REINHOLD ENVIRONMENTAL Ltd.

2015 APC Round Table & Expo Presentation

July 13 & 14, 2015, in Atlanta, GA / Hosted by Southern Company

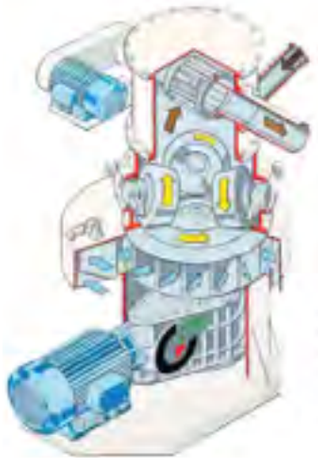
SmartMill Technology

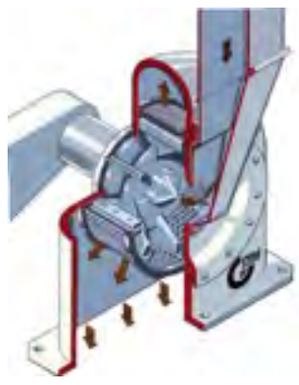
Guaranteeing Particle Size, Quality and Production with On-site Sorbent Milling

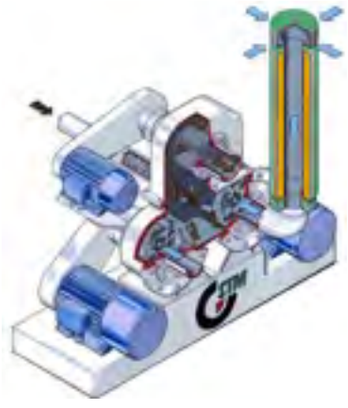
Milling & Feeding Technology

STM Line of Mills

- **Roller Mills**
- **Hammer Mills**
- **Screen Mills**
- **Jet Mills**
- **Pin Mills**
- **Cryogenic Mills**
- **Laboratory Mills**





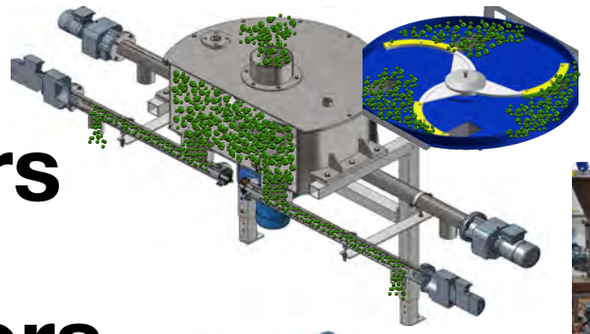


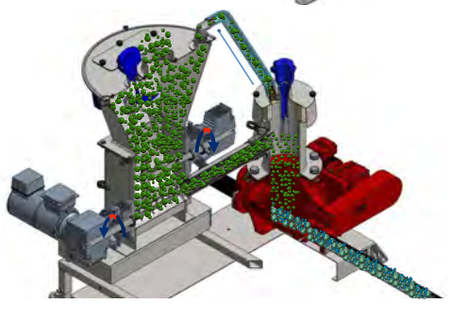


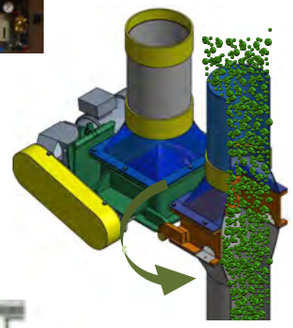
Milling & Feeding Technology

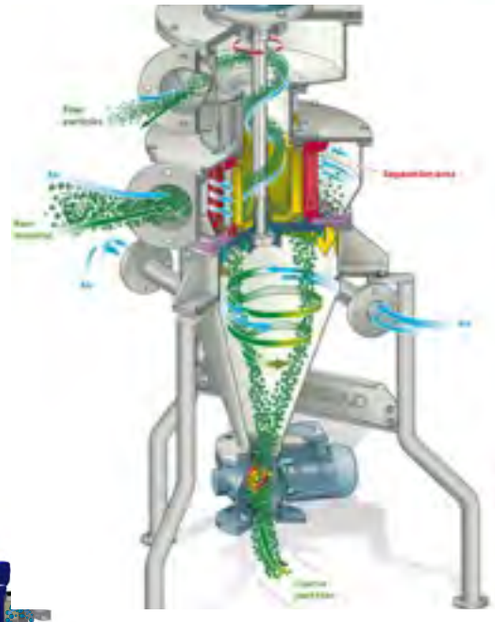
STM Line of Feeders, Injectors & Classifiers

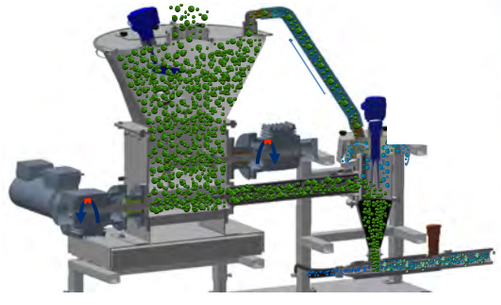
- **Volumetric Feeders**
- **Gravimetric Feeders**
- **Dry Eductors**
- **Wet Eductors**
- **Distributors**
- **Lump Breakers**
- **Dynamic Classifiers**

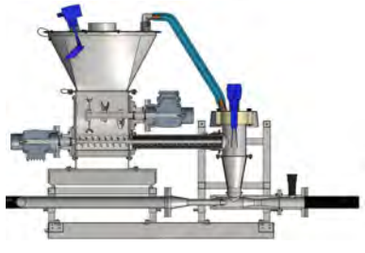












Sodium Sorbent Milling

Sodium Dry Injection Technology Experience

- **In the 90s, STM led the world in dry grinding for gas cleaning applications by helping a world-leading chemical supplier develop a novel gas cleaning approach using sodium sorbents.**

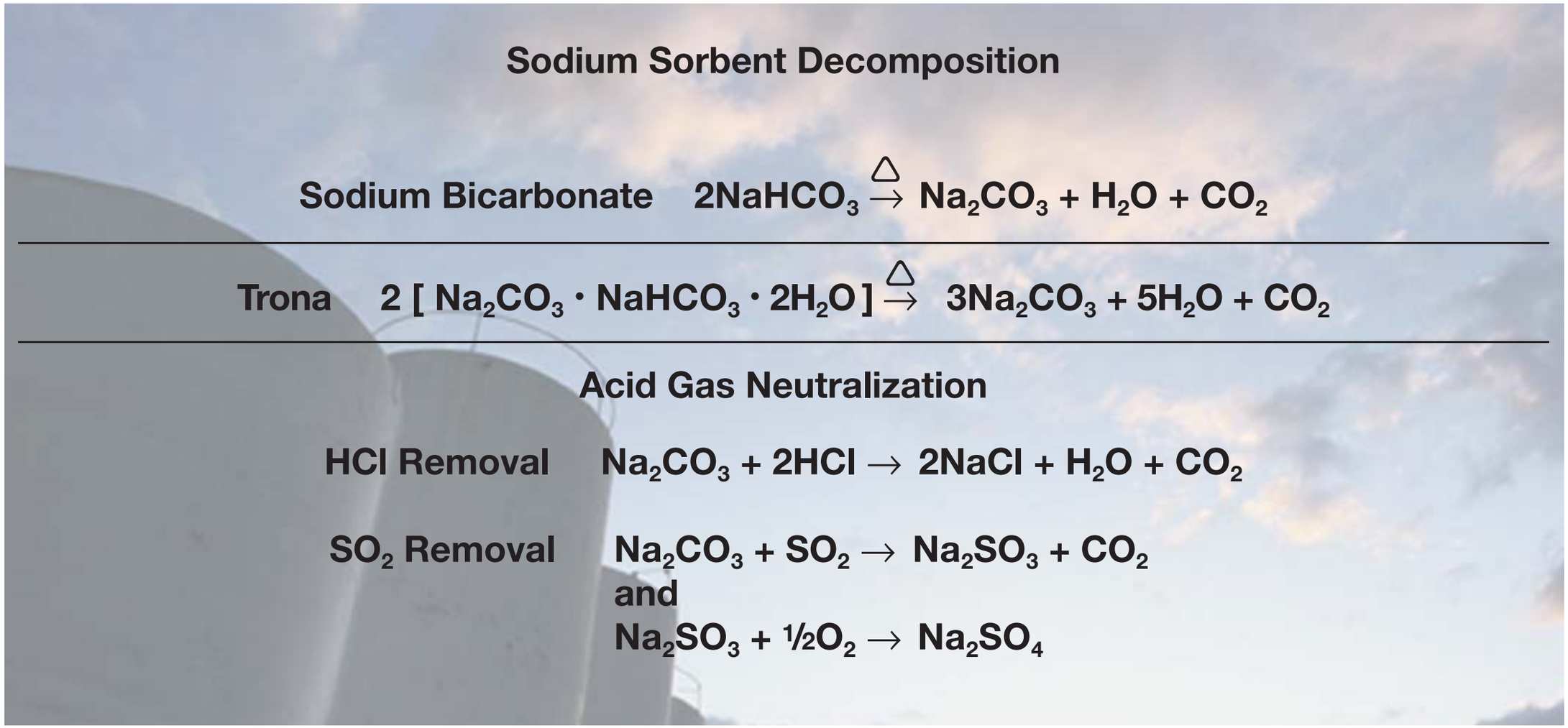
- **Today, STM has more sorbent mill installations than any other mill supplier, exceeding 500 installations.**

STM Serial No. 1. Reggio Emilia Incinerator, Italy

Latest STM Hammermill Design

Na Sorbent Decomposition

Behavior of Sodium Sorbents at Temperature



Slide Courtesy of Solvay

Gas Cleaning Systems

Optimal System for Each Application

Combustion Process	Sodium Sorbent Type	
	Sodium Bicarbonate	Trona
Industrial and Hazardous Waste Incineration	•	
Biomass	•	
Cement		•
Power	•	•
Water Treatment		
Metals Recovery Furnace	•	
Cremation	•	
General Combustion: Heavy Fuel Oil and Natural Gas	•	•
Municipal and Hospital Waste Incineration	•	•
Steel and Foundries	•	•
Glass	•	

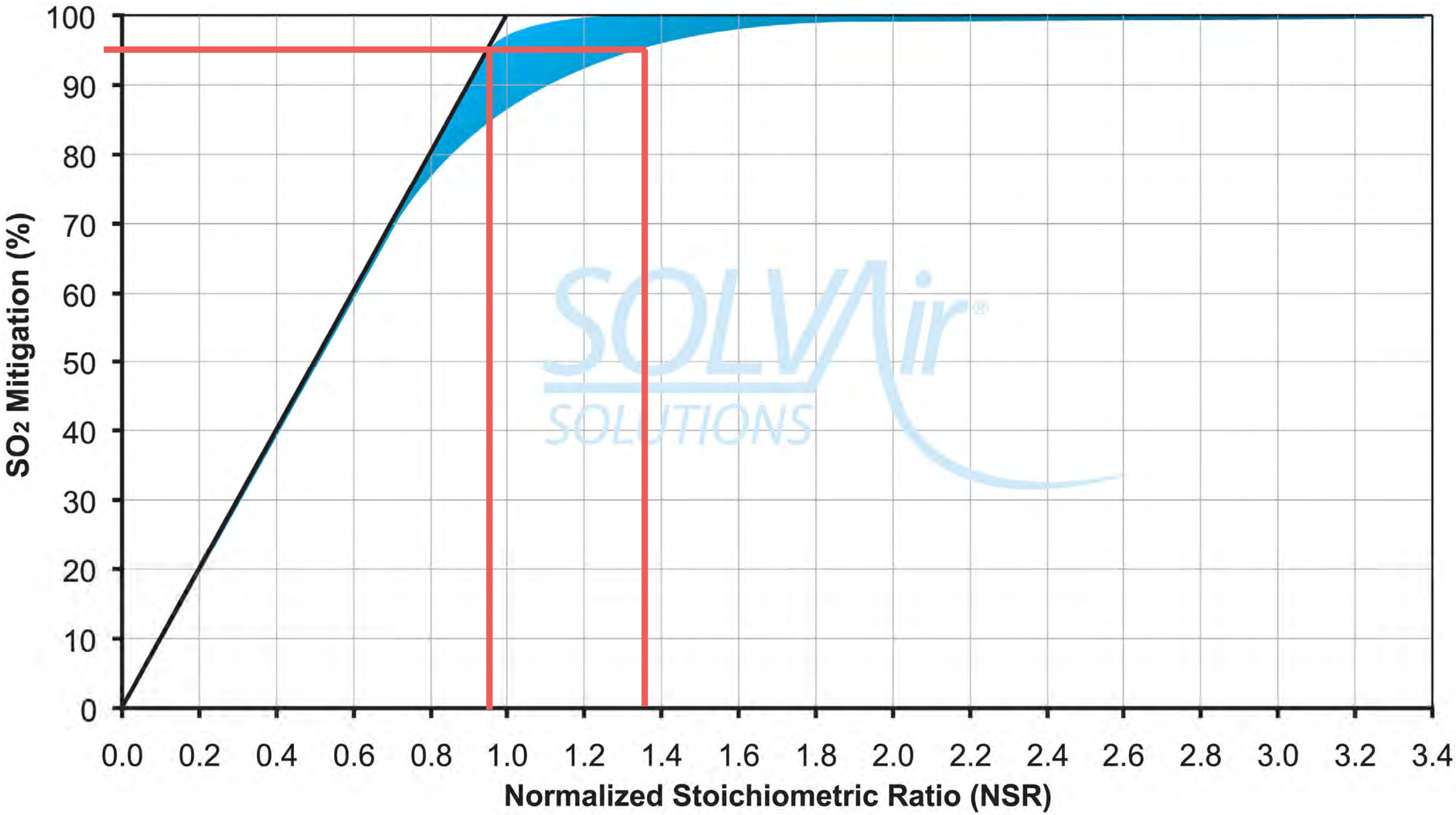
Gas Cleaning Comparison

Characteristics of Various Sodium Sorbents

	Sodium Bicarbonate	Trona
Stoichiometric Ratio	0.8-1.4	1.8-2.5
Gas Temperature	120-400 °C	135-800 °C
Reaction Time	>2 Sec	>4 Sec
HCl Efficiency	>99%	>95%
SO_2 Efficiency	>98%	>90%
SO_3 Efficiency	>98%	>95%

Na Performance curve

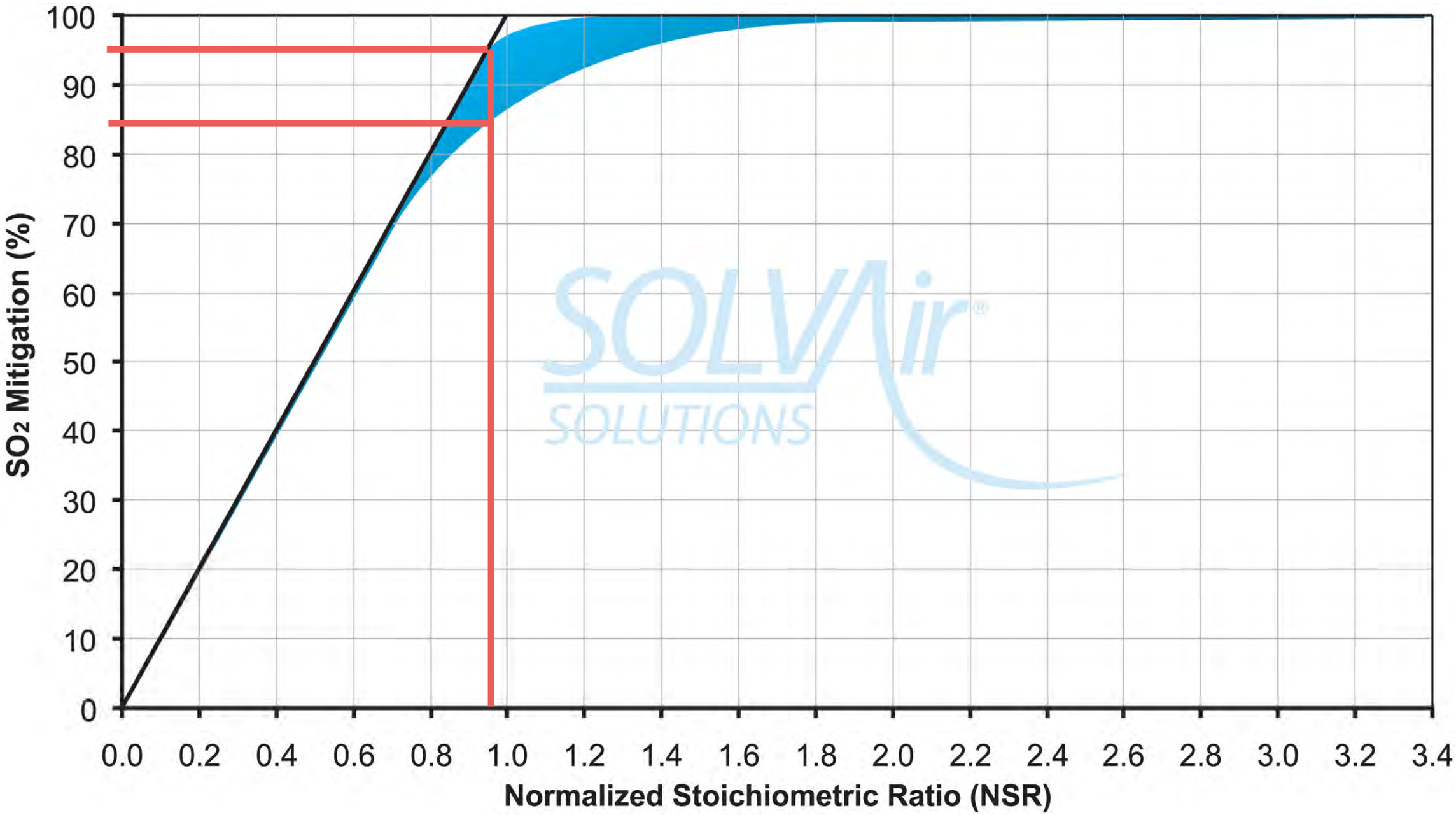
Variations in Stoichiometry for a Given Efficiency



Slide Courtesy of Solvay

Na Performance curve

Variations in Efficiency for a Given Stoichiometry

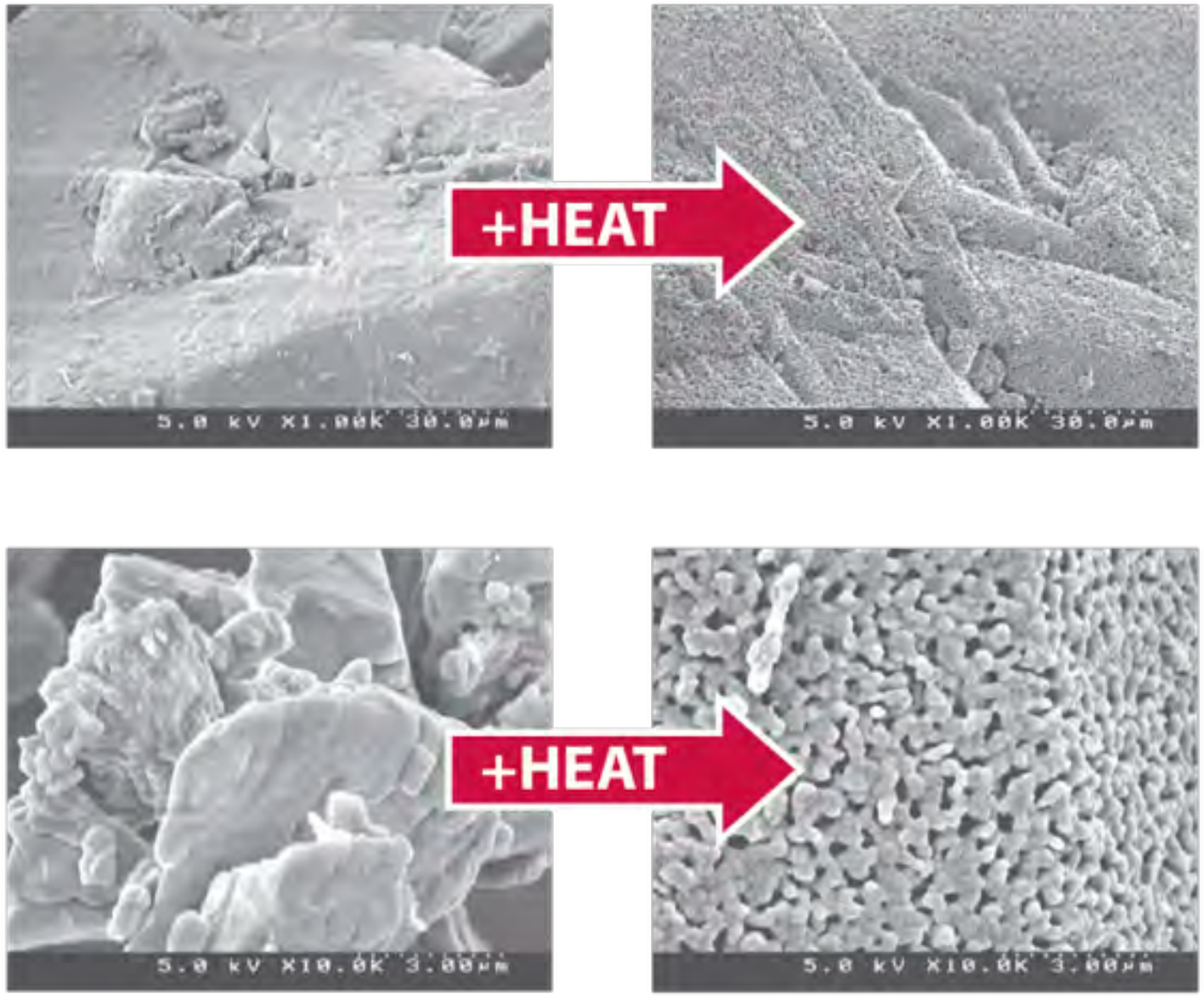


Slide Courtesy of Solvay

Na Calcining

Calcination occurs at elevated temperatures

$$2\,NaHCO_3 \xrightarrow{+HEAT} Na_2CO_3 + CO_2 + H_2O$$

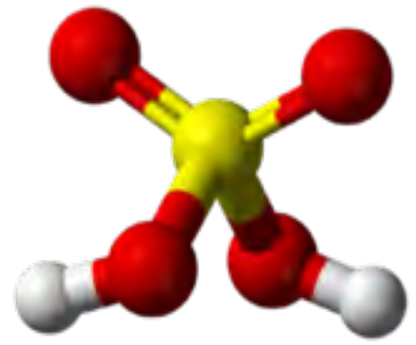


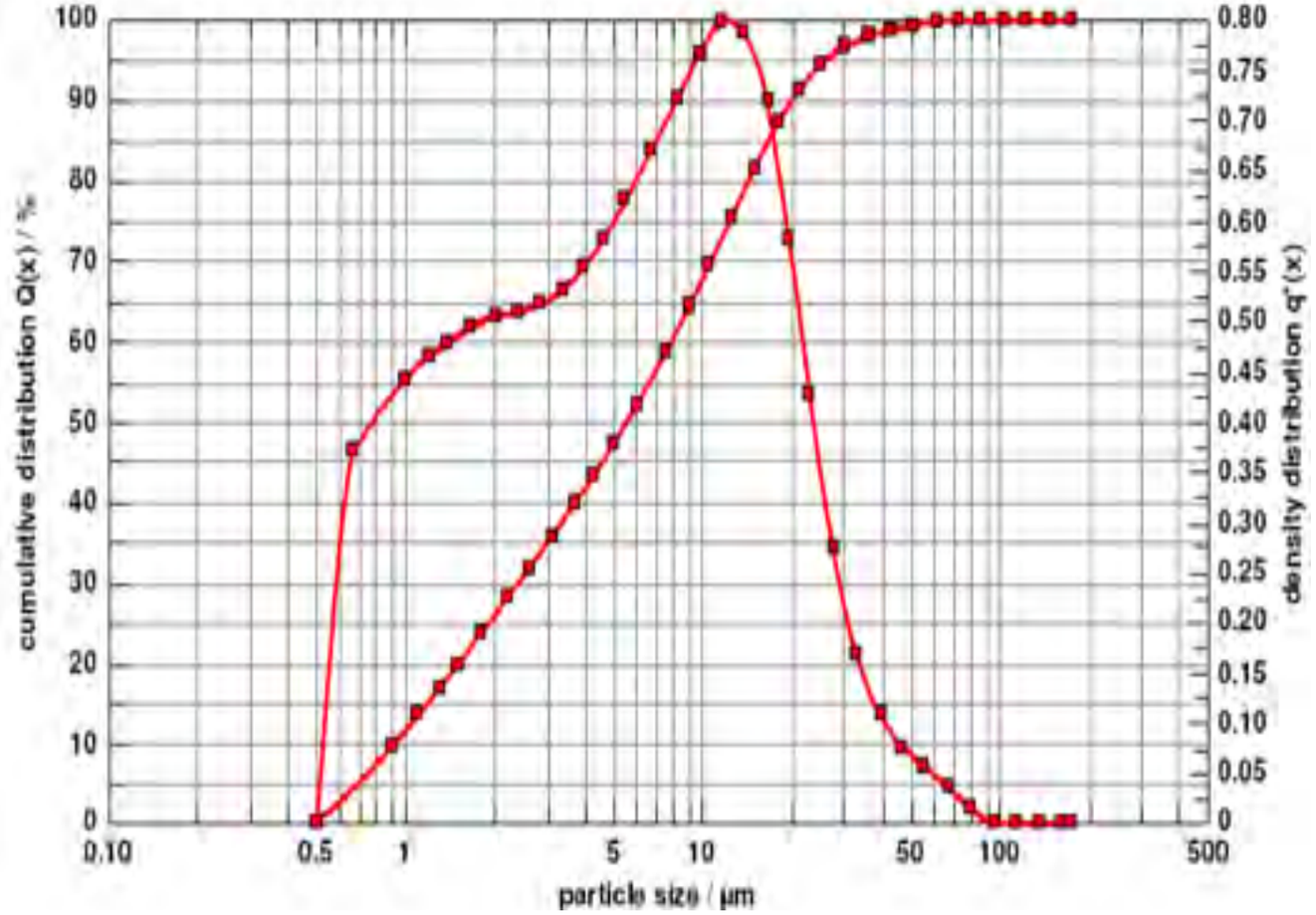
Slide Courtesy of Tata Chemicals

Sorbent Particle Size

Particle Size for SO_2 Removal

20 µm PARTICLE SIZE		
x_{10} = 0.93µm	x_{50} = 5.60µm	x_{90} = 20.15µm
x_{97} = 32.29µm	x_{98} = 37.55µm	x_{99} = 48.14µm

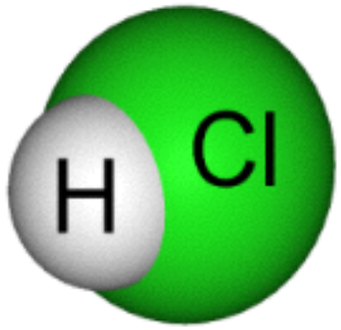


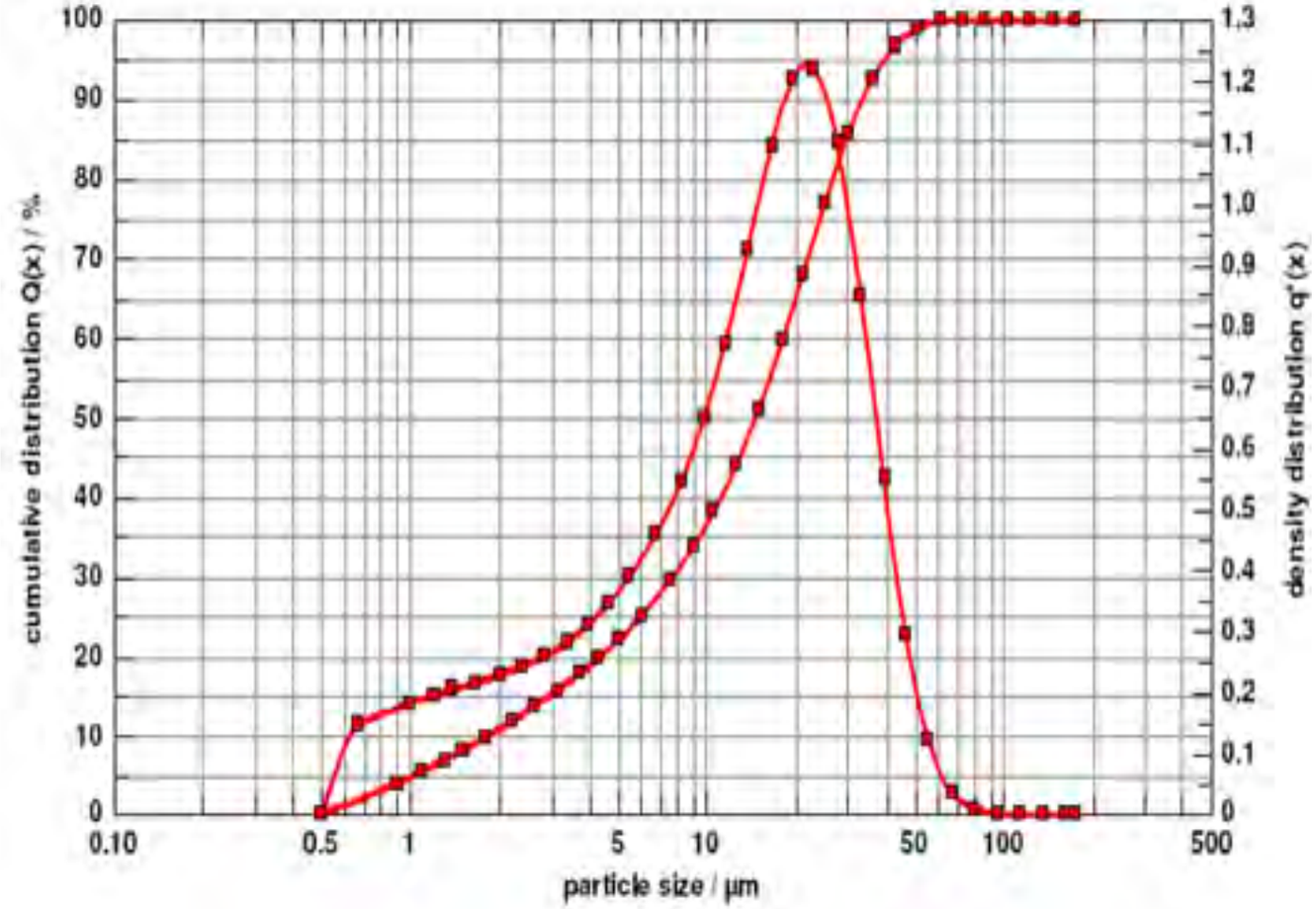


Sorbent Particle Size

Particle Size for HCl Removal

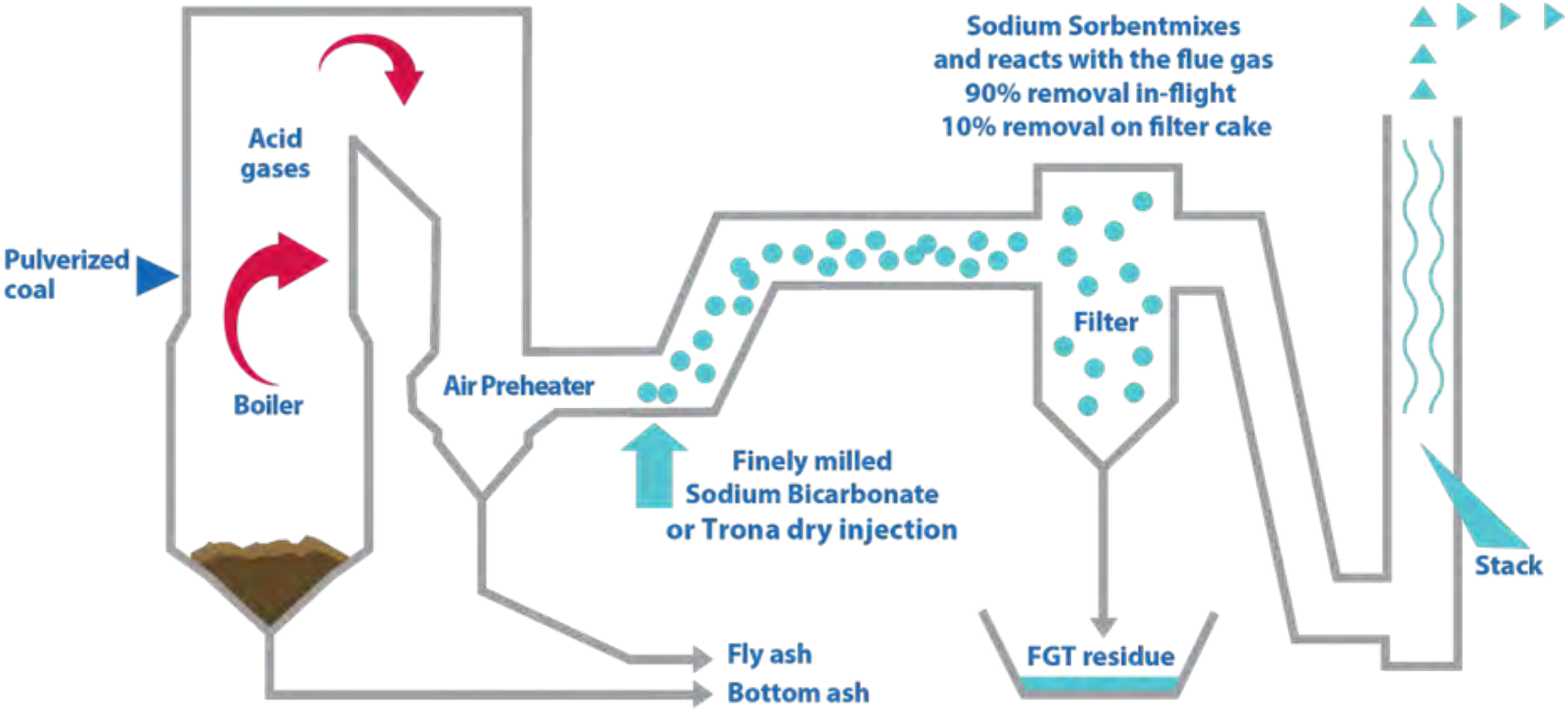
30 µm PARTICLE SIZE		
x_{10} = 1.87µm	x_{50} = 14.64µm	x_{90} = 33.88µm
x_{97} = 44.47µm	x_{98} = 48.19µm	x_{99} = 53.62µm





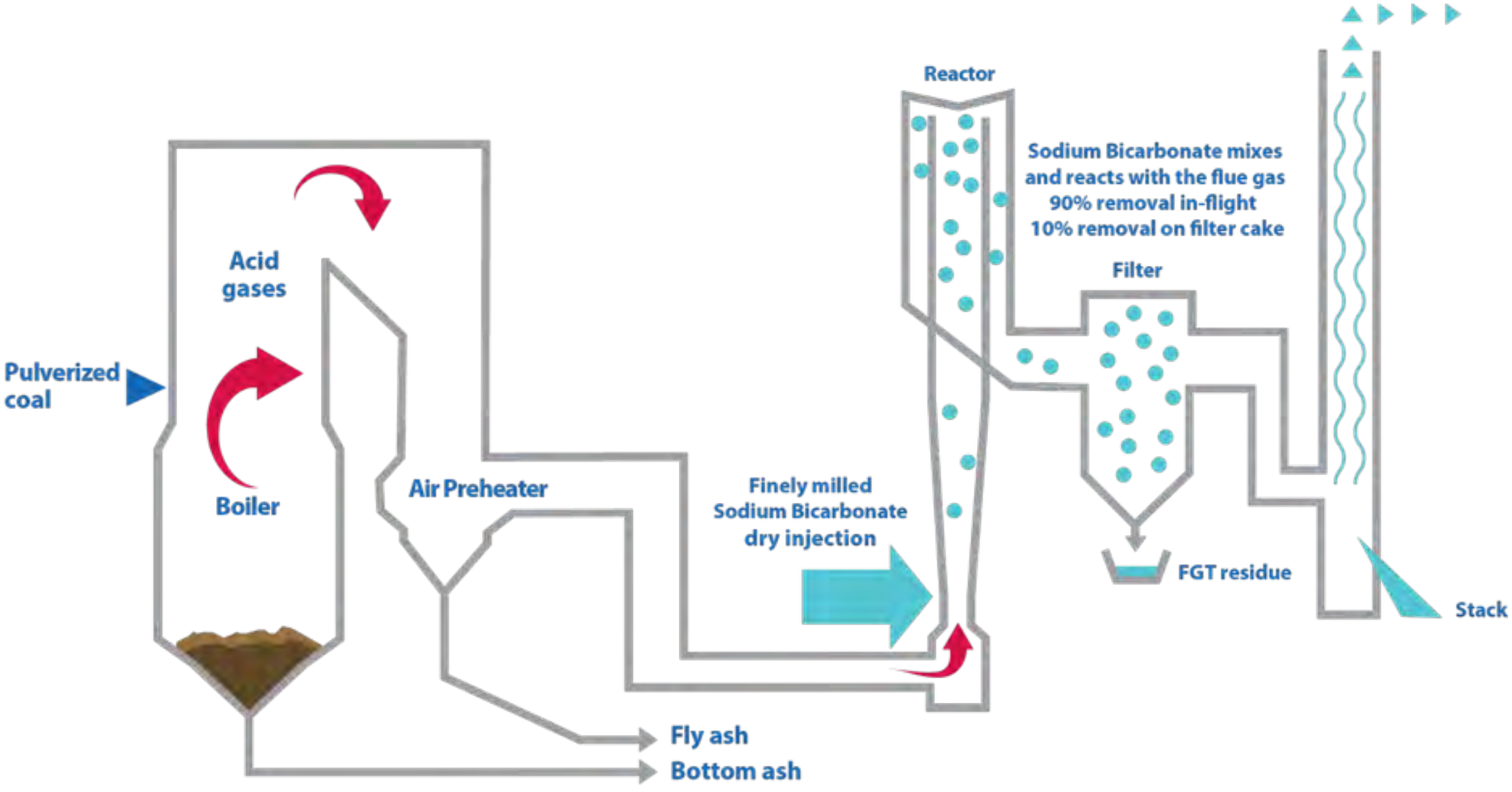
Sorbent Injection

Flowsheet for PC-fired Boiler with Duct Injection



Sorbent Injection

Flowsheet for PC-fired Boiler with Reactor



Sorbent Injection

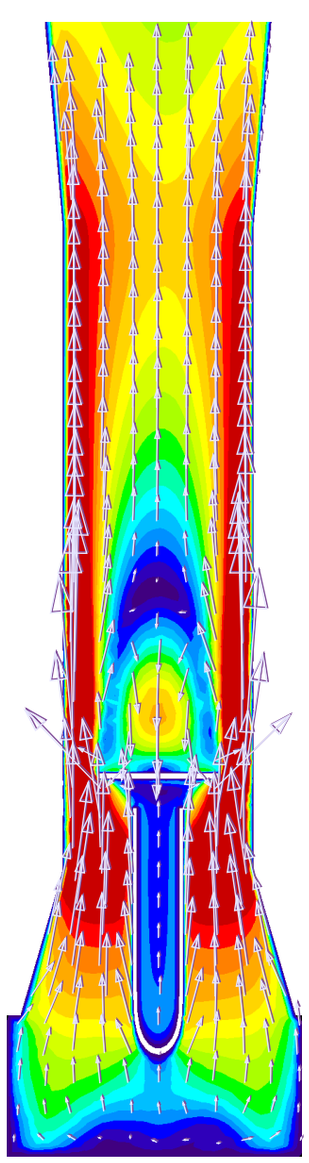
Typical Reactor Designs

Single Pass Reactor

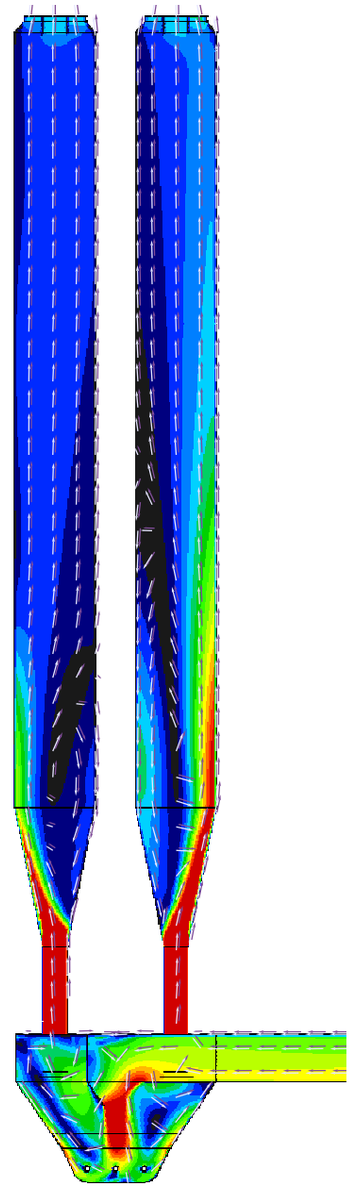
Double Pass Reactor

CFD Optimization

Need for Distribution Analysis



Single Pass Reactor



Double Pass Reactor

Efficiency Factors

Some of the Factors that Affect Acid Gas Removal

- **Gas Flow Factors**
  - Temperature
  - Mixing (turbulence)
  - Distribution
- **Sorbent Factors**
  - Particle Size
  - Purity
  - Material Integrity

Milled Sorbent Challenges

On-site Particle Size Reduction vs. Pre-milled

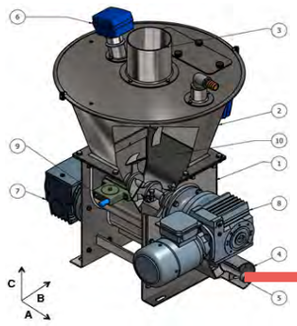
- **Pre-milled**
  - Storage silo release
  - Materials handling and transport
  - Particle size (clumping)
- **On-site Milling**
  - Maintenance
  - Particle size consistency
  - Operational issues (difficult to keep clean)

Basic Milling Technology

Dose, Mill, Classify, Propel

- **Components required for a properly working milling circuit**

Dosing Element



Raw Sorbent Feed

Propulstion Element

Propulsion Air

Grinding Element

Milled Sorbent

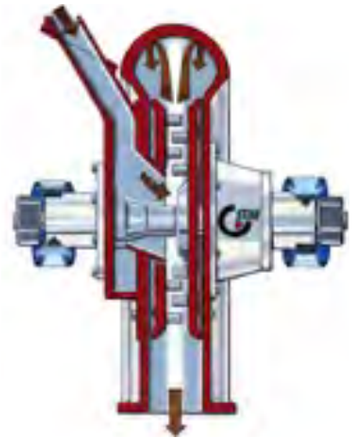
to Duct or Reactor

Separation Element

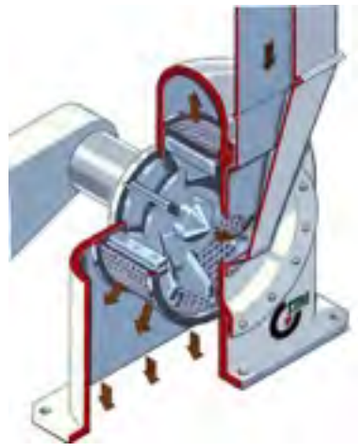
Basic Mill Technology

What mills have been used before?

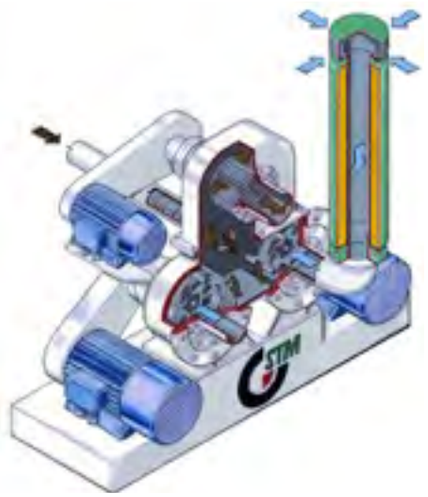
- **Pin Mill**
  - Uses pins rotating on rotors



- **Screen Mill**
  - Uses hammers rotating against a screen



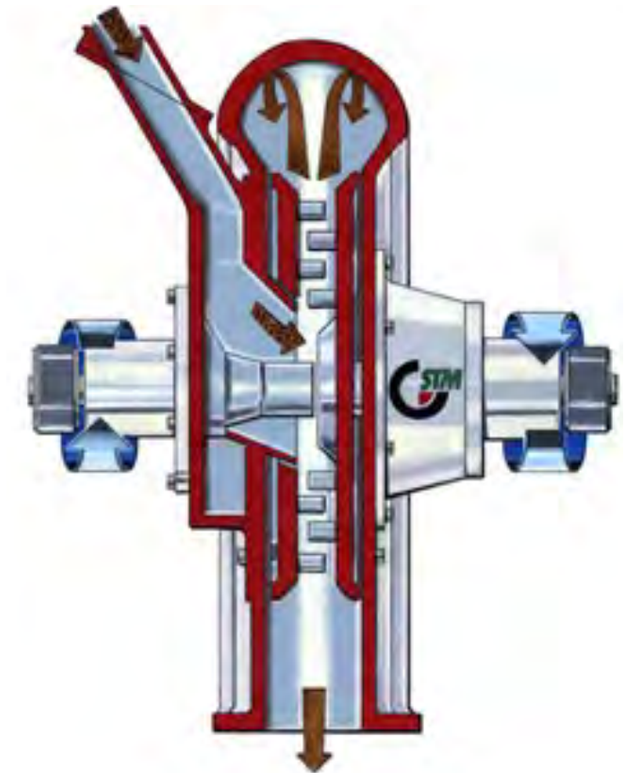
- **Hammer Mill**
  - Uses hammers rotating against a track



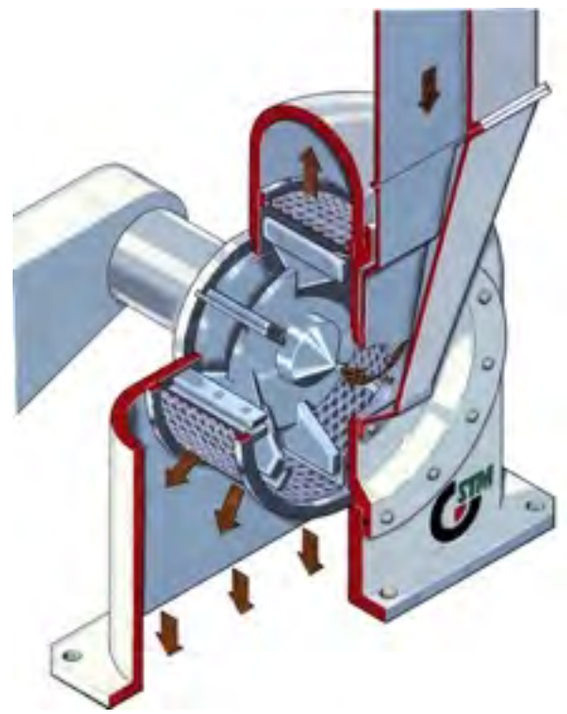
Basic Mill Comparison

Mills that should not be used and why

- **Pin Mill:**
  - Prone to build-up
  - Difficult to clean pins online
  - Requires frequent and long interventions
  - No classifier to separate fine particles



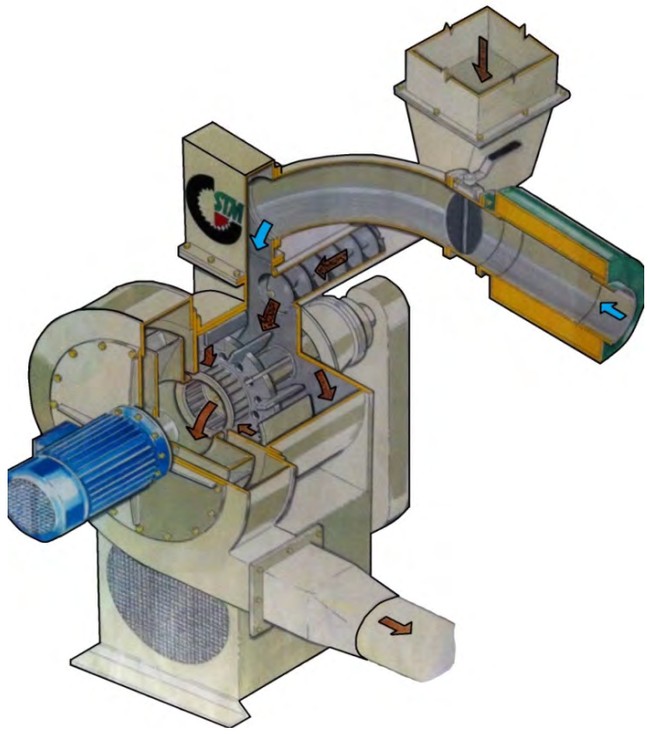
- **Screen Mill:**
  - Prone to build-up
  - Difficult to clean online
  - Requires frequent cleanings
  - No classifier to separate fine particles



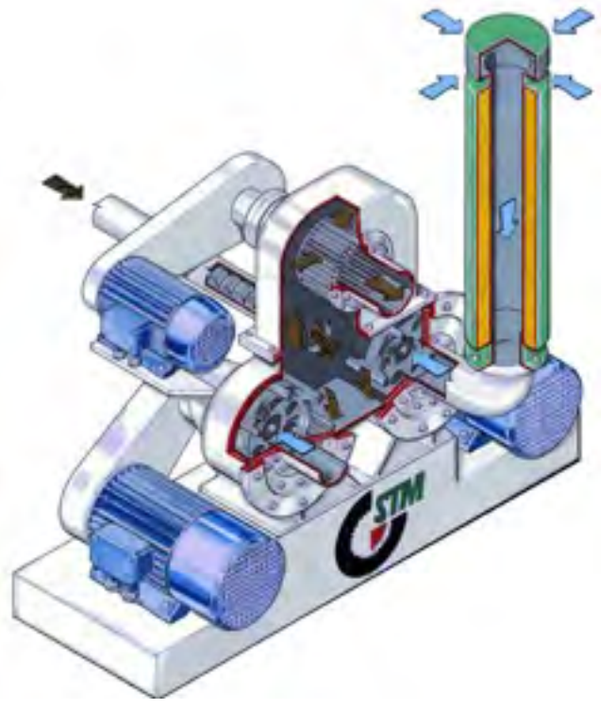
Basic Mill Comparison

Mills that could be used and why

- **Compact Hammer Mill:**
  - Easy to keep clean with glycol addition
  - Requires little maintenance
  - Built-in propulsion fan - negative pressure
  - Self classifier to separate fine particles



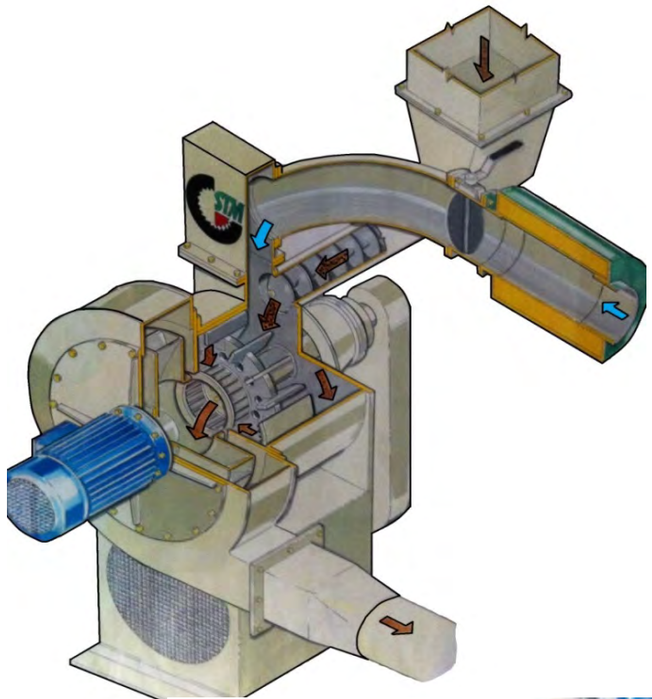
- **Twin Rotor Hammer Mill:**
  - Not as prone to build-up
  - Easy to clean and maintain
  - Twin rotors for higher production
  - Separate dynamic classifier



Compact Mill

Self-classifying, compact design

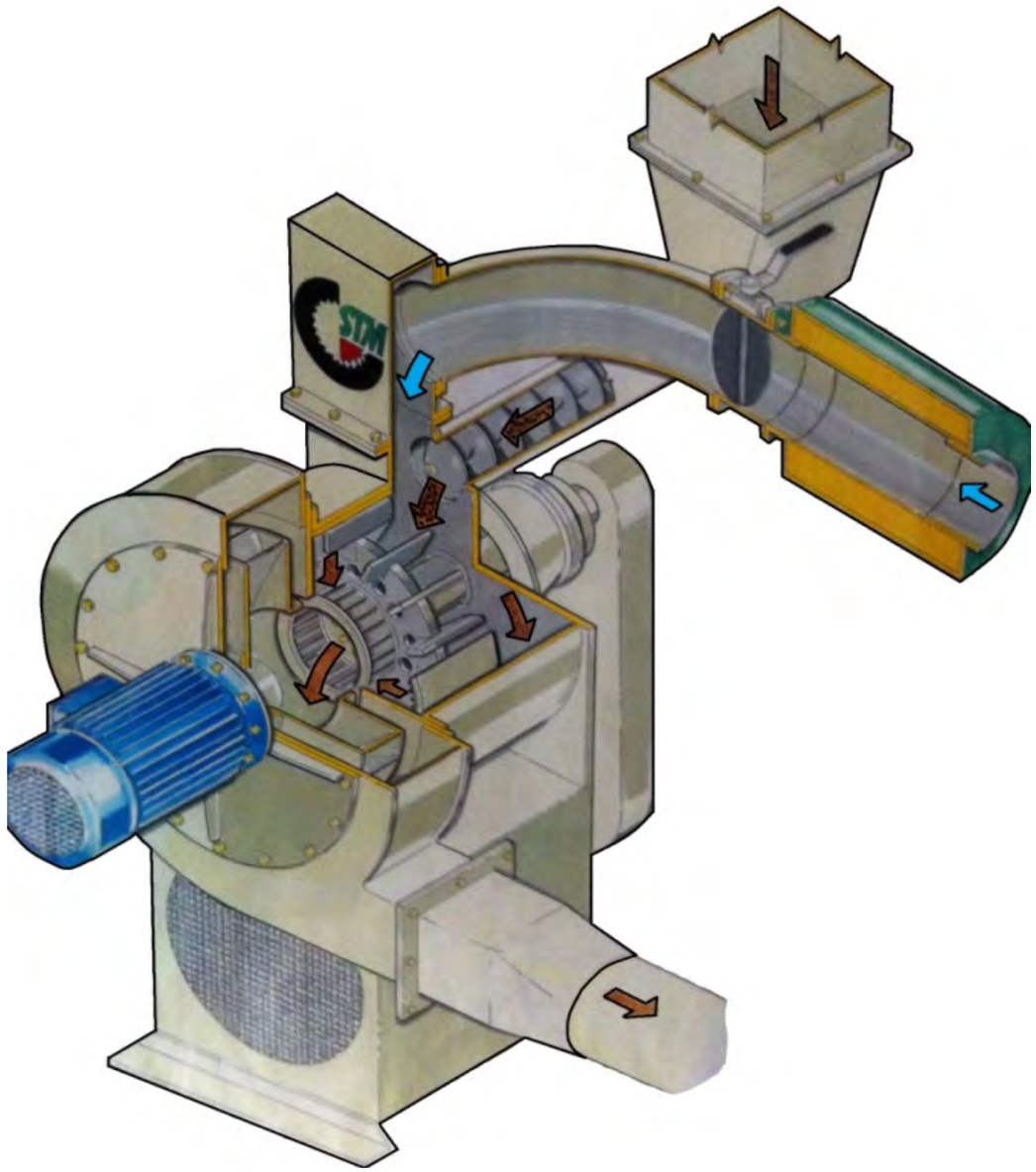
- **Flow-through, self-classifying mill coupled to a transport air fan. The self-classifying design makes it a good choice for applications where narrow particle size distribution is not critical.**
- **Ideal for low-cost retrofit applications.**
- **Operational advantages:**
  - Low energy consumption
  - Minimal maintenance needs
  - Compact, small space requirement
  - Ease of installation
  - Automatic operation



Compact Mill Limitations

Design limitations of a compact hammer mill

- **Limited size single rotor**
  - Limits production rate
  - Requires higher velocity
  - Typically used in smaller installations
- **In-line classifier**
  - Imperfect control over particle size distribution
  - D_{50} particle size ±10-15 µm
  - D_{90} particle size ±35-40 µm



Basic Twin Hammer Mill

Air classifying, twin rotor design

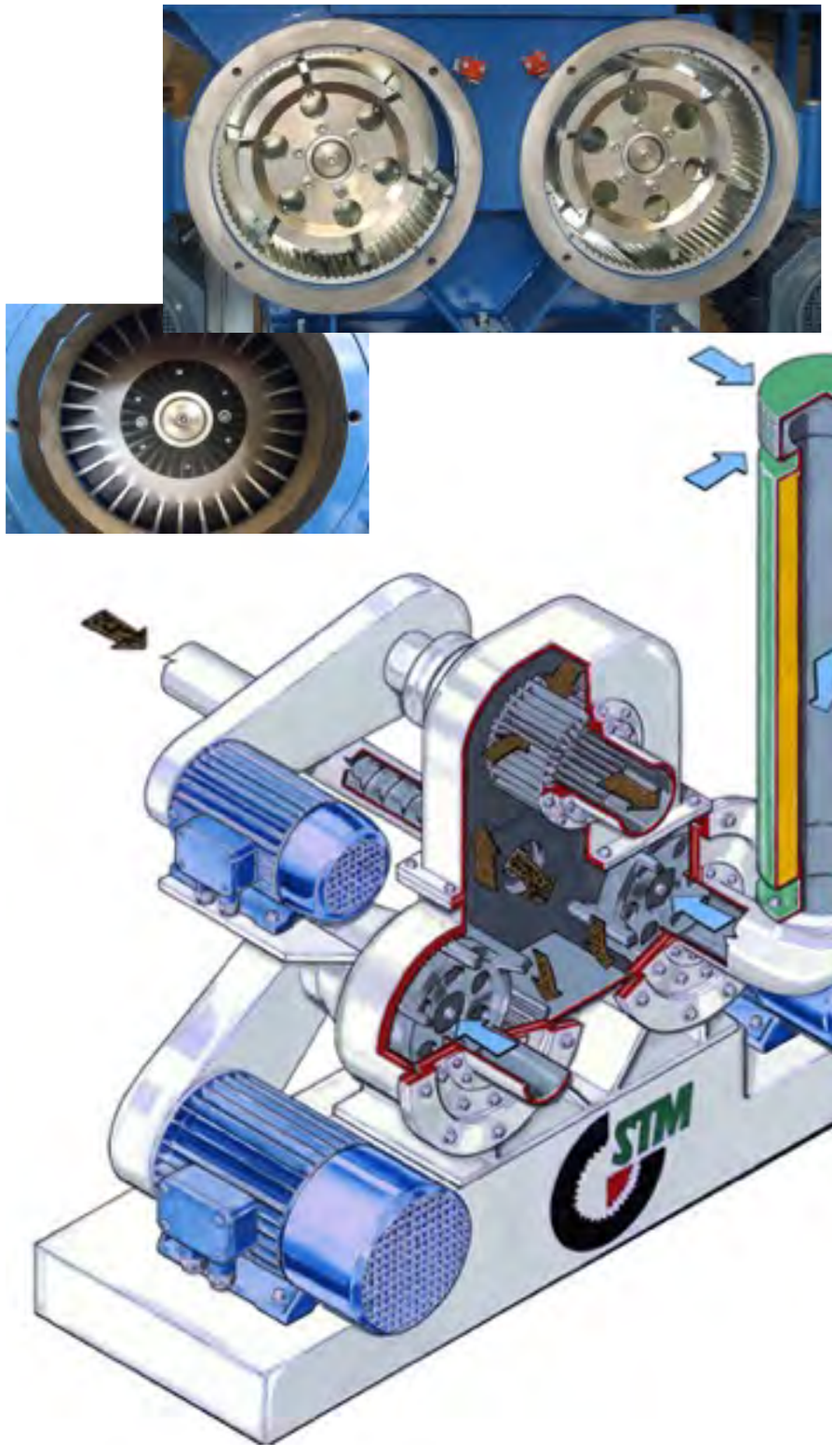
- **Twin rotor, air-classifying mill with a separate transport air fan. The twin rotor design makes it a good choice for applications where mill temperature and particle integrity is not critical, such as calcium-based materials.**
- **Ideal for medium/large gas cleaning plants and for low-cost retrofit applications.**
- **Operational advantages:**
  - Low energy consumption
  - Minimal maintenance needs
  - Compact, small space requirement
  - Ease of installation
  - Automatic operation

Basic Hammer Mill

Hammer Mill Limitations

Mills that could be used and why

- **Older generation mill**
- **Medium size twin rotors**
  - Limits production rate
  - Requires higher velocities
- **Dynamic classifier**
  - Better control over particle size distribution
  - D_{97} particle size ±15-20 µm
- **Significant heat build-up**
  - Like all ACMs, heat build-up makes it less desirable for milling sodium

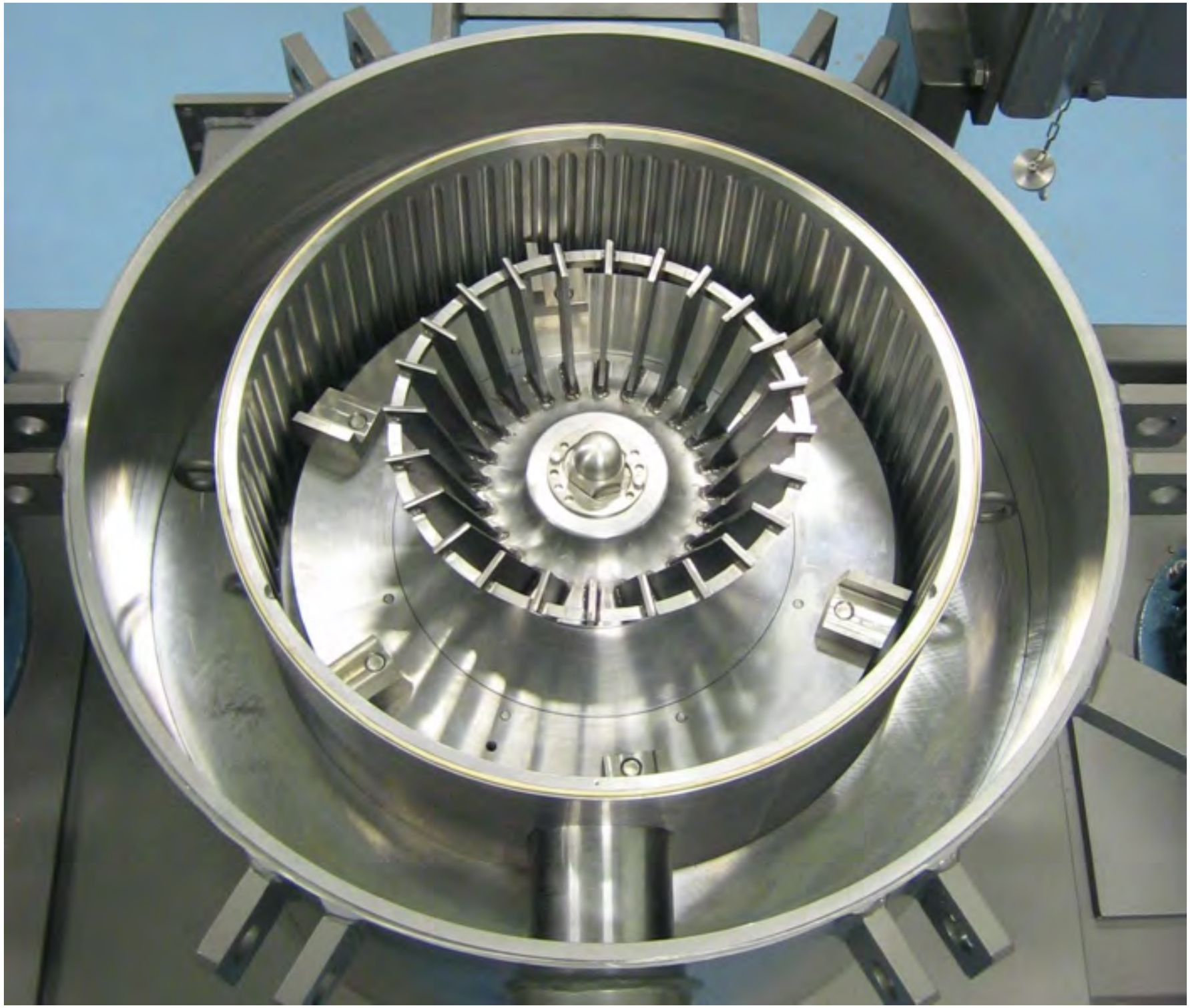


Typical ACM

Popular Air Classified Mill Design for Sorbent Milling

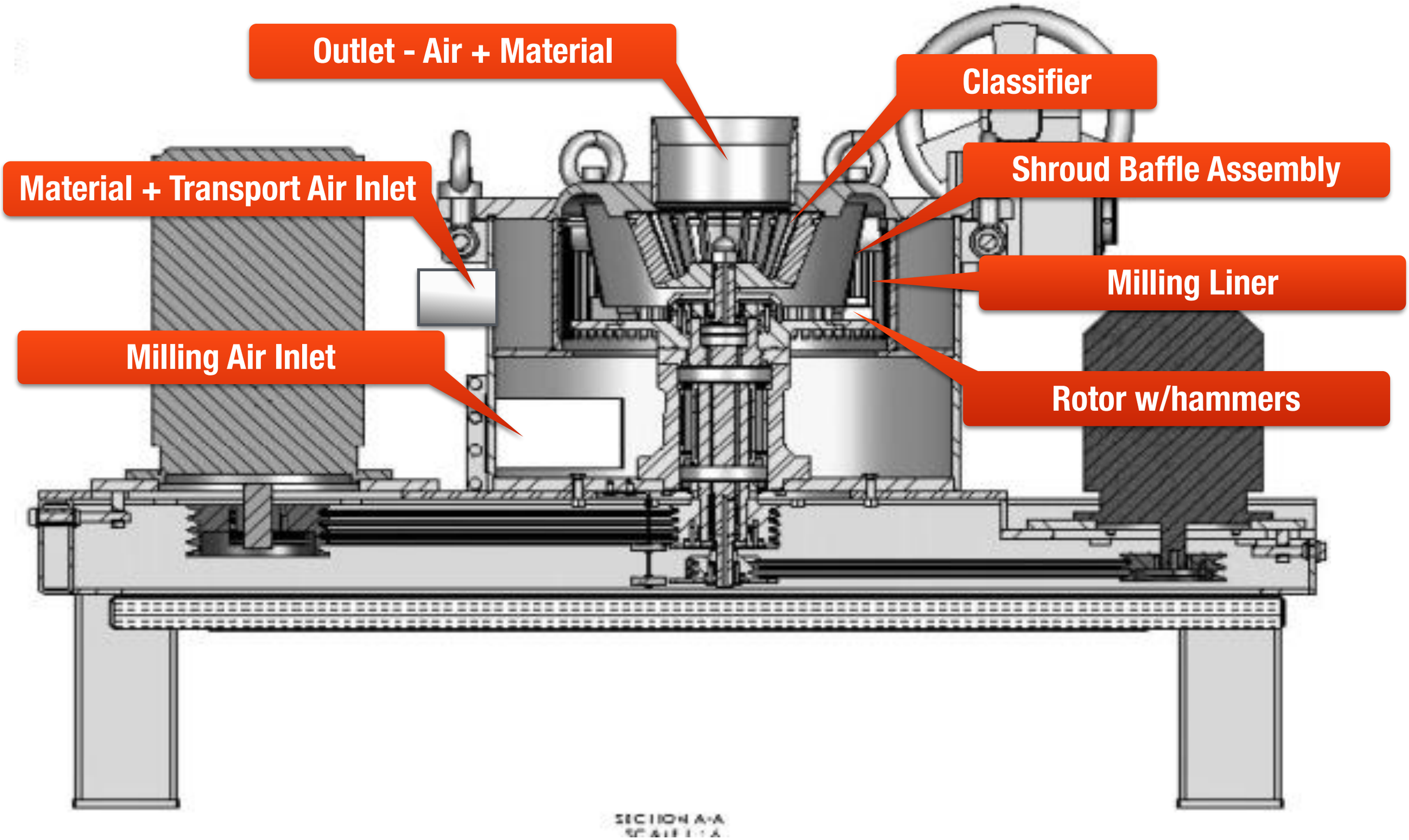
Typical ACM

Air Classified Mill Internals



Typical ACM

Air Classified Mill - Design



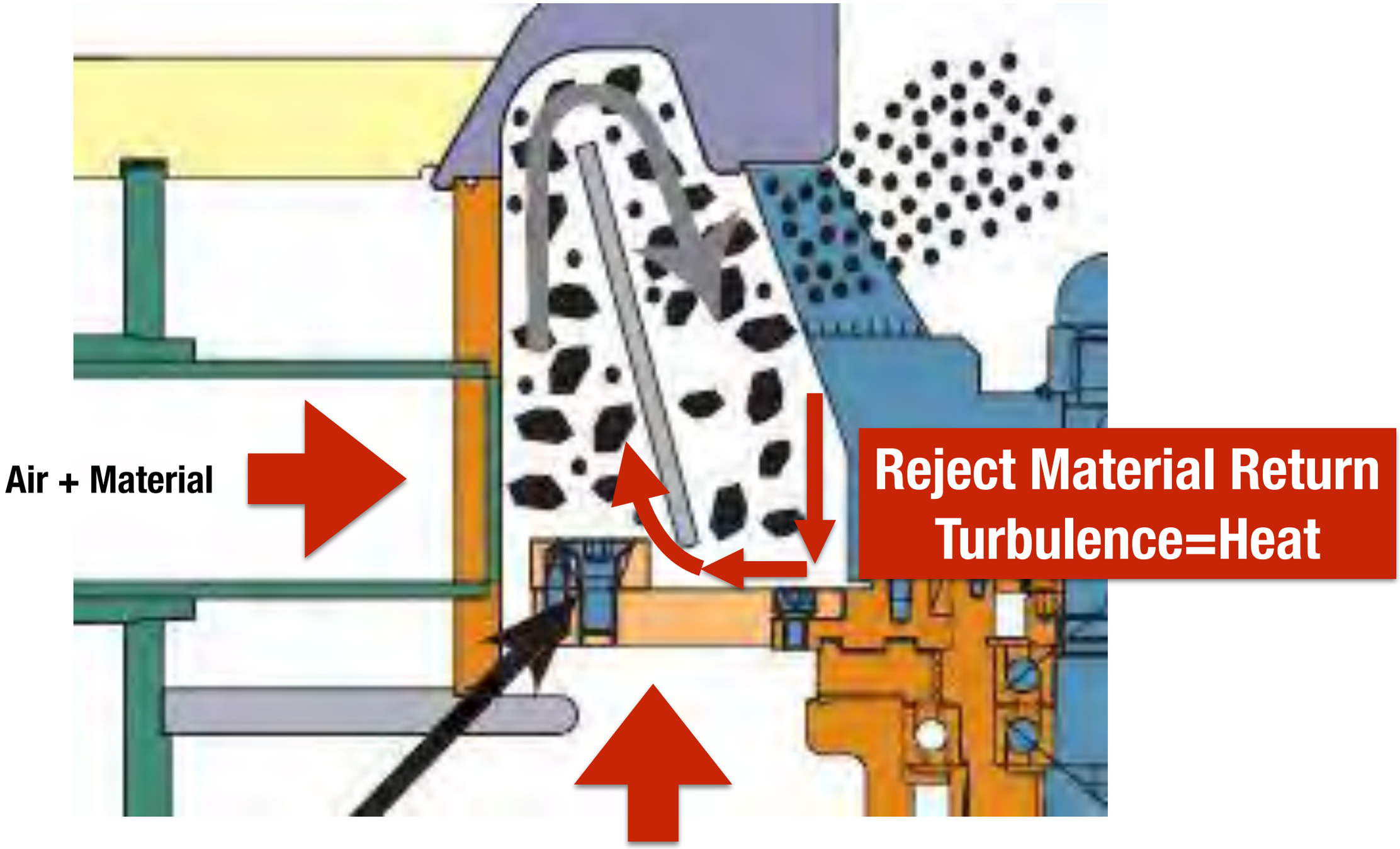
Other Hammermills

Competitive Mill - Positive Pressure and Excess Heat

- **Older generation mill**
- **Shroud baffle assembly**
  - Requires that first pass milled material flow around it
  - Designed to create circuit for rejects to return to mill hammers
  - Flow field around shroud baffle plate causes excess heat
- **Dynamic classifier**
  - Better control over particle size distribution
  - D_{97} particle size ±15-20 µm
- **Significant material build-up**
  - Heat causes build-up making it less desirable for milling sodium

Other Hammermills

Competitive Mill - Positive Pressure Operation



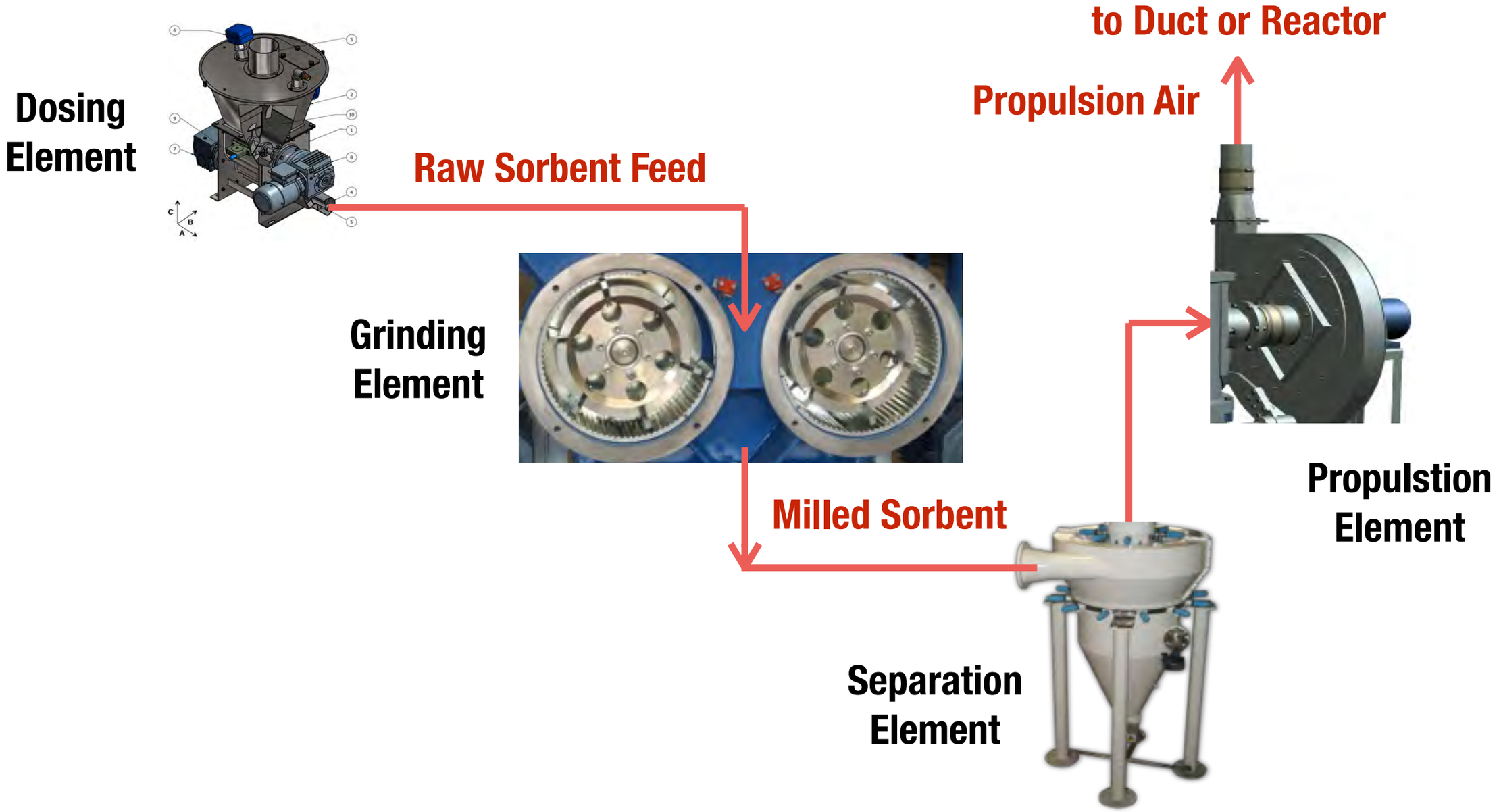
Other Hammermills

Competitive Mill - Positive Pressure Operation

Basic Milling Technology

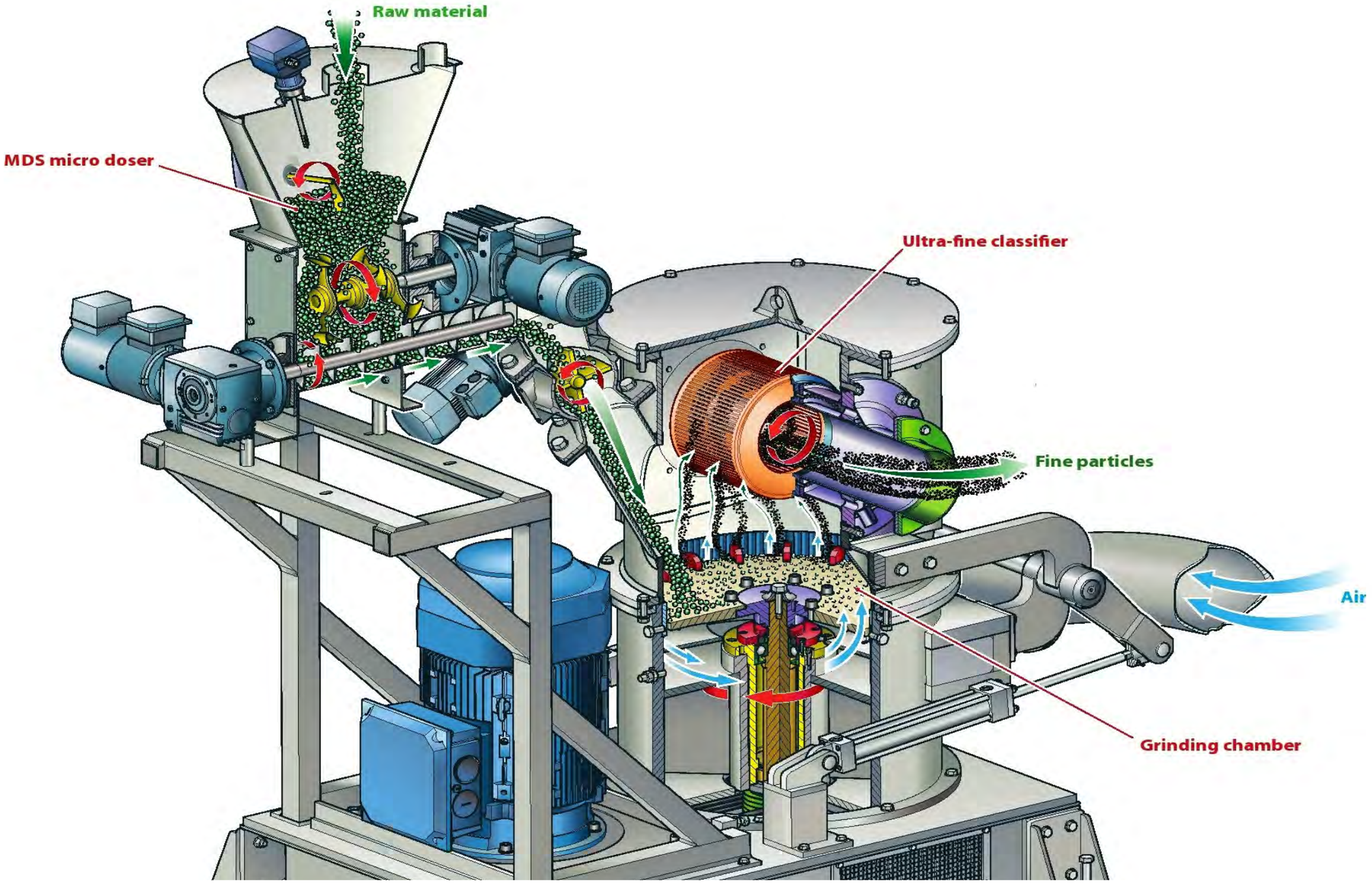
Dose, Mill, Classify, Propel

- **Components required for a properly working milling circuit - Rearranged**



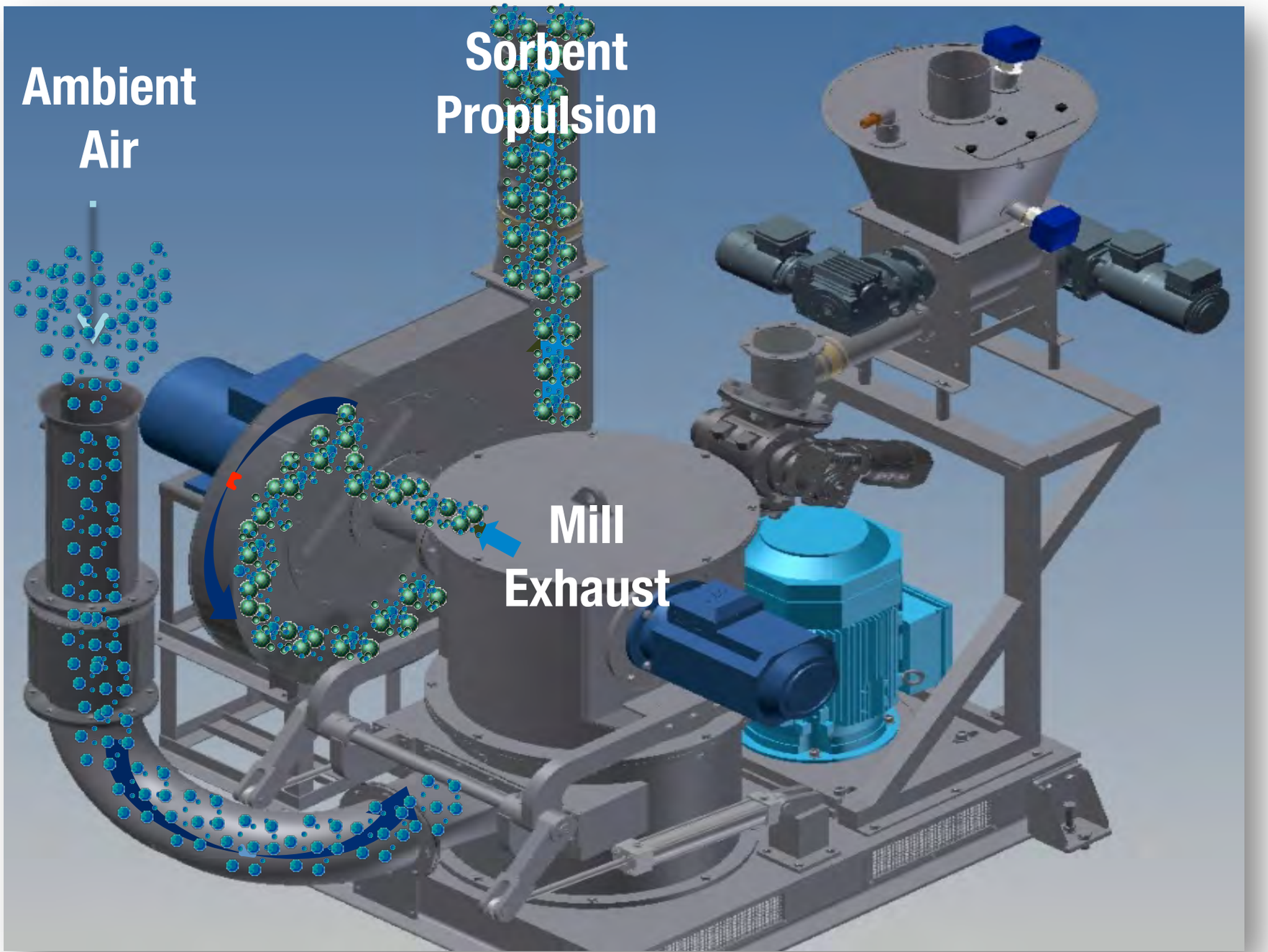
Smart Mill

Operational Schematic



Smart Mill

Airflow Schematic



Bicarmill Smart Hammermill

Negative Pressure and Heat / Build-up Control

- **Newest generation hammer mill**
- **No shroud baffle assembly**
  - Has its own circuit for rejects to return to mill hammers
  - No turbulence to create excess heat
- **Dynamic classifier**
  - Better control over particle size distribution
  - D_{97} particle size ±10-15 µm
- **No material build up**
  - Heat build-up makes it less desirable for milling sodium

Smart Hammermill

The Guts

- **Full-feature classifying mill coupled to a transport air fan.**
- **Operational features:**
  - High energy efficiency
  - Low noise emissions
  - Minimal maintenance needs
  - Compact, small space requirement
  - High reliability and quality
  - Ease of maintenance

Basic Smart Mill Mechanical Components

Features of a Smart Mill

Smart Bicarbonate Hammermill Functions

- **Temperature control**
- **Airflow control**
- **Dosing control**
- **Separating control**
- **Build up control with glycol**

Auto-greasing Operation

Built-in Airflow Sensor

Built-in Vibration Sensor

Built-in Temperature Sensor

STM Smart Mill Technology

Enclosed Smart Mill with 8400 Hour Online Guarantee

- **Classifying mill coupled to a transport air fan, complete with controller for all functions of a milling circuit.**
- **Is able to guarantee online operation without stopping for a minimum of <u>8400 hours</u>.**
- **Main features of a smart mill:**
  - Packaged machine with controller
  - Low noise emissions
  - Automatic operation - on-board instrumentation
  - Low maintenance - all external access
  - High reliability and quality
  - Alarming features

BicarMill Smart Mill

Technical Data Bicarmill

Equipment Specifications and Capacity

Model	Installed Power	Absorbed Power	Capacity*	Acid Gas	Particle Size	Air Flow	Pressure	Noise
Type/Size	kW	kW	Range kg/h	Type	Range µm	m^3/h	mm H_2O	dbA
JCF 300	18.4	16.6	10-250	HCl SO_2	d_{90}<30µm - d_{50}<10µm d_{90}<20µm - d_{50}<5µm	800	500	<75
JCF 400	29.2	26.3	40-450	HCl SO_2	d_{90}<30µm - d_{50}<10µm d_{90}<20µm - d_{50}<5µm	1500	800	<75
JCF 630	64.2	57.8	100-1000	HCl SO_2	d_{90}<30µm - d_{50}<10µm d_{90}<20µm - d_{50}<5µm	2700	800	<75
JCF 800	98.0	88.2	100-1400	HCl SO_2	d_{90}<30µm - d_{50}<10µm d_{90}<20µm - d_{50}<5µm	4700	1000	<75
JCF 1000	129.0	116.1	100-1800	HCl SO_2	d_{90}<30µm - d_{50}<10µm d_{90}<20µm - d_{50}<5µm	6000	1000	<75
JCF 1250	205.0	188.7	120-2925	HCl SO_2	d_{90}<30µm - d_{50}<10µm d_{90}<20µm - d_{50}<5µm	9750	1000	<75
JCF 1500	284.0	261.2	150-4050	HCl SO_2	d_{90}<30µm - d_{50}<10µm d_{90}<20µm - d_{50}<5µm	13500	1000	<75

***Capacities Stated for Sodium Bicarbonate**

Smart Mill

Mill with Pneumatic Cylinder Removal Assist

BicarMill 630

Smart Mill with Automatic Control System

Smart Mill

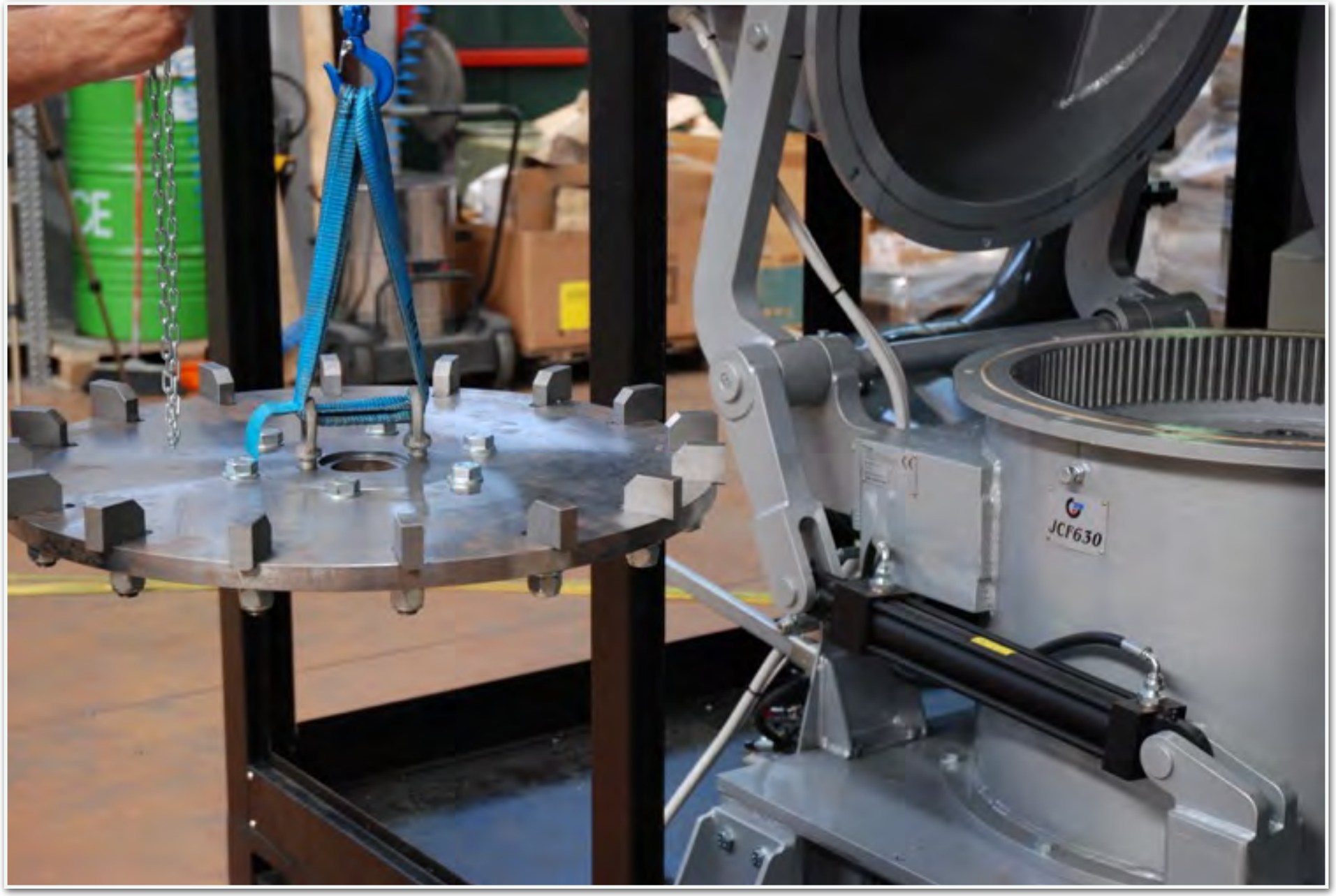
Internal View of Doser and Mill with Pneumatic Open Assist

Smart Mill

Internal View of Doser and Mill with Hoist Assembly

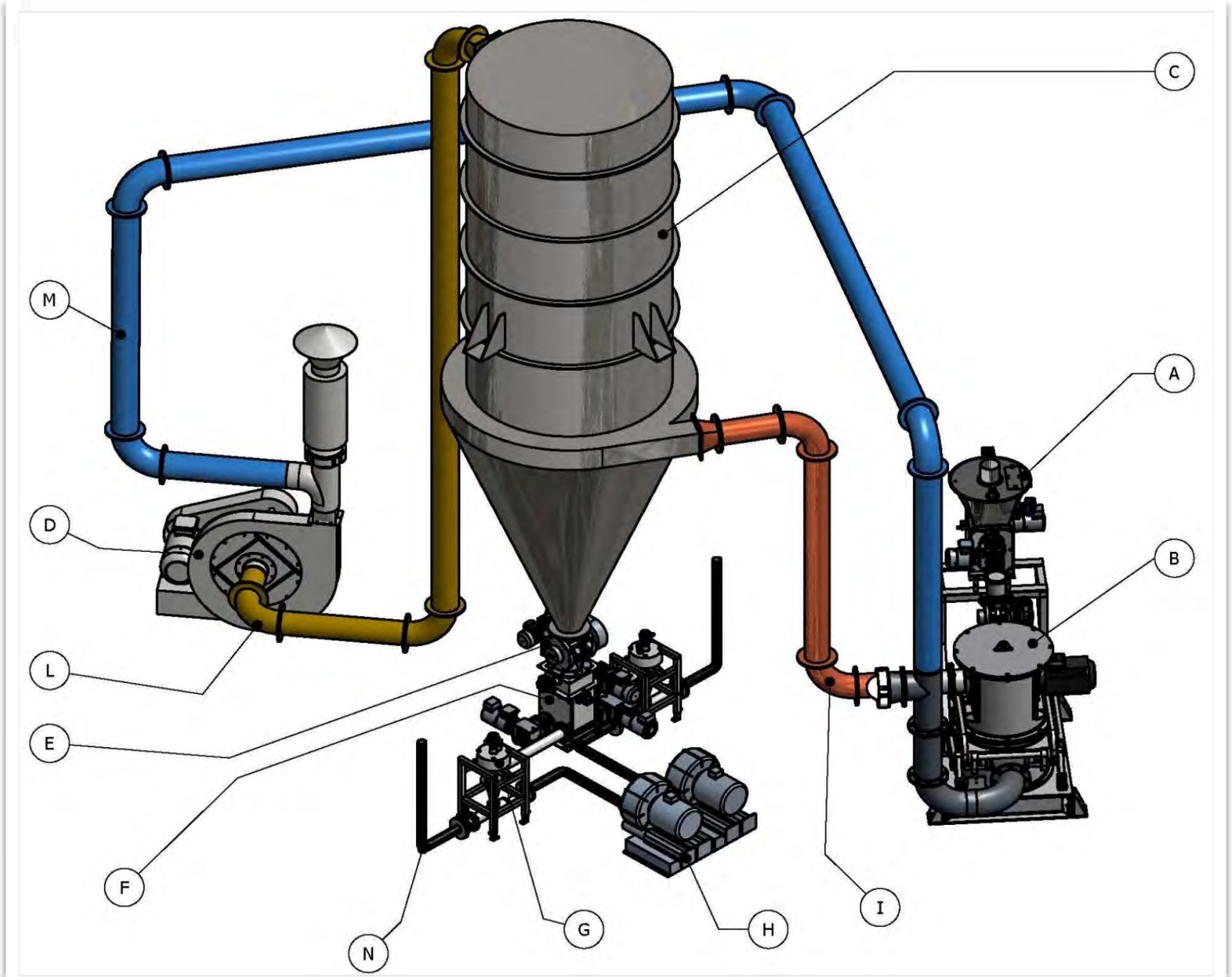
Smart Mill

Rotor Disc Removal with Hoist Assembly



Smart Mill Indirect Injection

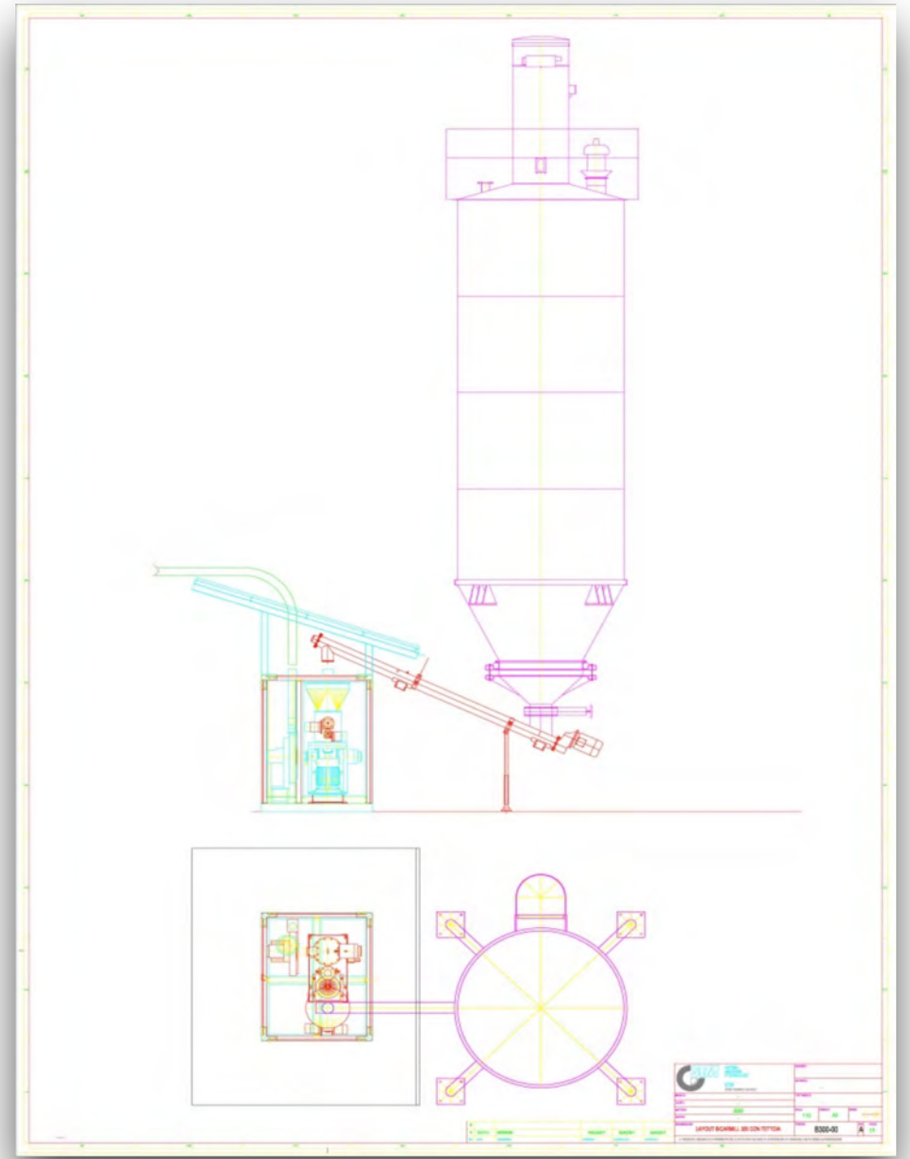
Smart Mill with Multiple Dosing Units



A - Dosing System
B - Mill
C - Filter/Reciever
D - Suction Fan
E - Rotary Valve
F - Double Dosing System
G - Eductor Venturi
H - Regenerative Blower
I - Mill to Filter Duct
L - Filter to Fan Duct
M - Air Recycle Loop
N - Injection Point Piping

Smart Mill Installation

Typical Installation on Dry Sorbent Injection System



Gas Cooling, Milling & Dosing Technologies for the Environment

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