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SDIMI 2013

Separation Technologies LLC

Triboelectric Beneficiation of Fine Particle Minerals

Milos, July 2nd 2013

Sustainable Development in the Minerals Industry
6th International Conference

ST Presentation

1. Who are we? What do we do?
2. Conventional Electrostatic Separation
3. ST Patented Triboelectrostatic Belt Separator
4. ST Minerals Separation Proven Trackrecord

Who are we? What do we do?

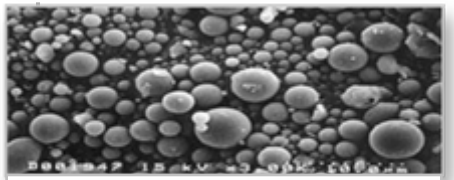
History of Separation Technologies

Startup founded by MIT engineer to develop Triboelectric Belt Separator.

Titan America acquires ST. First international project in Scotland.

+ Mineral Activity

1989 | 1995 | 2002 | 2011 | Currently



ST begins commercial fly ash processing.

Fly ash installations at 13 power plants. 19 separators in 4 countries: US, UK, Canada, Poland.

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Titan Cement Group

A vertically-integrated, multiregional building materials company

Group Overview

- Founded in Greece in 1902
- More than €1 billion sales in 2011
- 14 cement plants in Europe, East Med and US
- Concrete, aggregates, mortars and fly ash

Global Presence

U.S.A.

2	CEMENT PLANTS
5	QUARRIES
107	READY MIX PLANTS
14	DISTRIBUTION TERMINALS
9	CONCRETE BLOCK PLANTS
6	FLY ASH PROCESSING PLANTS IN THE U.S.A.
1	FLY ASH PROCESSING PLANT IN CANADA

GREECE & WESTERN EUROPE

4	CEMENT PLANTS
28	QUARRIES
30	READY MIX PLANTS
4	DISTRIBUTION TERMINALS
1	DRY MORTAR PLANT
1	FLY ASH PROCESSING PLANT

SOUTH EASTERN EUROPE

5	CEMENT PLANTS
9	QUARRIES
7	READY MIX PLANTS
2	DISTRIBUTION TERMINALS

EASTERN MEDITERRANEAN

3	CEMENT PLANTS
2	GRINDING PLANTS
15	QUARRIES
4	READY MIX PLANTS

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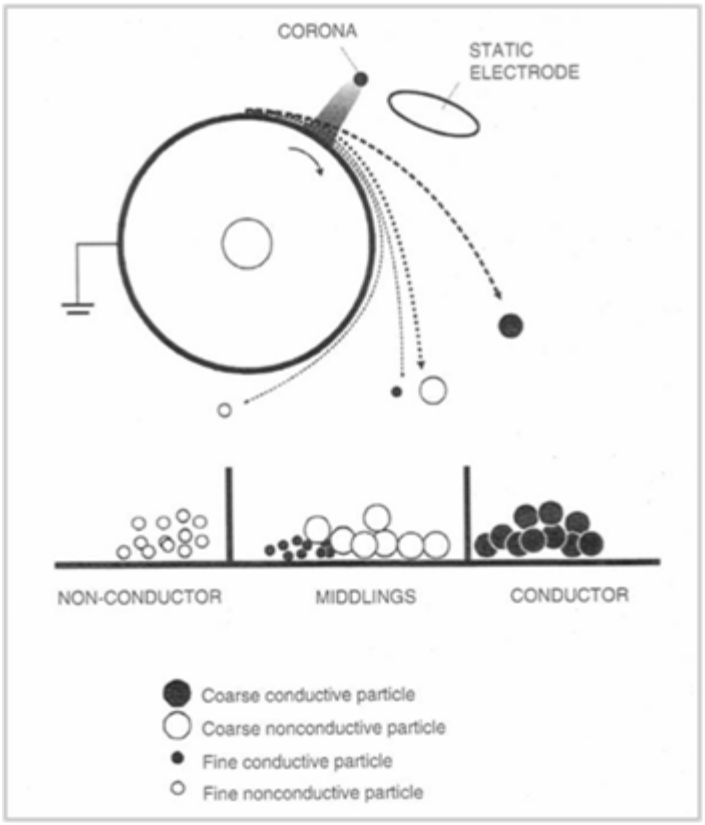
Existing Drum Electrostatic Separators Have Limitations

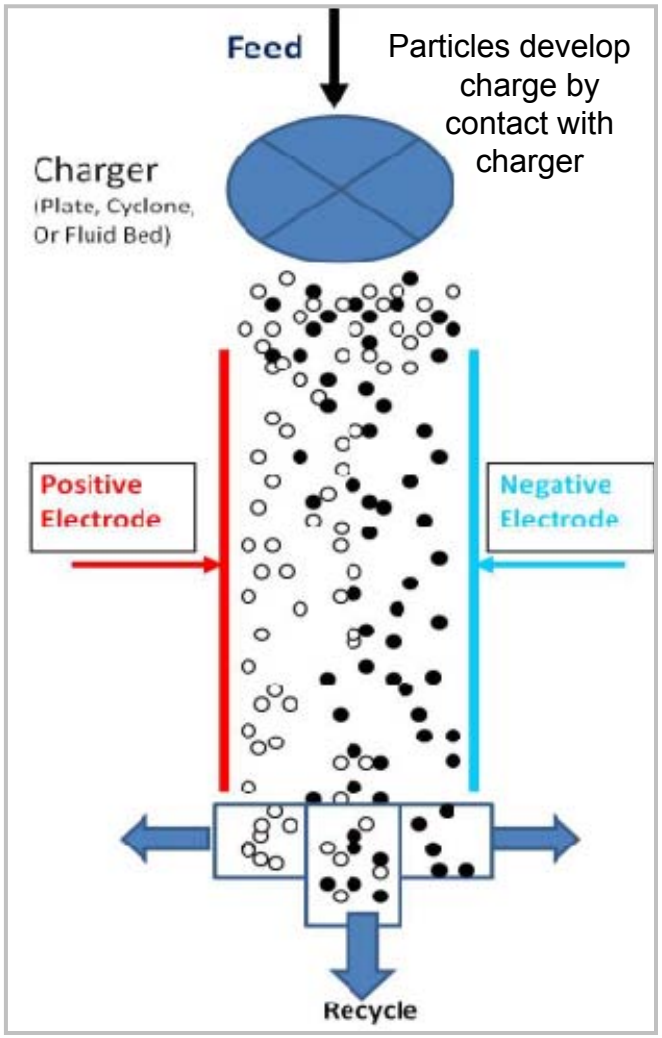


Source: Elder and Yan, 2003

Example: Corona Charging

- Separates conductors from non-conductors
- All particles must contact drum surface
- Lower particle size limit: ~75µm

Existing Free Fall Triboelectric Separators are limited in Particle Size and Capacity



Source: Elder and Yan, 2003

Limitations

- Physical footprint
- Single stage separation
- Must maintain laminar flow
- Avoid particle-to-particle contact in separation zone
  - Large electrode gap
  - High applied voltage
  - Low particle loading
  - Low throughput / capacity

Particle Size Effects

- Too large – No separation
- Too small – Collects on Electrodes
- Motion influenced by aerodynamics
- Lower particle size limit of ~75µm

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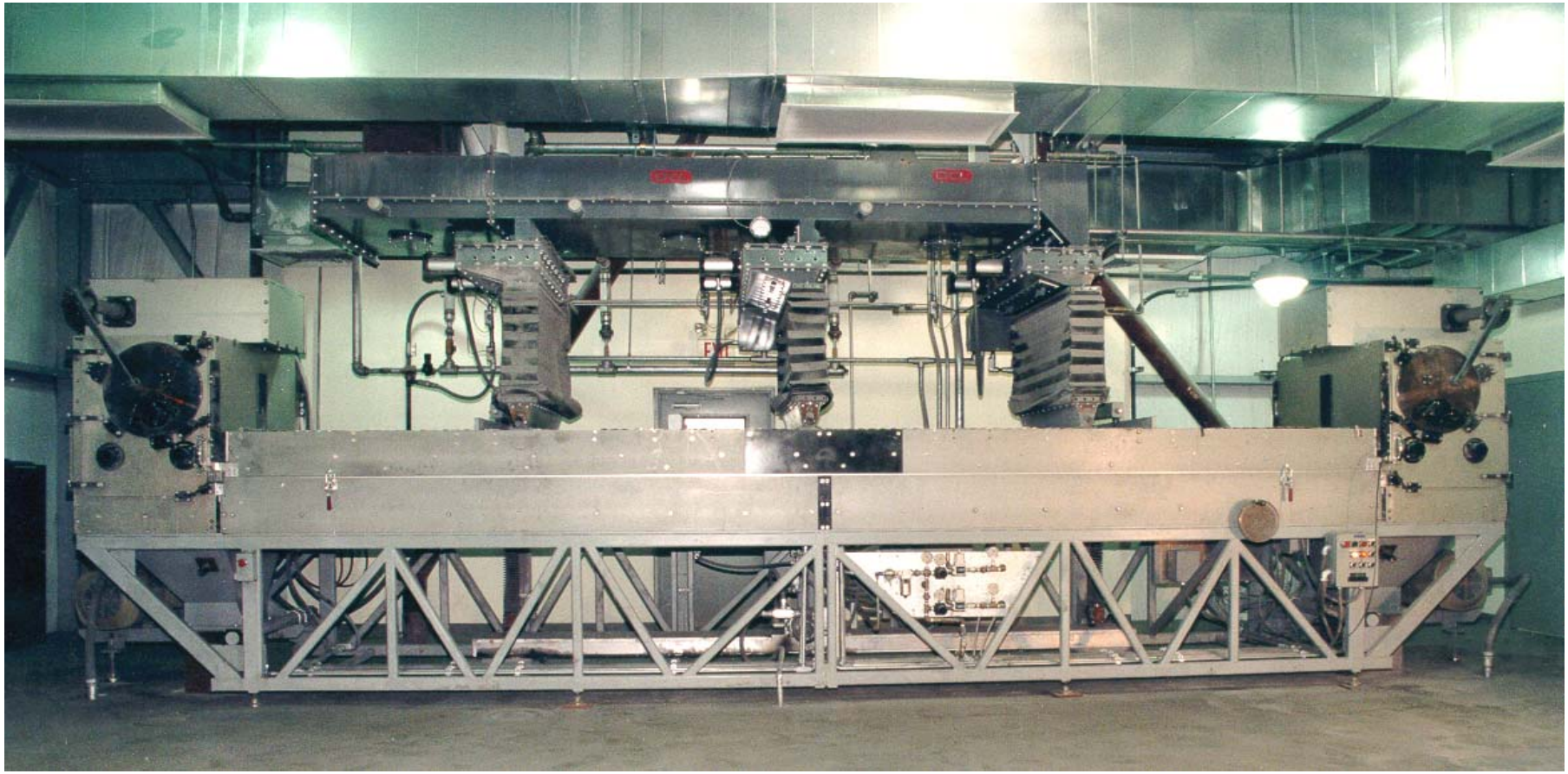
The ST Triboelectric Belt Separator



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ST unique patented technology offers many advantages

- Charged by particle-to-particle contact (transfer of electrons based on different surface chemistry – “work function”)
- Does not depend on electrical conductivity of particles (can separate dielectric materials “corona” drum separators can’t)
- Does not depend on particle contact with electrode or charger surface
- Effective on particles from <1µm to 300µm

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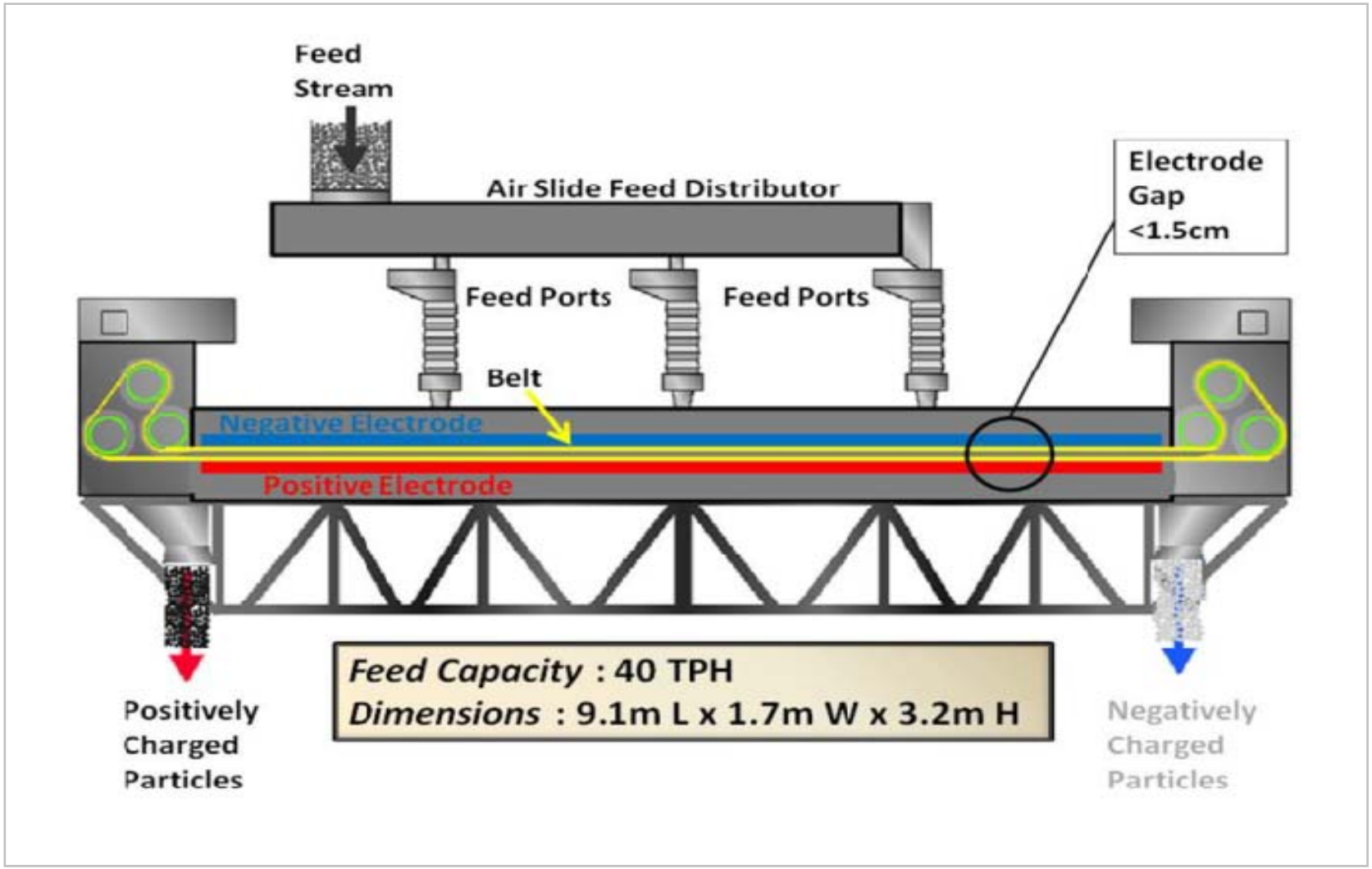
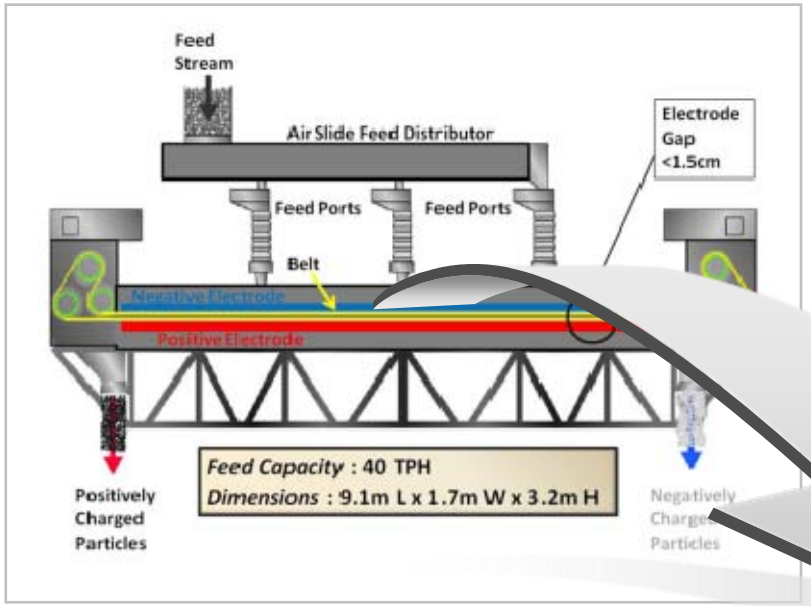
Fundamentals of ST Process

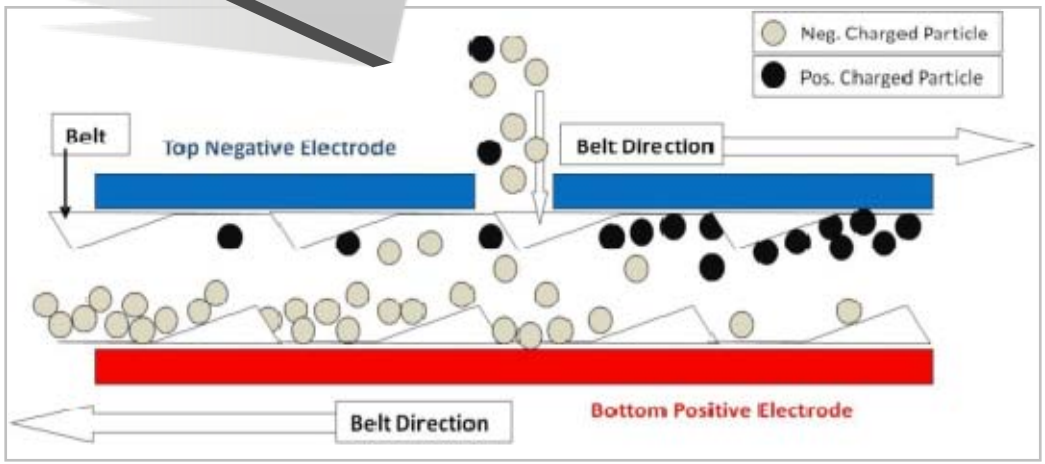
Schematic of the Separator and Electrode Gap



Fundamentals of ST Process

Schematic of the Separator and Electrode Gap





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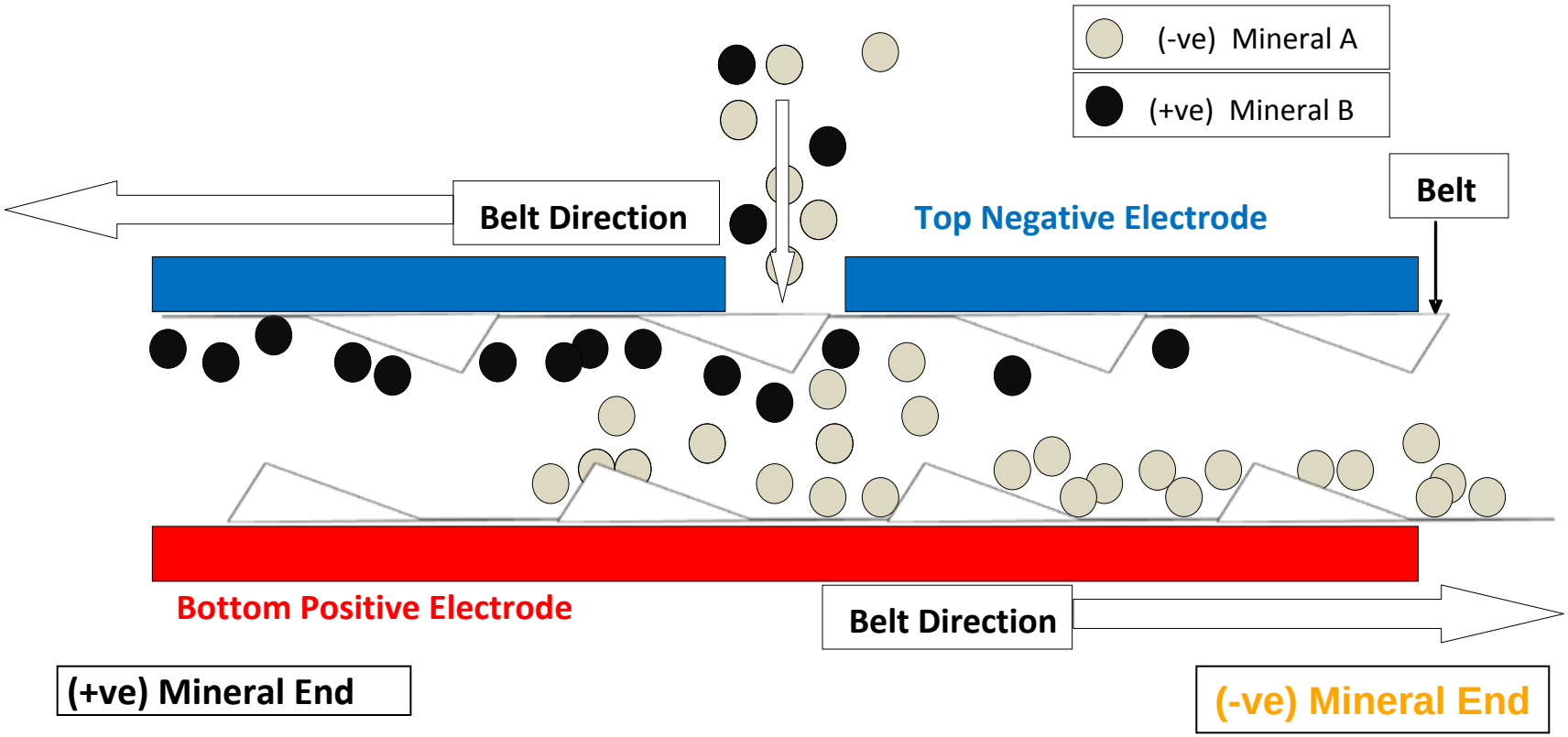
Dynamic Action of Belt is Key



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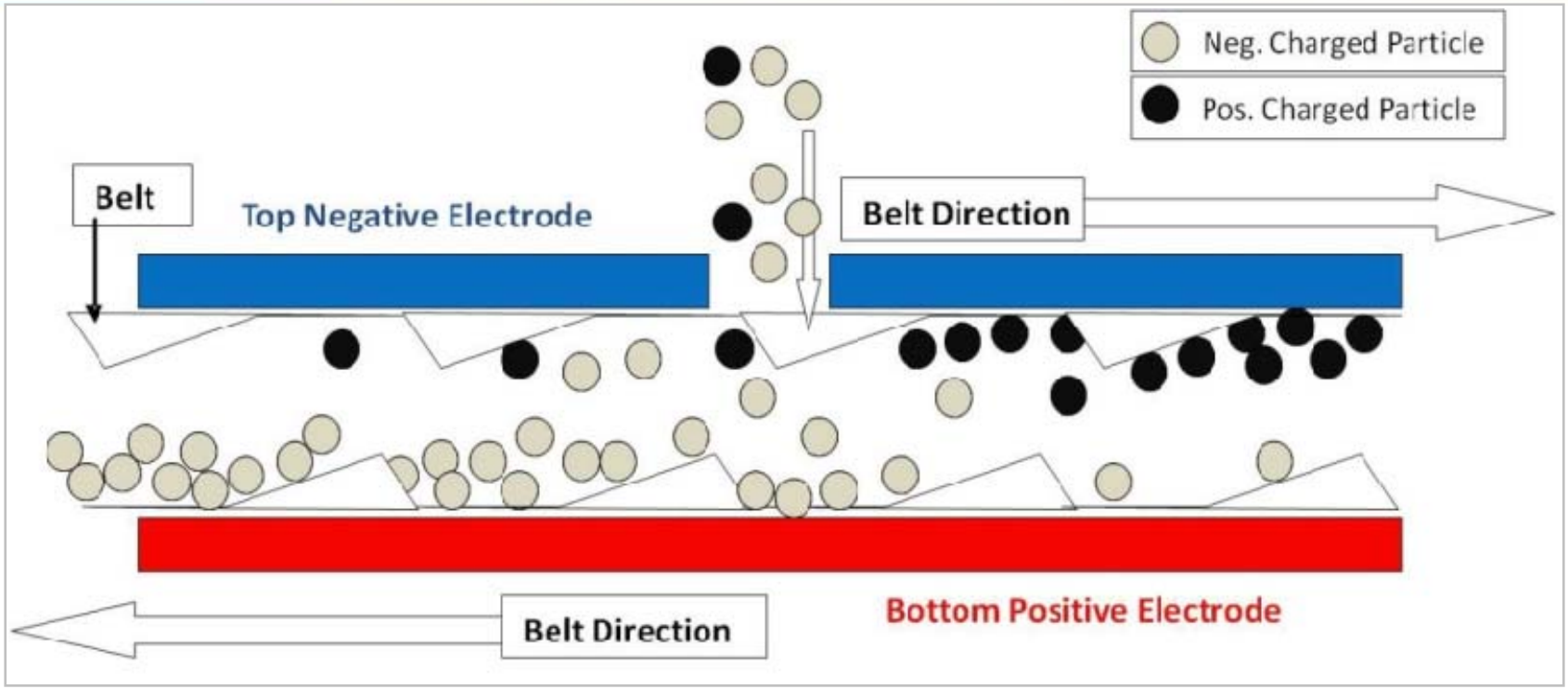
Multi-stage separation occurs in a single pass



- ➢Small gap and vigorous agitation
- ➢High electric field strength with moderate applied voltage (typ. 8 kV)
- ➢High efficiency multi-stage separation through charging/recharging & internal recycle

➢Very low residence times	<1 sec
➢Large particle size range	<1 µm to ~300 µm
➢High capacity	40 TPH

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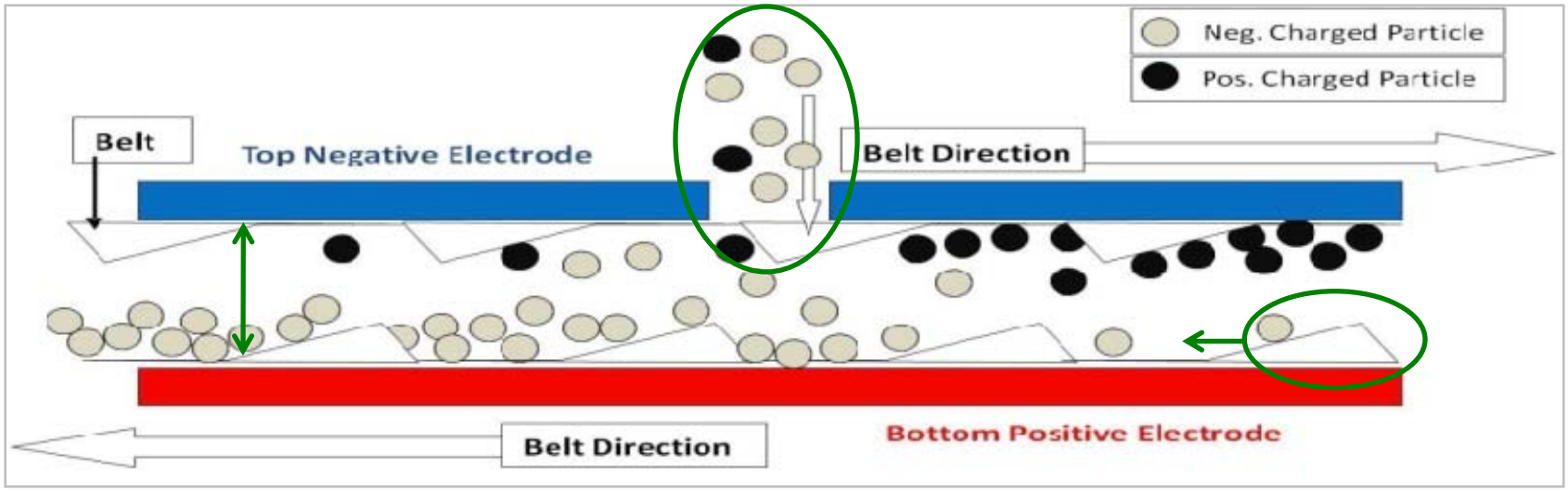
Fundamentals of ST Process

Multiple parameters available for optimization

Optimization

- Feed Conditioning
- Operational Variables
  - Feed Point
  - Belt Speed
  - Electrode Gap
  - Electrode Voltage
  - Feed Rate
- Enables consistent product from highly variable feed material



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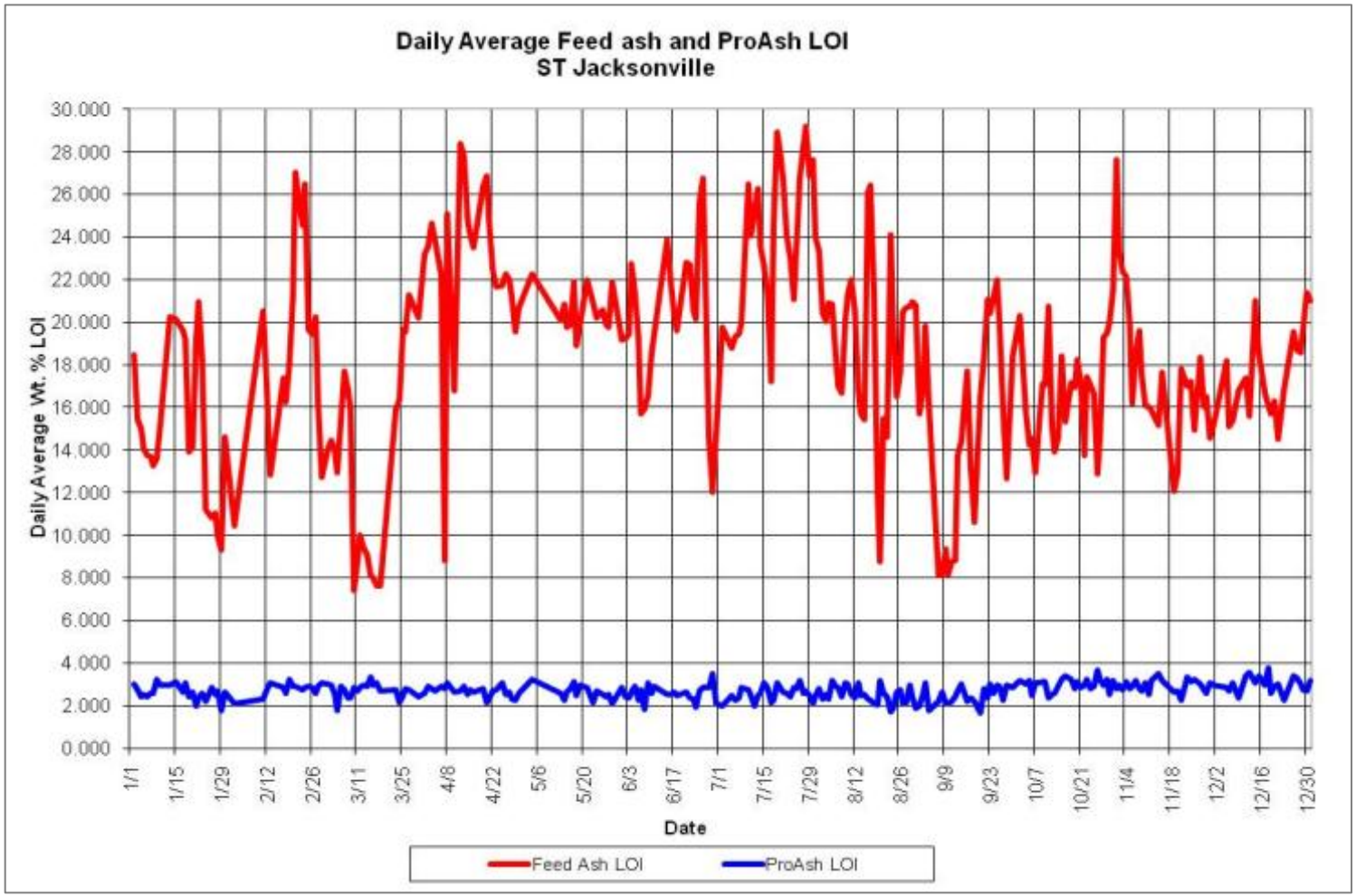
The consistent quality of product is independent from feed variability



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ST Separator Benefits

A sustainable separation process

Sustainability Benefits

- Small physical footprint
- Dry process: no water treatment
- Low energy consumption: ~1kWh/tonne
- Environmentally friendly
  - ✓ No water / no wastewater treatment / little to no chemicals
  - ✓ Easy to permit – single dust collector
  - ✓ Resource optimization: use of lower quality ore possible, waste stream & middlings minimized, loops closed

Further Benefits

- High rate: up to 40-50 TPH
- Separates fine to moderately coarse particles: <1µm to ~300µm (liberation size does matter)
- Ease of operation
  - ✓ Rapid start-up and shut-down
  - ✓ Rapid response to feed variability
  - ✓ Amenable to feed forward / back automation
  - ✓ Limited qualification of operators required
  - ✓ Possibility to produce several grades of products

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ST Experience with Industrial Minerals

Mineral Applications

- ST Separator applicable to any dry mixture of discrete particles (liberation does matter)
- Differential charging between particles of different surface chemistry
- Performance depends on
  - Particle surface chemistry
  - Size distribution
  - Shape
  - Surface Moisture
  - Aging
  - Contaminants
- New applications must be empirically investigated in pilot plant

ST Pilot Plant Separator

- Full length
- 1/7th width
- Nominal 3 – 8 TPH
- 10 kg "batch" runs
- ~1000 kg feed sample lot needed
  - In sealed drums
  - Must be dry

Electrostatic Mineral Separation Experience

Electrostatic Mineral Separations	Reported in Literature	ST Experience
Potash – Halite	✓	✓
Talc – Magnesite	✓	✓
Limestone – Quartz	✓	✓
Brucite – Quartz	✓	✓
Iron Oxide – Silica	✓	✓
Phosphate – Calcite – Silica	✓	
Mica – Feldspar – Quartz	✓	✓
Wollastonite – Quartz	✓	✓
Boron Minerals	✓	✓
Barite – Silicates	✓	✓
Zircon – Rutile	✓	
Silver and Gold Slags	✓	
Carbon – Silica	✓	✓
Beryl – Quartz	✓	
Fluorite – Silica	✓	✓
Fluorite – Barite – Calcite	✓	

Removing carbon from fly ash : More than 10 m tonnes of ProAsh produced in 15 different plants

Plant	Location	Country	Separators	Start Year
New England Power	Salem, MA		1	1995/2006
Progress Energy	Roxboro, NC		2	1997/1998
CPSG	Brandon Shores, MD		2	1999/2005
Scottish Power	Longannet, Scotland		1	2002
Jacksonville Electric SJRPP	Jacksonville, FL		2	2003/2004
SMEPA	Morrow, MS		1	2004
NB Power	Belledune, NB		1	2005
RWE	Didcot, England		1	2005
PP&L	Brunner Island, PA		2	2007/2008
TECO	Big Bend, FL		3	2008
RWE	Aberthaw, Wales		1	2008
EDF Energy	W. Burton, England		1	2008
ZGP (Lafarge / Ciech)	Janikowo, Poland		1	2010
Lafarge	Warsaw, Poland		1	2013
KOSEP YONG HEUNG 5 & 6	Seoul, South Korea		1	2013

ST Experience with Industrial Minerals

Limestone and Talc

	Limestone	Talc
Goals	▪ Reduce quartz / silicate content to increase value – from initial SiO_2 content 9.5% ▪ Recover max quantity of $CaCO_3$	▪ Reduce magnesite content ▪ Feed – 58% talc / 42% magnesite
Results	▪ Recovered product • SiO_2 content <1% • 82% mass recovery of feed • 89% $CaCO_3$ recovery ▪ Improved Brightness	▪ Two grades recovered in single pass • 95% talc / 5% magnesite – 77% talc recovery • 88% talc / 12% magnesite – 82% talc recovery
	▪ Other sources of $CaCO_3$ also successfully processed	▪ Other sources of talc also successfully processed

Sustainable Development projects with ST

	Waste / Middlings /Tailings	Pre concentration
Issues	▪ Waste generated by industrial process goes to landfill	▪ Raw material is tranported from mine to processing plant (flotation)
Benefits	▪ Recovered product: ressource management efficiency ▪ Reduce landfill footprint	▪ Near to Face pre-processing: diminution of mass transportation ▪ Increase overall flotation plant capacity with same equipment ▪ Lower Energy and Water consumption / Lower chemical usage ▪ Possibility to use lower grade ore

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