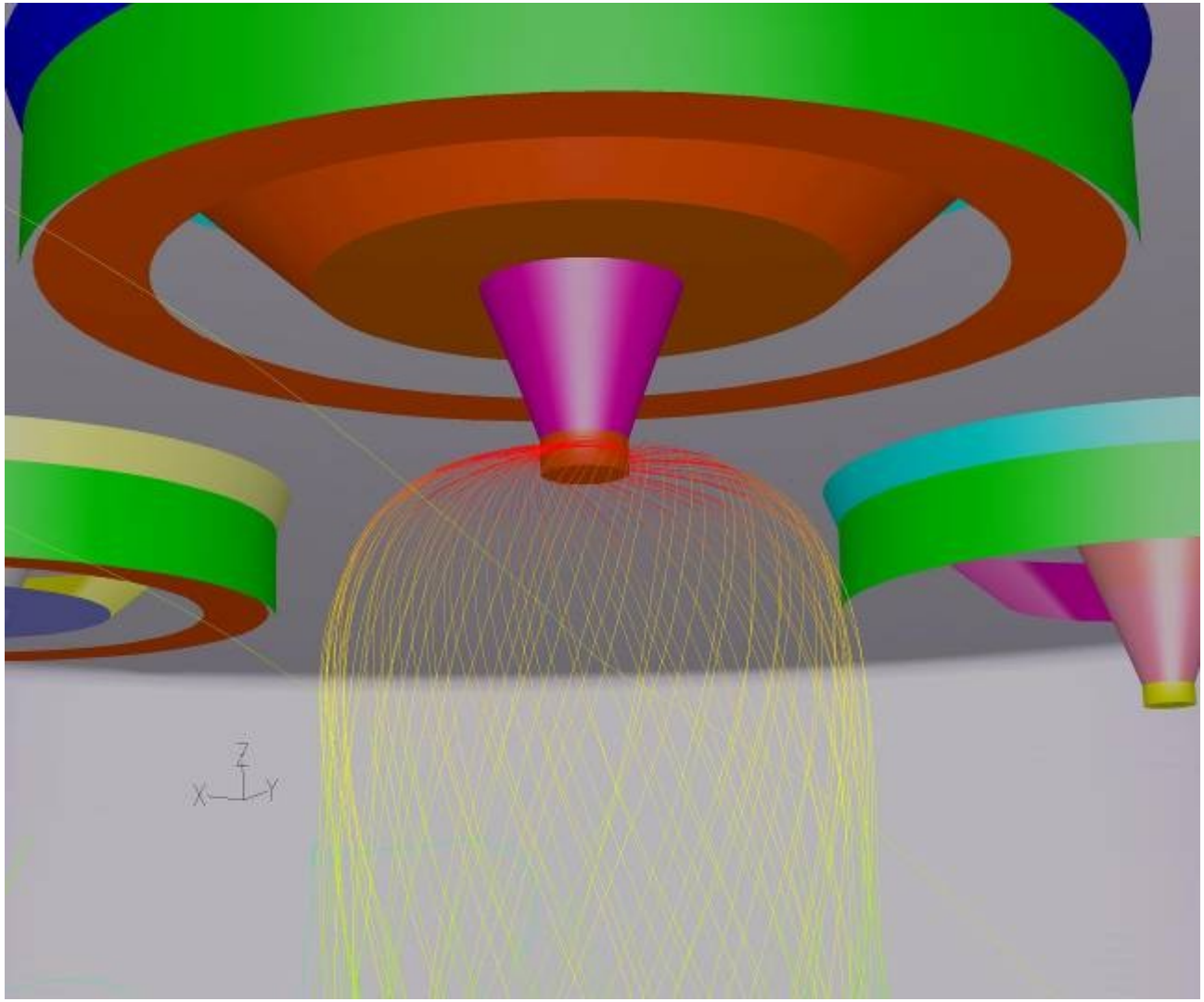
Rotary Atomizer –CFD Model



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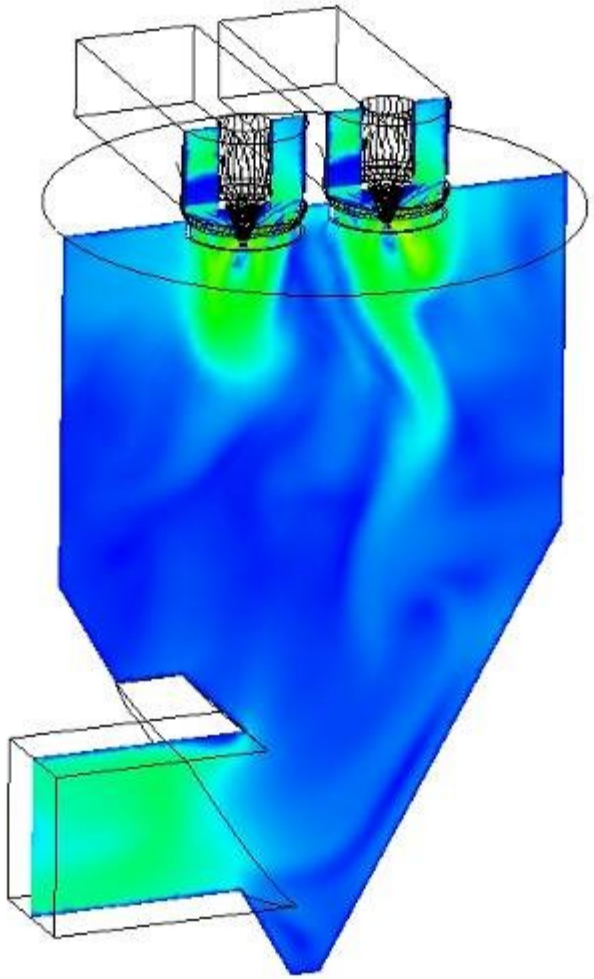
Reactor Design

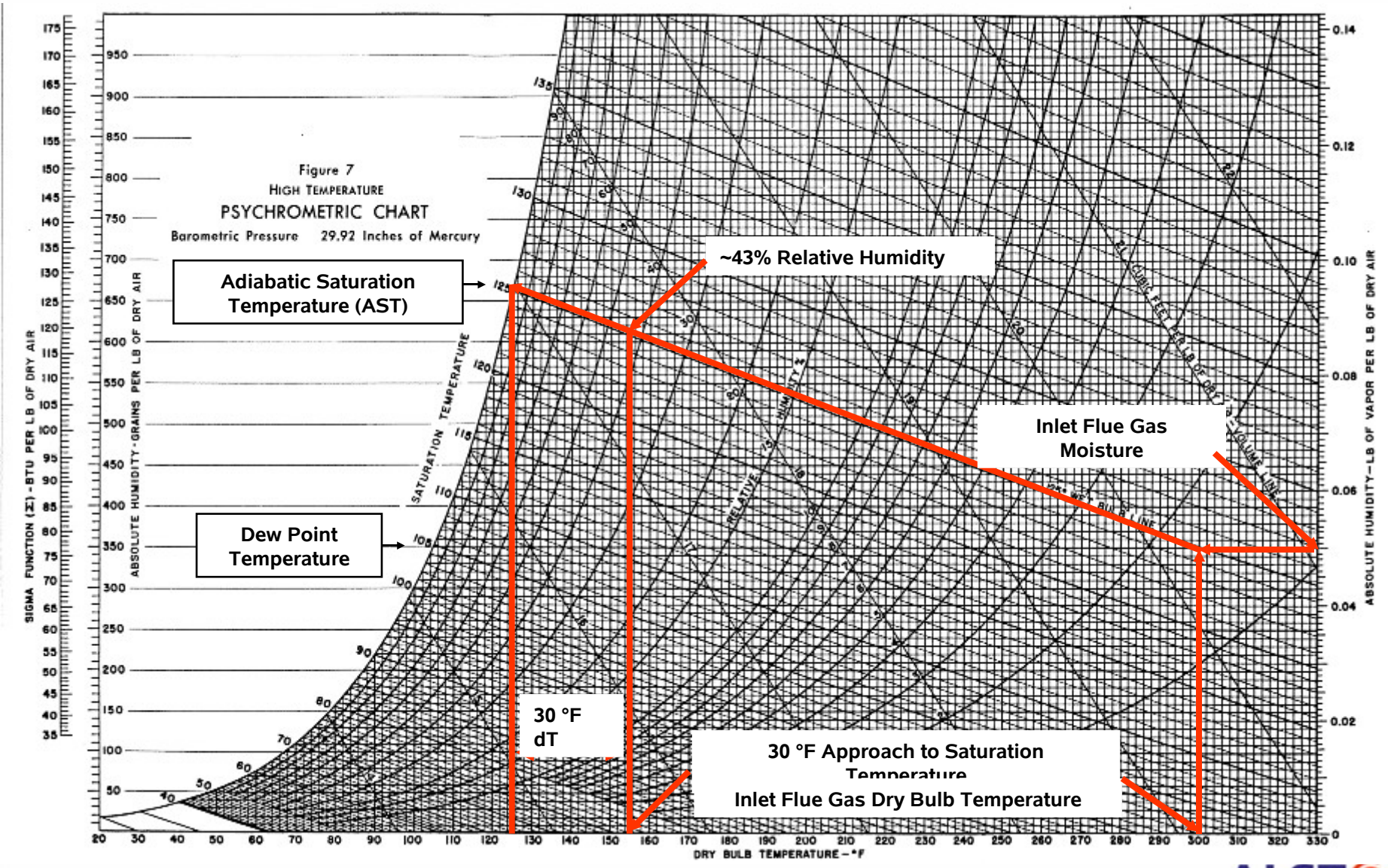
- Slurry drying and acid gas scrubbing
- 10 to 15 seconds gas retention time
- Reactors from 3 ft to 69 ft diameter
- Single or multiple atomizers
- Can be designed with an installed spare atomizer
- Physical and CFD models



Temperature Control

- Dry Bulb Temperature
- Wet Bulb Temperature
- Approach Temperature

Psychrometric Chart



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DFGD Reactions & Products

- Lime Slaking
- $CaO + H_2O \rightarrow \mathbf{Ca(OH)_{2(s)}}$
- Acid Gas Scrubbing
- $SO_2 + Ca(OH)_2 \rightarrow \mathbf{CaSO_3\text{-}½H_2O_{(s)}} + ½H_2O_{(g)}$
- $SO_2 + Ca(OH)_2 + H_2O + ½O_2 \rightarrow \mathbf{CaSO_4\text{-}2H_2O_{(s)}}$
- $SO_3 + Ca(OH)_2 + H_2O \rightarrow \mathbf{CaSO_4\text{-}2H_2O_{(s)}}$
- $CO_2 + Ca(OH)_2 \rightarrow \mathbf{CaCO_{3(s)}} + H_2O_{(g)}$
- $2HCl + Ca(OH)_2 \rightarrow \mathbf{CaCl_2\text{-}2H_2O_{(s)}}$
- $2HF + Ca(OH)_2 \rightarrow \mathbf{CaF_{2(s)}} + 2H_2O_{(g)}$

System Components

Reagent Preparation

- Lime Slaking Accomplished by:
  - Detention
  - Paste
  - Milling
  - Slaking must take place at high temperature
- Final Slurry Preparation Combines
  - Lime Slurry
  - Dilution Water (waste water)
  - Dry Recycle (optional)

Lime Quality

a. Particle Size: 3/4” x 0” with no more than 50% less than 10 mesh.

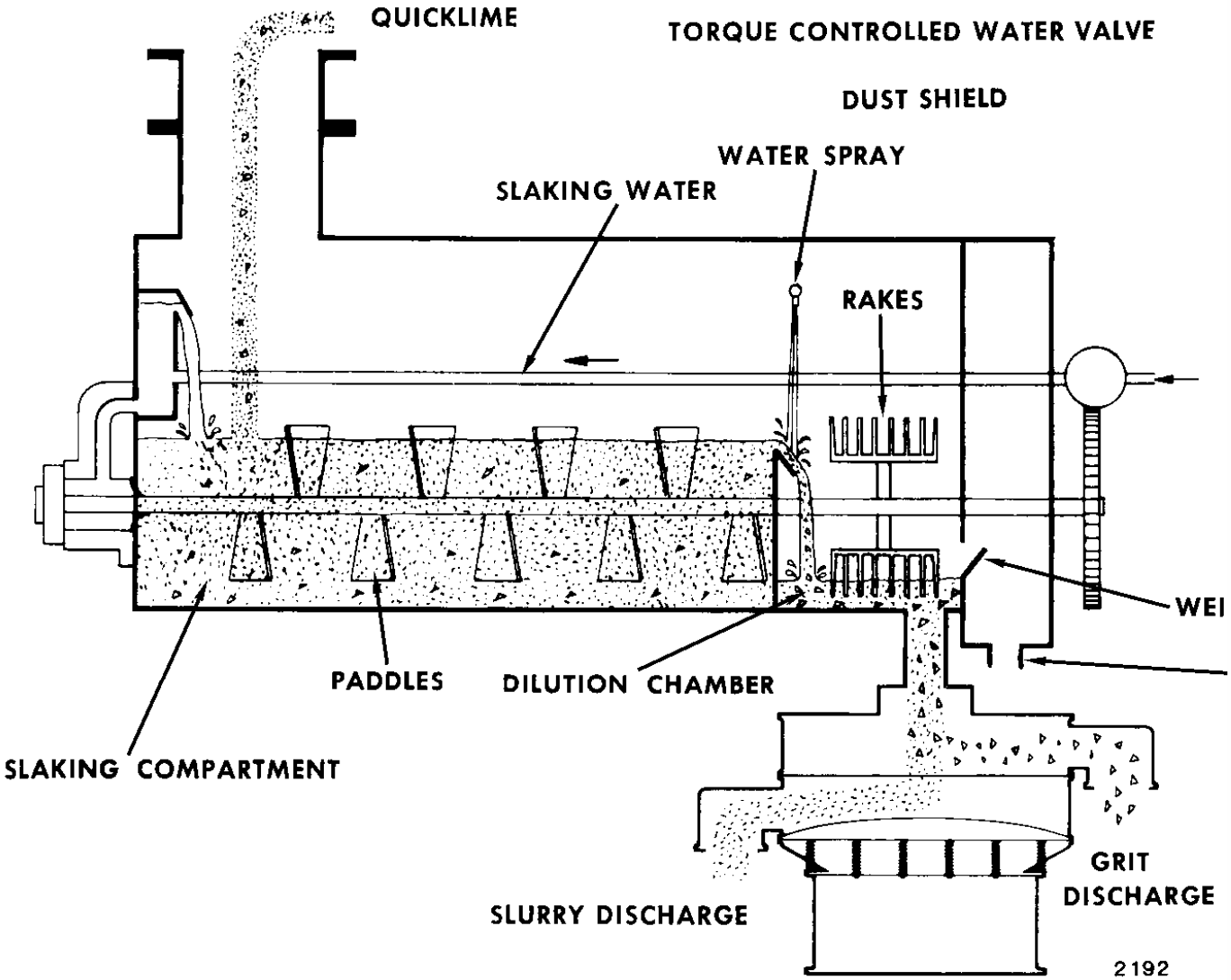
b. Availability: 90 % CaO or greater as measured by ASTM Method C25.

c. Reactivity: Greater than 40 °C temperature rise at three minutes as measured by ASTM Method C110.

Lime Slaking Guidelines

- Slaking Temperature - 175°F +/-
- Diluted to 20% solids
- Filtered to 20 mesh or less
- Settled Volume after 24 hrs >50 ml @ 10% solids

Paste Slaker



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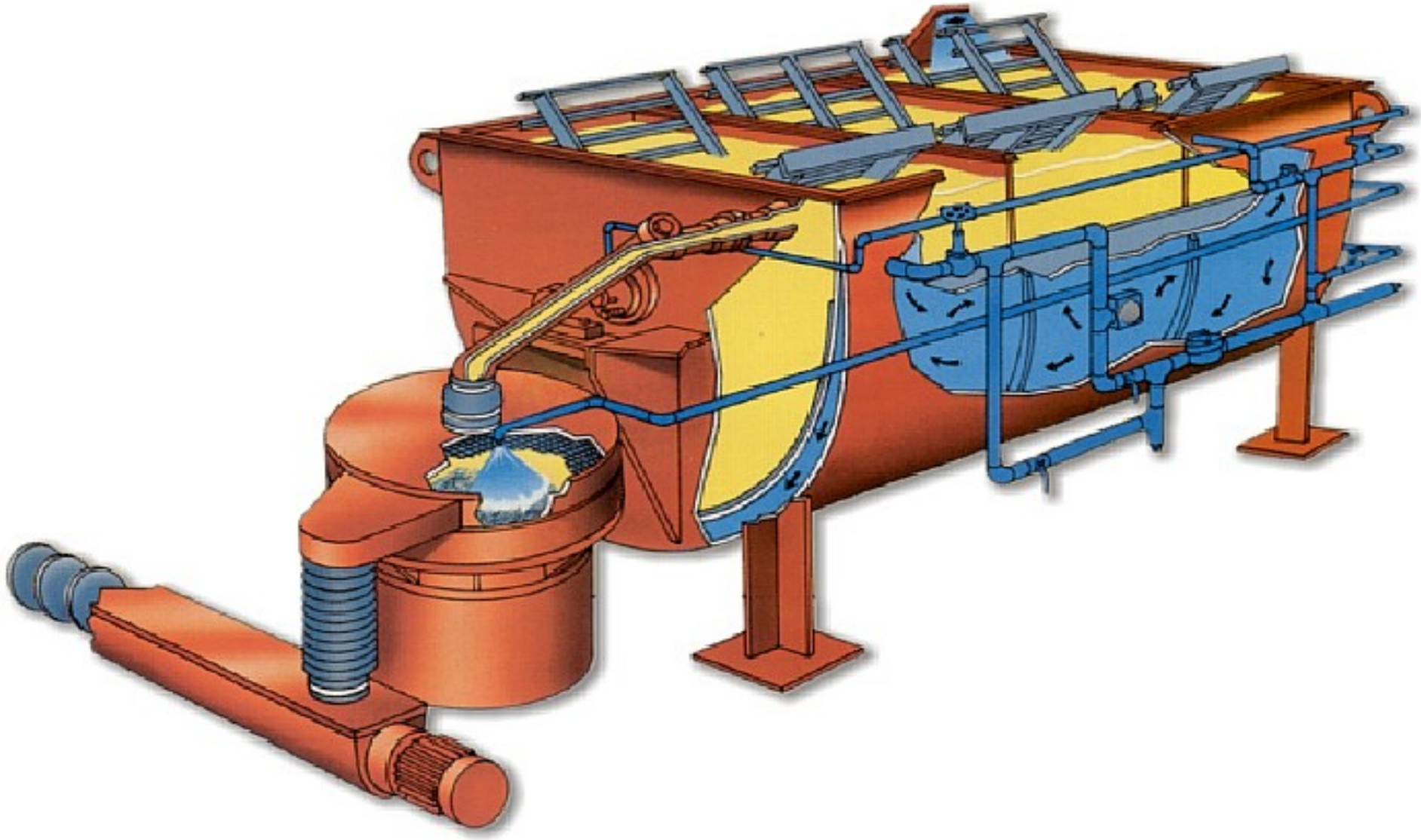
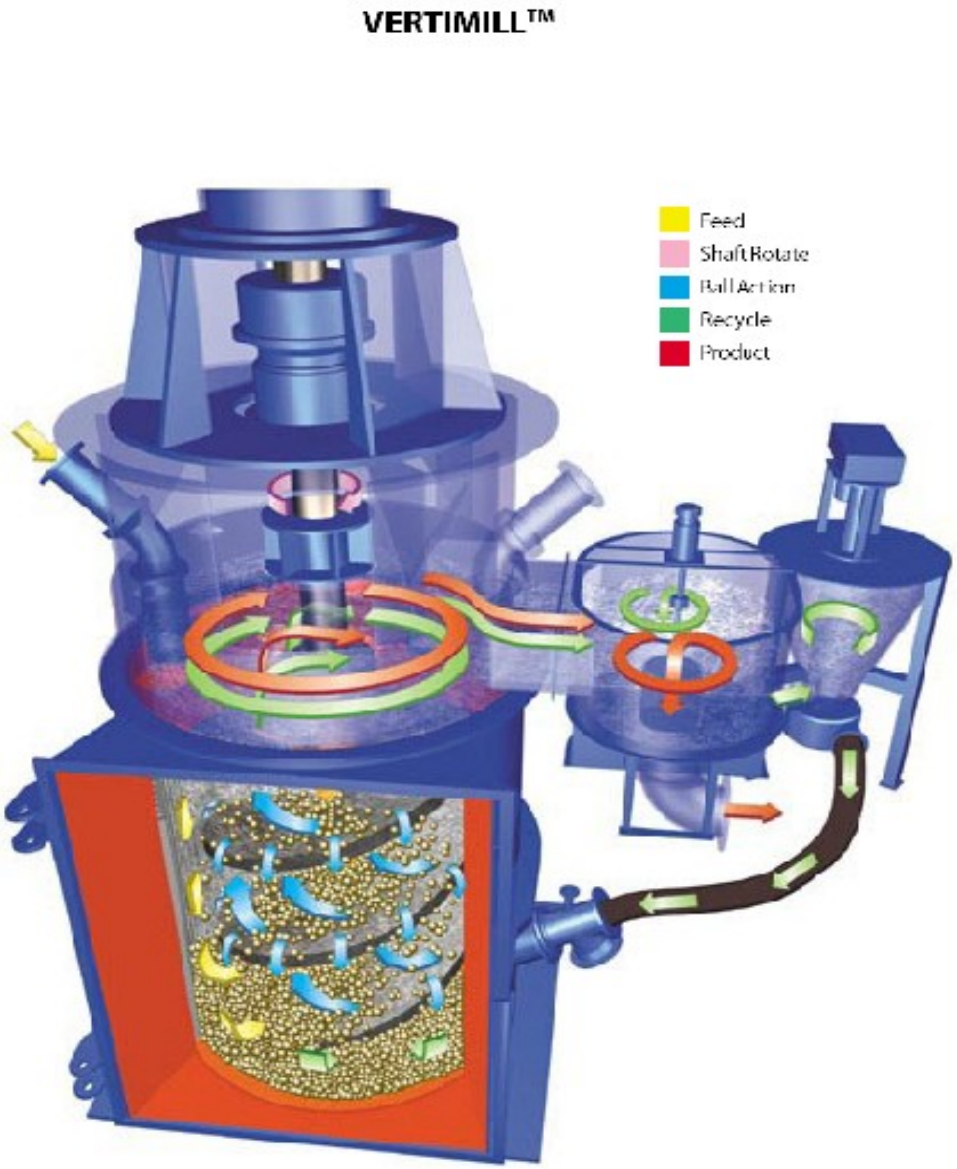
Detention Slaker



Vertical Mill Slaker



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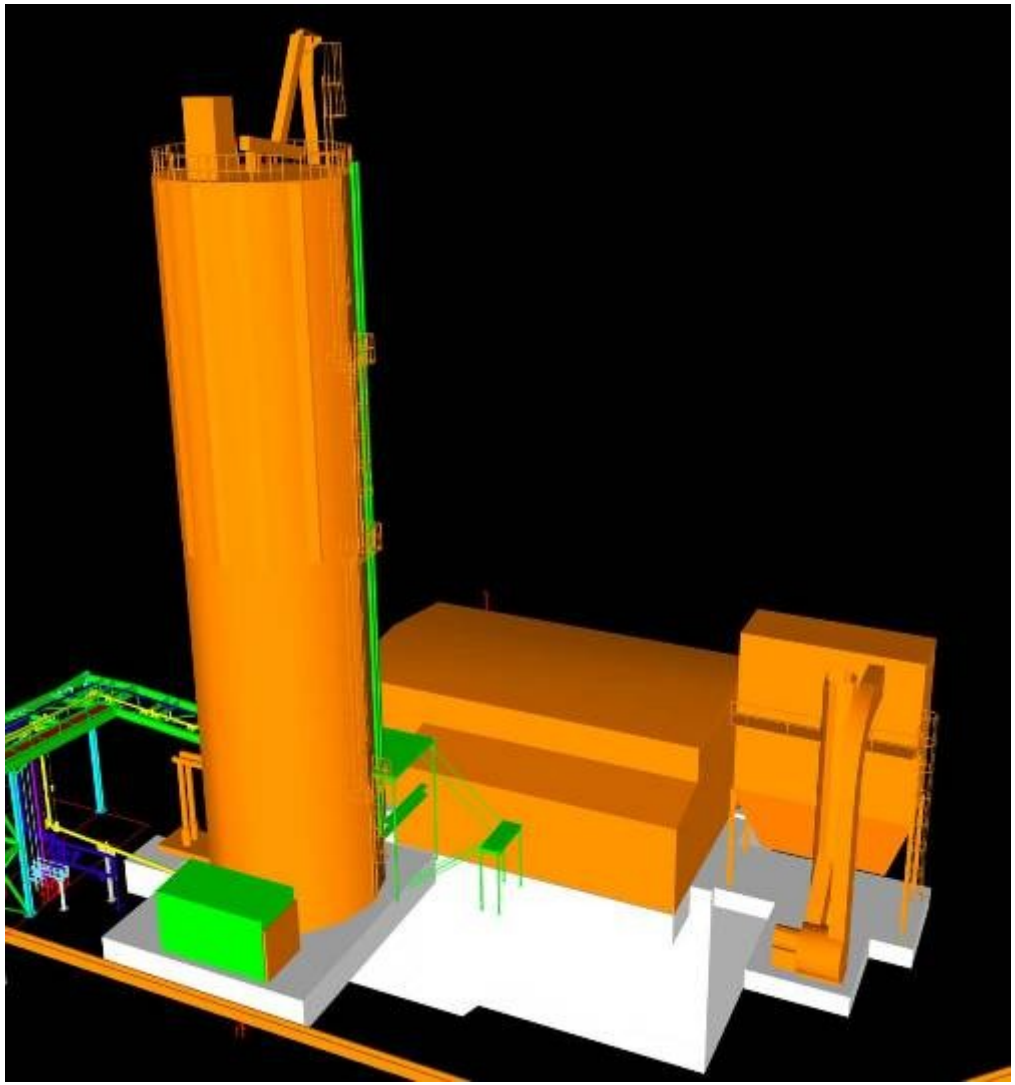
Reagent Preparation Area



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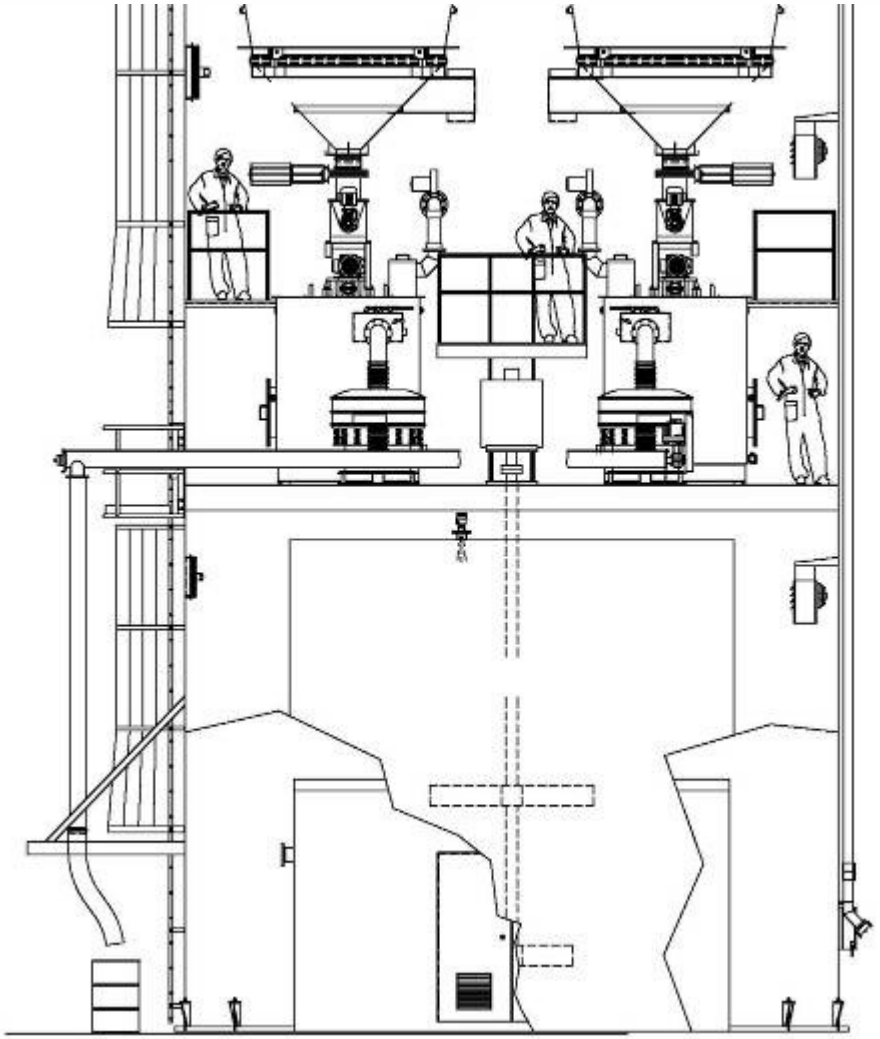
Lime Slaking and Storage



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Alstom SDA

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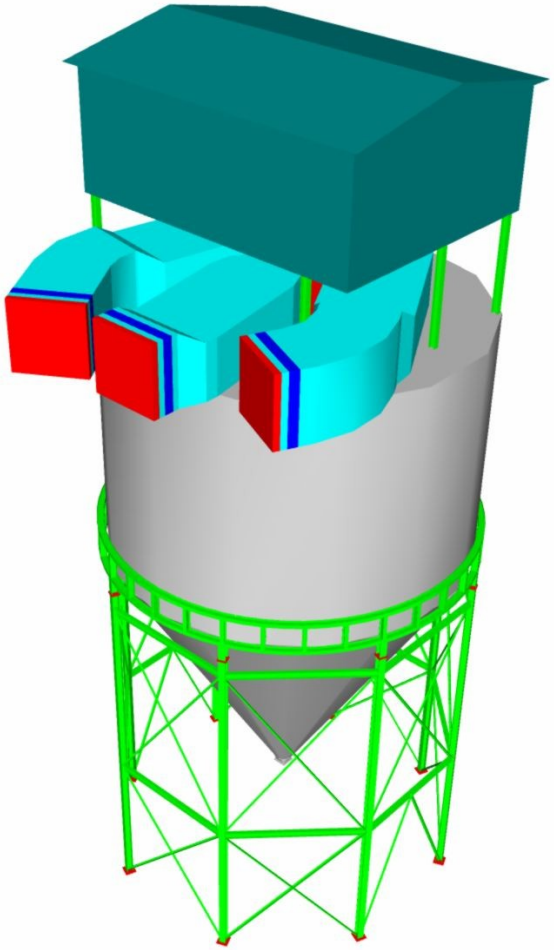
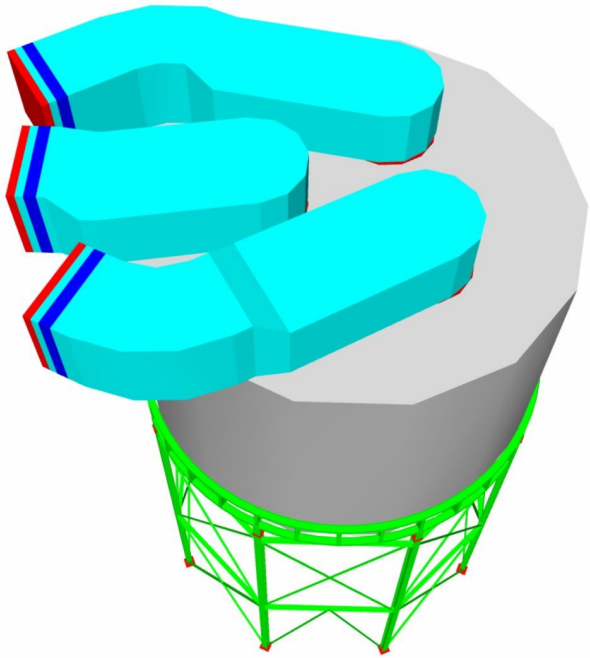
Flue Gas Inlet Ducts





B&W SDA

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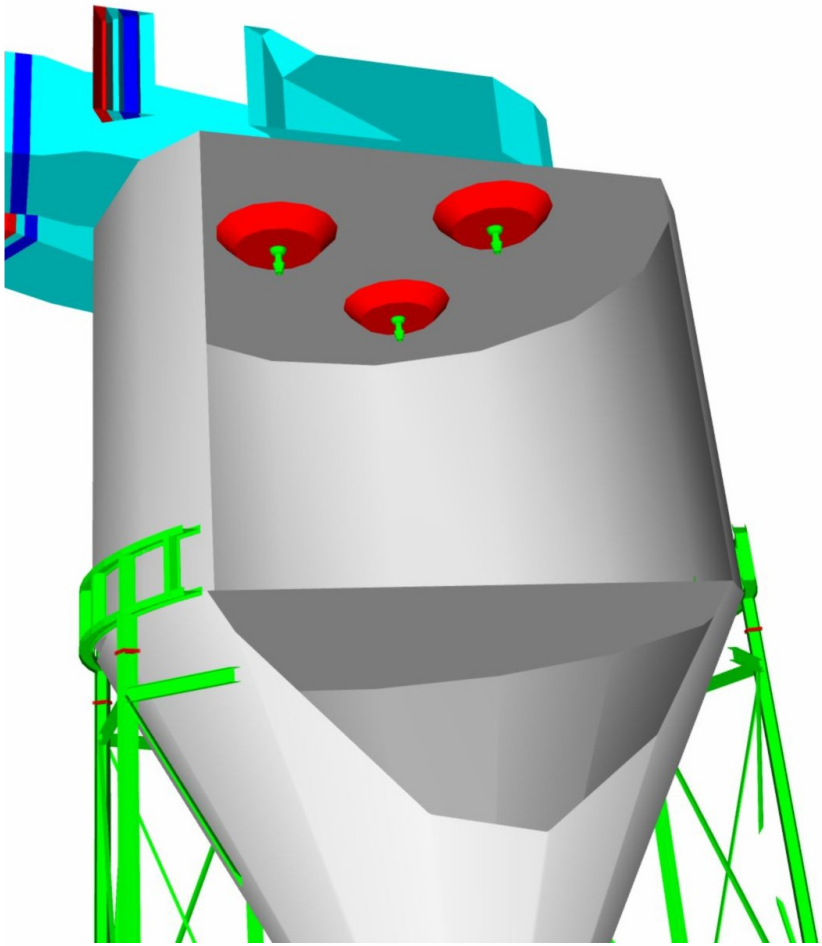
Gas Disperser

Multiple Atomizers

- Each Atomizer Acts Independently
- Excellent Interface Between Flue Gas and Lime Spray for SO_2 Collection
- Three atomizers per SDA
- Optional operation with two out of 3 atomizers at full load
- Turndown to 10% load
- Designed for 12 Second Retention Time



Rotary Atomizer

Rotary Atomizer Assembly

- Each has up to 150 MW flue gas scrubbing capacity
- 450 MW Capacity Spray Dryer with 3 Atomizers
- Assembly Can Be Hoisted Up While the Spray Dryer is in Operation
- Proven Reliable Design 30 years of power plant service
- Over 150 Rotary Atomizers in Operation

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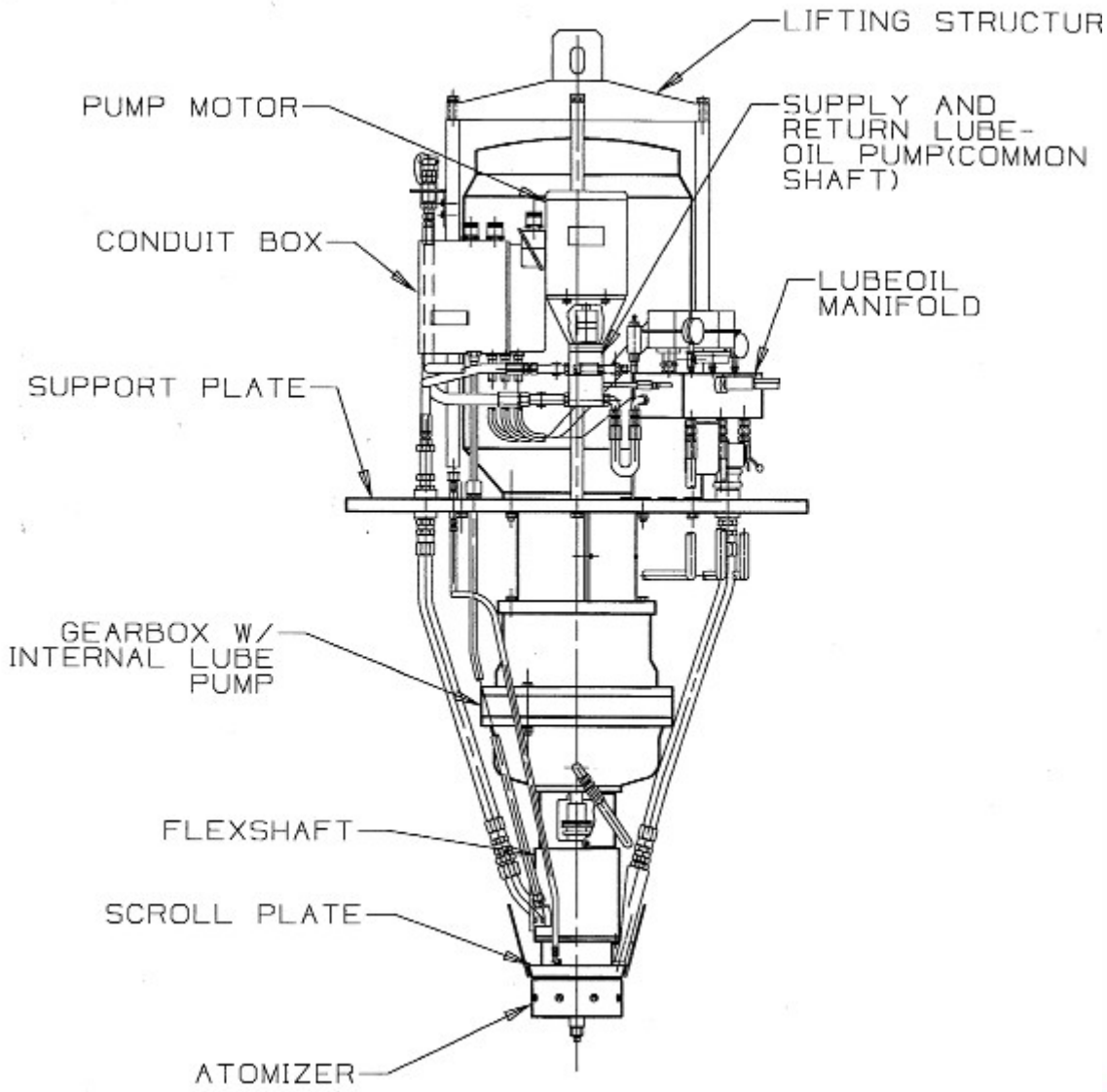
Rotary Atomizer Assembly

- US manufactured
- 150+ Machines in daily service
- 40 Locations
- 60 – 400 hp
- 8,000 to 15,000 rpm



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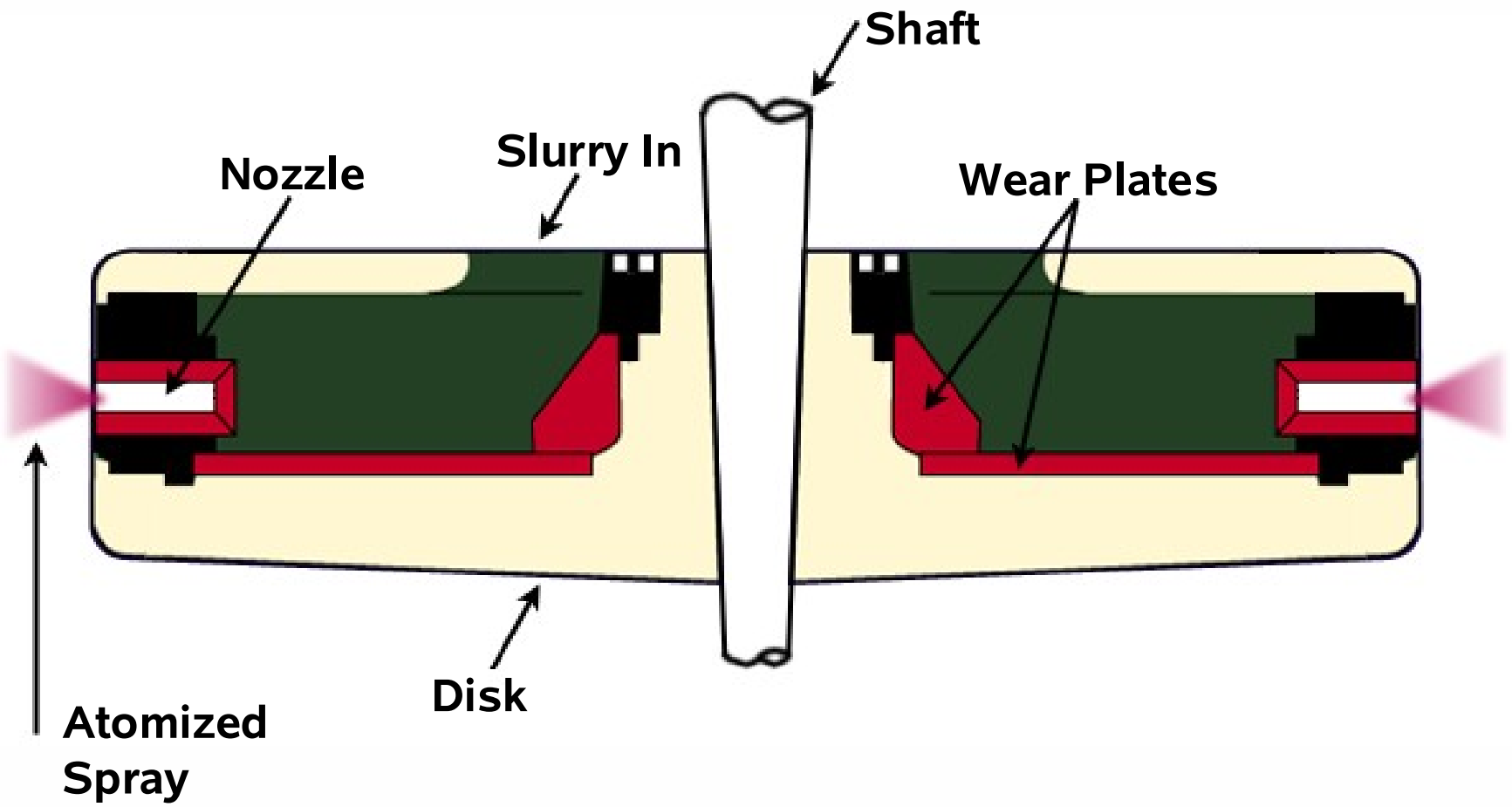
Rotary Atomizer

- Reliable Operation:
- Vibration Monitors are Standard
- Sophisticated Lubrication System with Filters and Coolers
- Careful Selection of Bearings and Gearbox Components
- Quick Removal from Spray Dryer Vessel for Inspection and Service

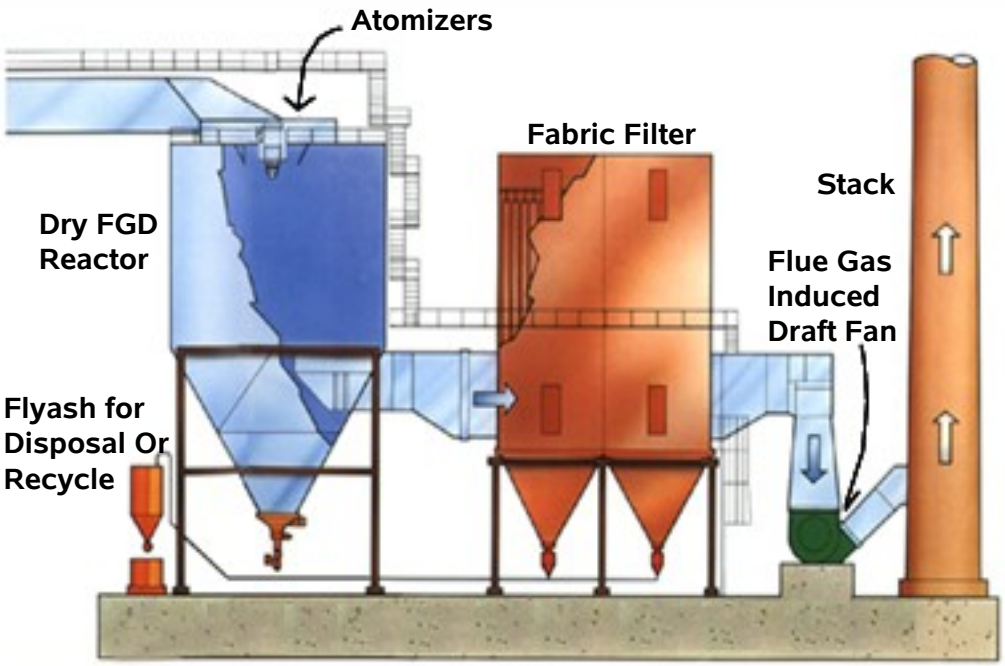
Rotary Atomizer Disk



Fabric Filter as a Chemisorption Device

Applications:

- SO_2 SO_3 HCl HF Dioxin, Mercury Removal
- Spray Dryer
- Dry Injection
- Lime, Sodium Bicarbonate, Carbon



SO_2 and HCl Removal with Spray Dryer

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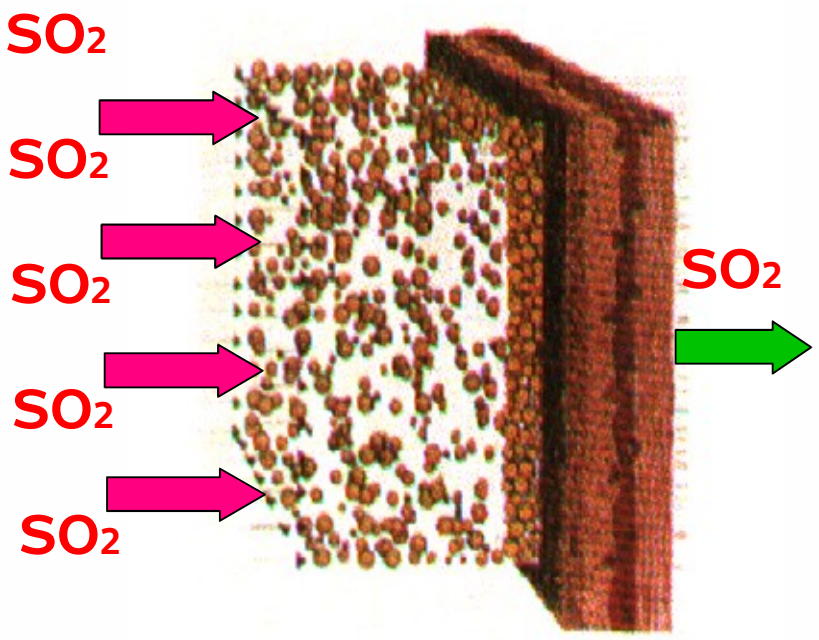
FABRIC FILTER

- Important part of DFGD
- Reaction
  - Second Stage SO2 Removal
  - Patented Process (No. 4,197,278)
- Collection
  - Fly ash
  - Reaction Products



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FF Compartment Plan View

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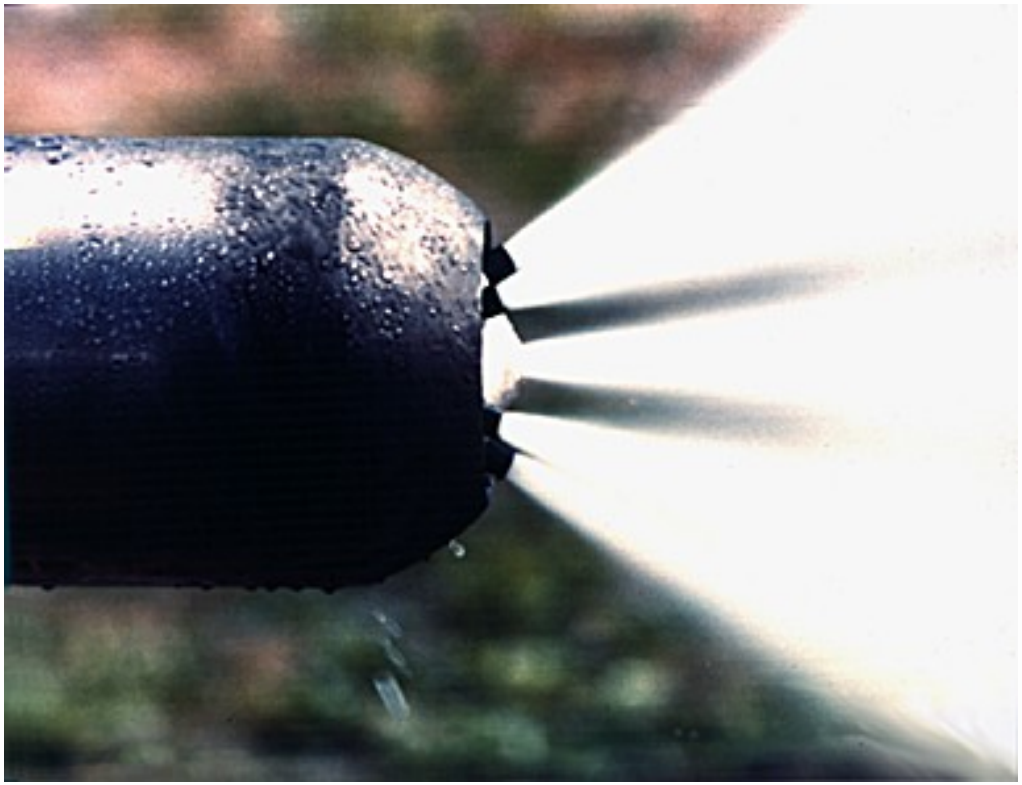
Rotary vs. Dual Fluid Atomization

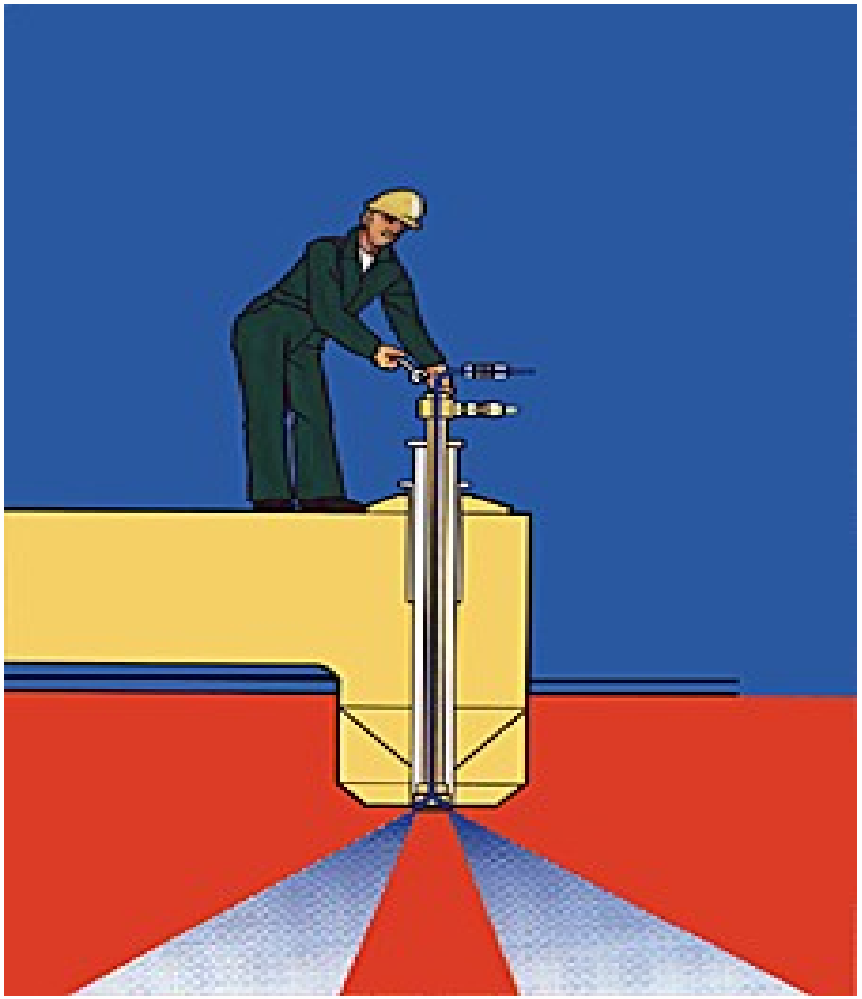
Dual Fluid Nozzle Atomization

- Air is Used to Atomize the Slurry to Fine Droplets
- Droplet Distribution 20 to 60 Microns
- Abrasion Resistant Nozzle Tips Ensure Long Life



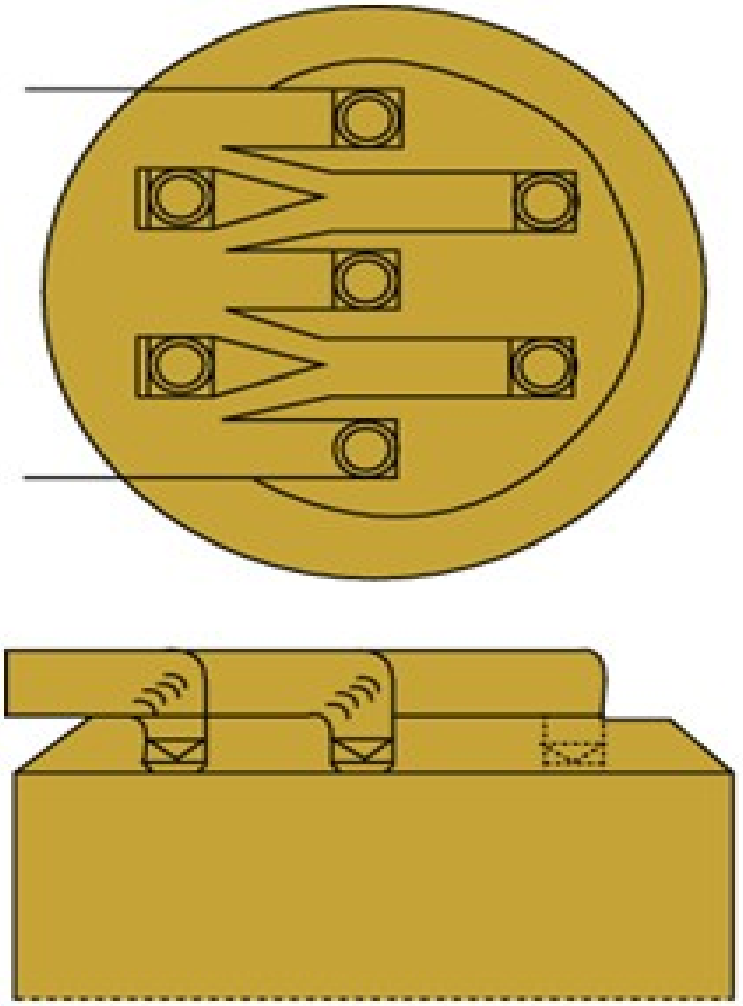
Dual Fluid Nozzle Gas Disperser

- Lime Slurry is Atomized by Compressed Air
- Individual Nozzles Can Be Removed While the Spray Dryer is On-Stream
- Spray Pattern is Tailored to the Spray Dryer Vessel Configuration



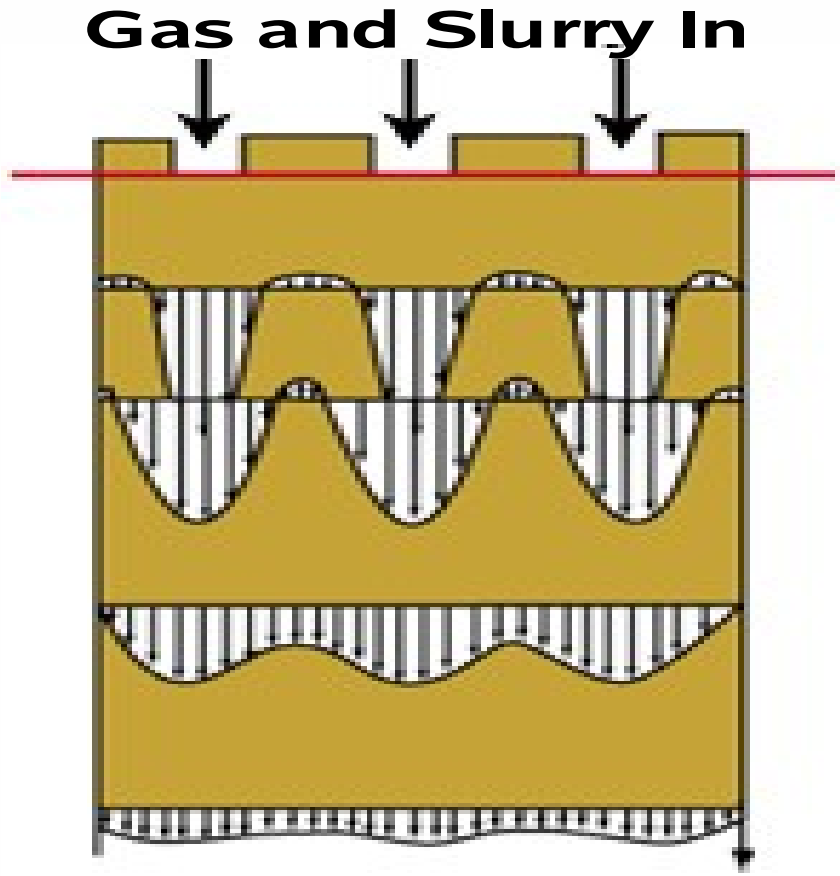
Nozzle Spray Dryer Gas Inlet

- Flue Gas is Balanced and Directed to Individual Nozzle Assemblies
- Turning Vanes Ensure Equal Gas Distribution at the Nozzle Tips



Nozzle Spray Dryer Gas Distribution

- Equal Gas Distribution at Each Nozzle Ensures Even Gas Distribution at the Reactor Bottom
- Multiple Nozzles Minimize Flue Gas "Bypass" Inside the Reactor
- Gas Flow Evens Out as the Gas Flows Downward Toward the Bottom Outlet



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Dual Fluid Nozzle Disadvantages

- Limited slurry flow rate per nozzle requires many nozzles and complex piping
- Each rotary atomizer has 10x larger capacity thus fewer are needed
- Air compressors are inefficient
- Much of the energy in the compressed air is wasted by the nozzle
- Rotary atomizers are over 90% efficient
- Power savings can be over a MW

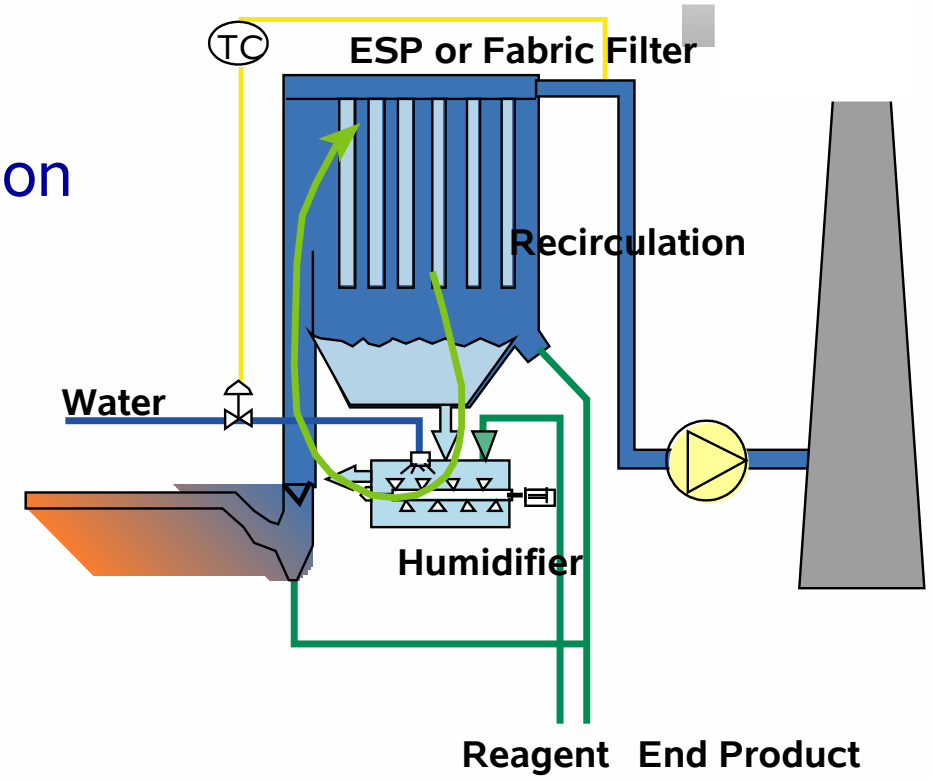
Atomization design of Major suppliers of Dry FGD

- Original Developers of DFGD in 1978
  - Joy / Niro - Rotary
  - B&W - Nozzle
  - Rockwell - Rotary
  - CE - Both
  - Carborundum - Nozzle
  - Flakt - Nozzle
- Consolidation over past 30 years
  - B&W - Rotary
  - Alstom - Rotary
- Over 90% of all DFGD systems use Rotary Atomizer

Spray Dryer Alternatives

Flash Dryer Process Concept

- Very High Solids Recirculation
- No Slurry Handling
- “Dry” Product
- High Utilization of Reagent



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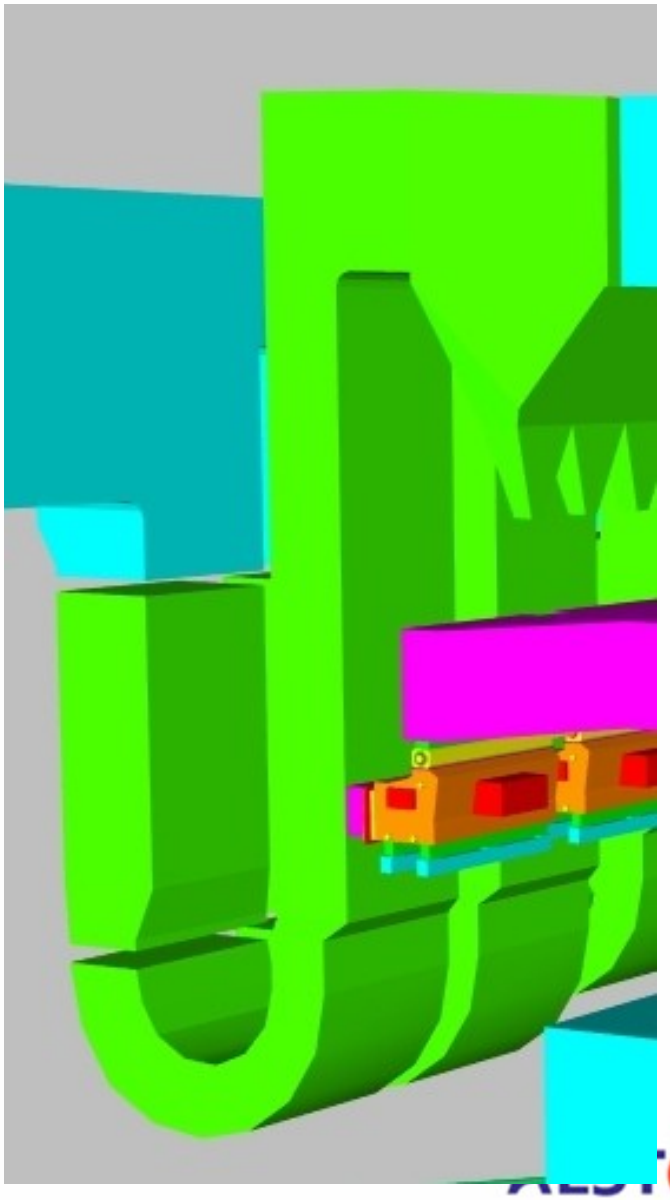
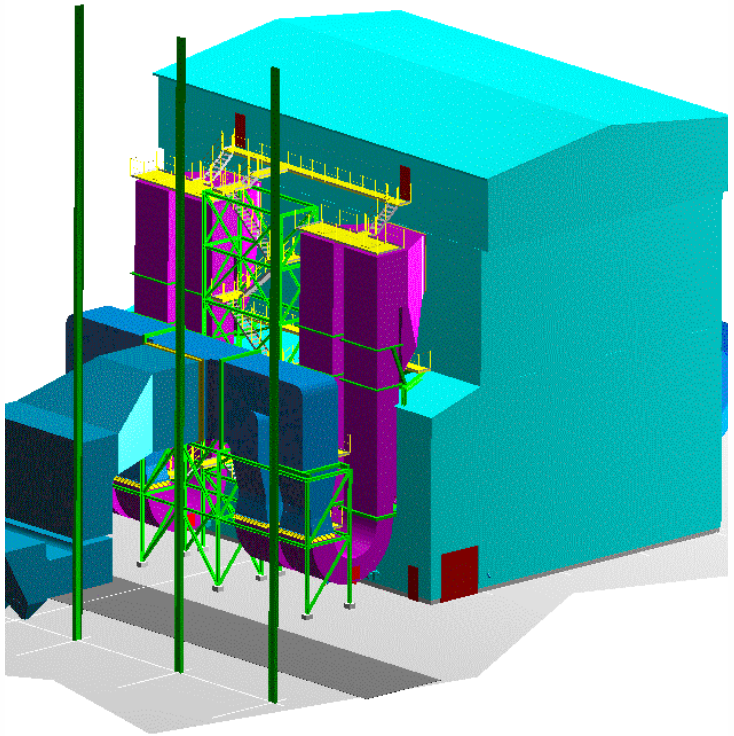
Flash Dryer Absorber

- Modular design
- Operations are closer to grade
- High Reliability
- Approximately 1.2 seconds gas residence time
- No high pressure or high speed atomizers
- No slurry handling



FDA Multiple Module System

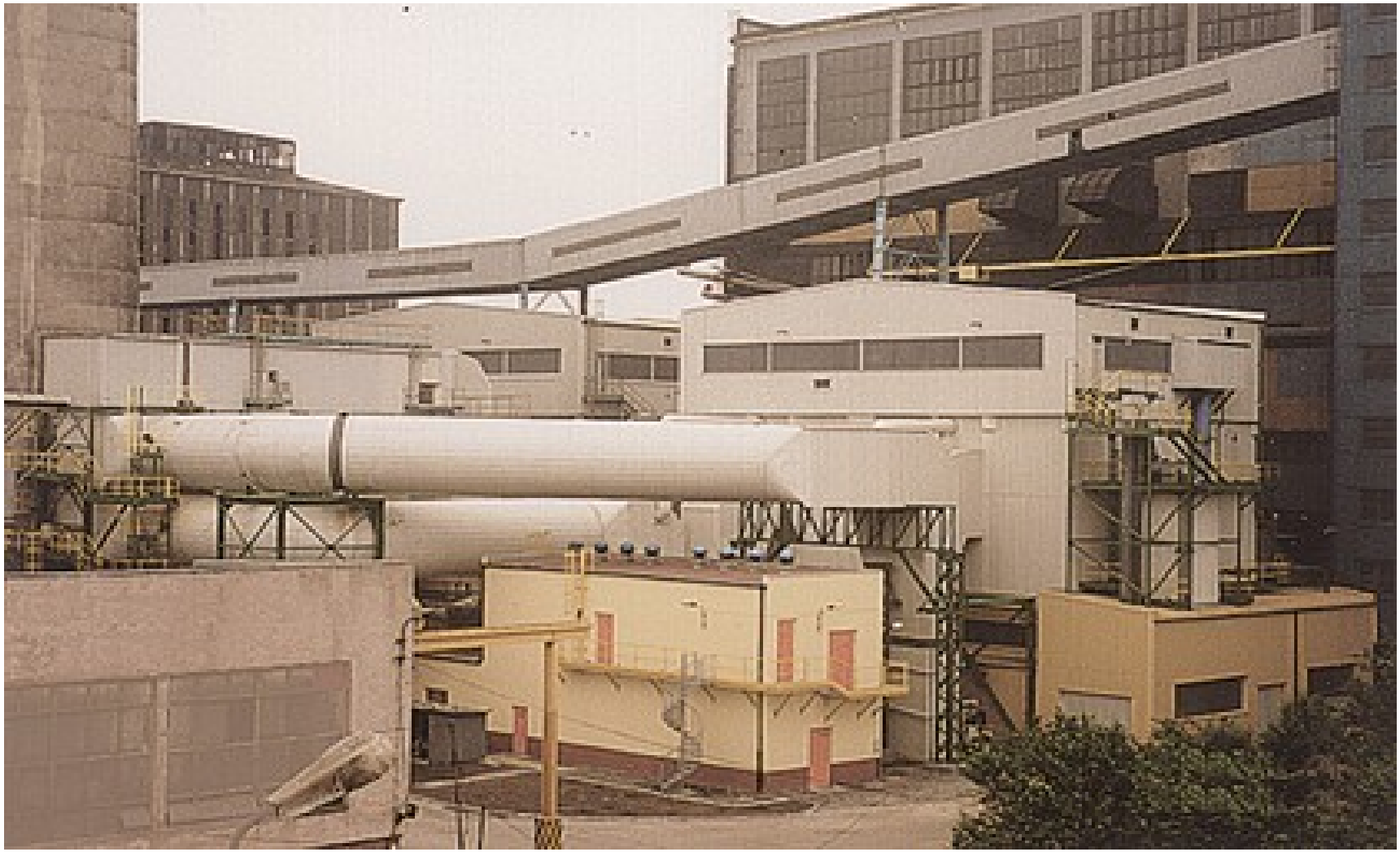
- Each Mixer Acts Independently
- Excellent Interface Between Flue Gas and Humidified Recycle for SO2 Collection
- Continuous Recirculation with Air Slides and Fluidized Troughs
- Controlled Water to Recycle Ratio
- Dry Waste Product Calcium Sulfite/Sulfate



FDA History

- Pilot Plant at Univ. of Tennessee – 1988
- Pilot Plant at TVA Shawnee – 1992
- European pilots – 1995
- Full Scale Laziska Retrofit - 1996
- Currently 62 installations - over 6000 MW

FDA – Laziska Power Plant 2x125 MWe



FDA / Fabric Filter (3 x 120 MW_e)

AES Fifoots Point PS, Wales, UK

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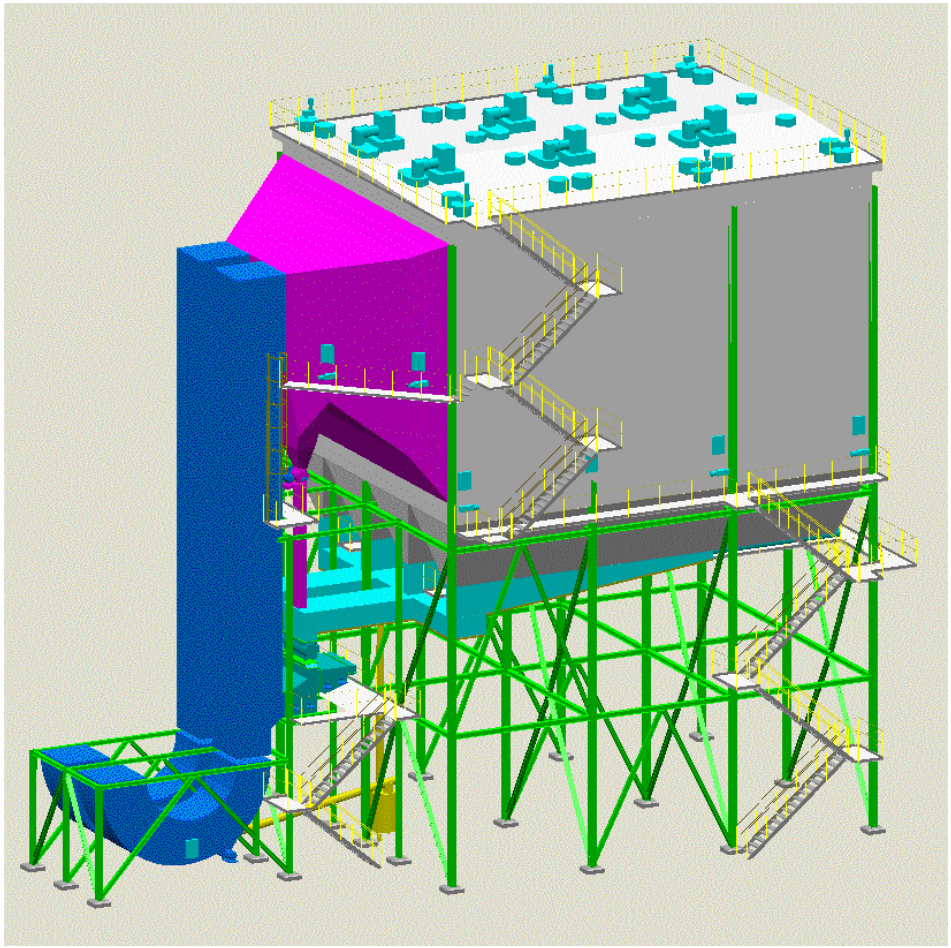
Reliant - Seward Station
Flash Dryer Absorber (FDA)

FDA + ESP 70 MW



Zhejiang # 8, PRC

FDA/ESP

Juhua Group / ZCE Boiler No. 8, Zhejiang, PRC

FDA – Advantages

- Low investment
- Less Equipment
  - ✘ Spray dryer
  - ✘ Slurry handling equipment
  - ✘ less maintenance
- Reduced power consumption
- Compact reactor design housed under the particle collector
- High SO_2 removal efficiency

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