RAP Processing

BUILT TO **CONNECT**

MAPA Conference

February 2025

From Ancient Roman Roads…

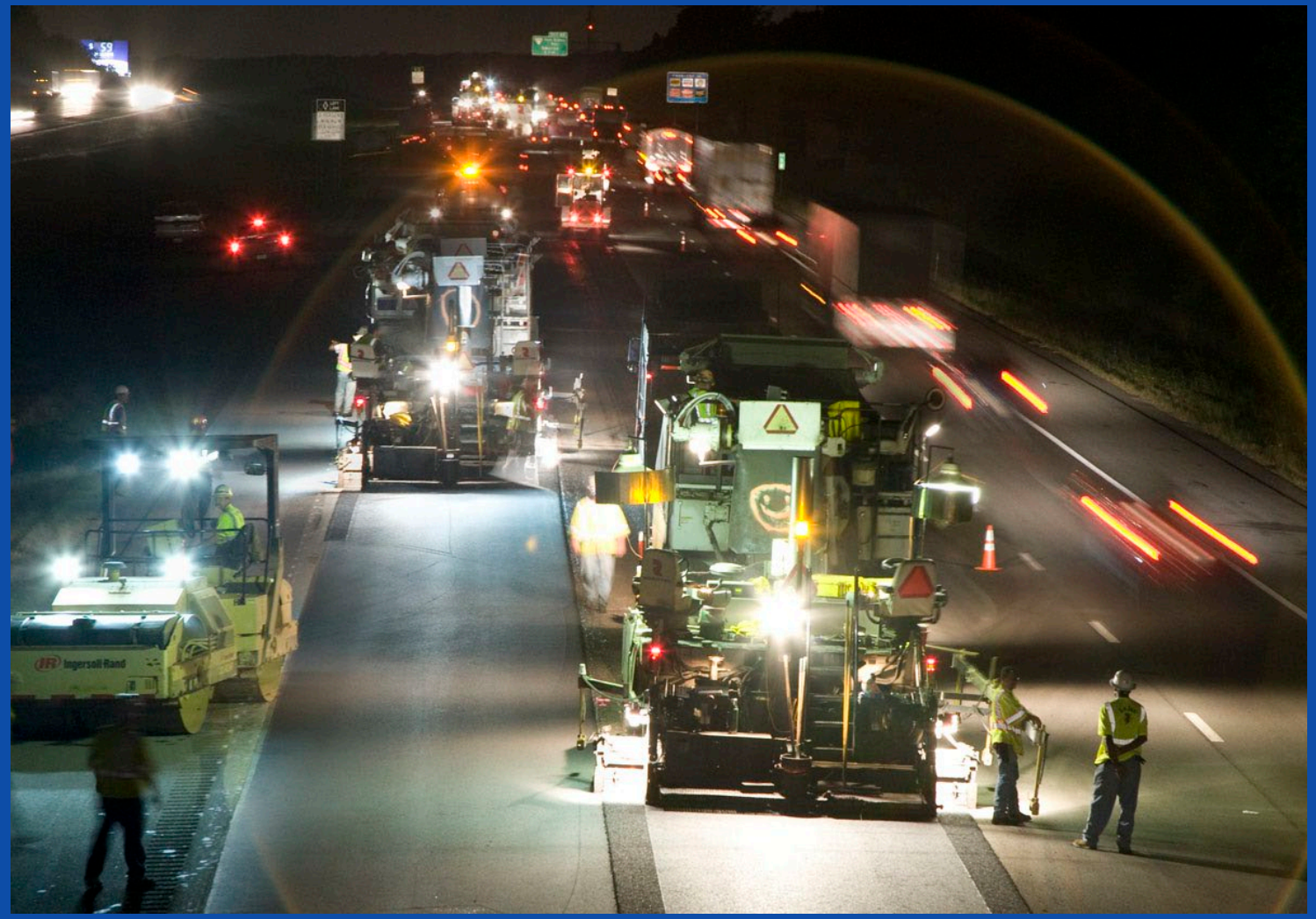
Even the ancient Romans recycled

Jerusalem,
March 2011

To modern USA Interstate Highways

From early asphalt roads…

To modern paving technology



Asphalt plant innovation

1912

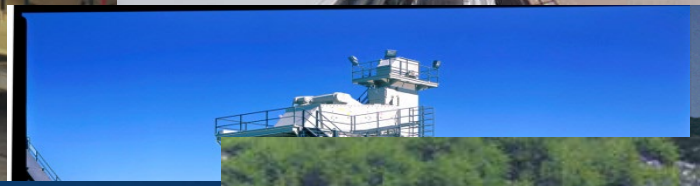
1960s

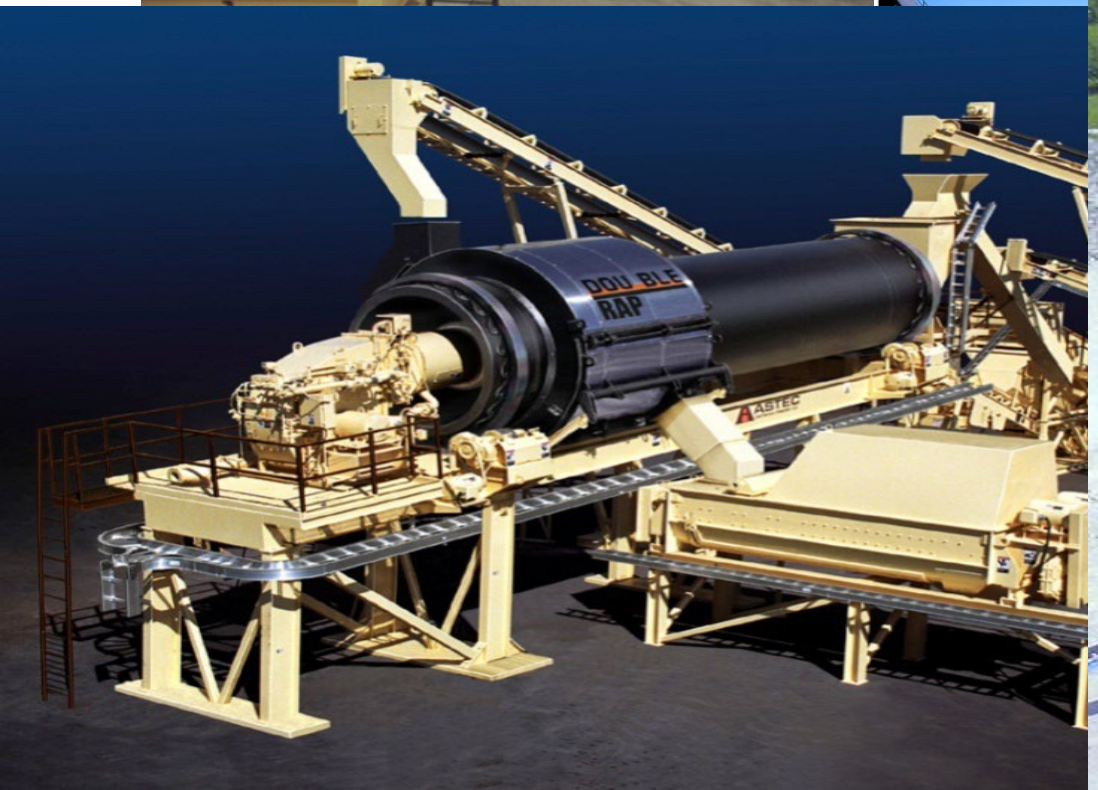
Batch Technology

Best Current Technology

Continuous Technology


DOUBLE
BARREL




DOU BLE
RAP
ABTEC


BITUMEN
BITUMEN

What drives innovation?

- **Competition** – Better or cheaper
- **Regulations** (e.g. Clean Air Act)
- **Economics** (RAP use)
- **Industry changes** (mix designs)

} **Market forces**

- Companies with innovation in their DNA (High expectations)
- The innovators (Contractors + manufacturers)

Innovation Drivers

ECONOMICS, MIX DESIGN, REGULATION, COMPETITION

CREATES NEED

AVAILABLE TECHNOLOGY

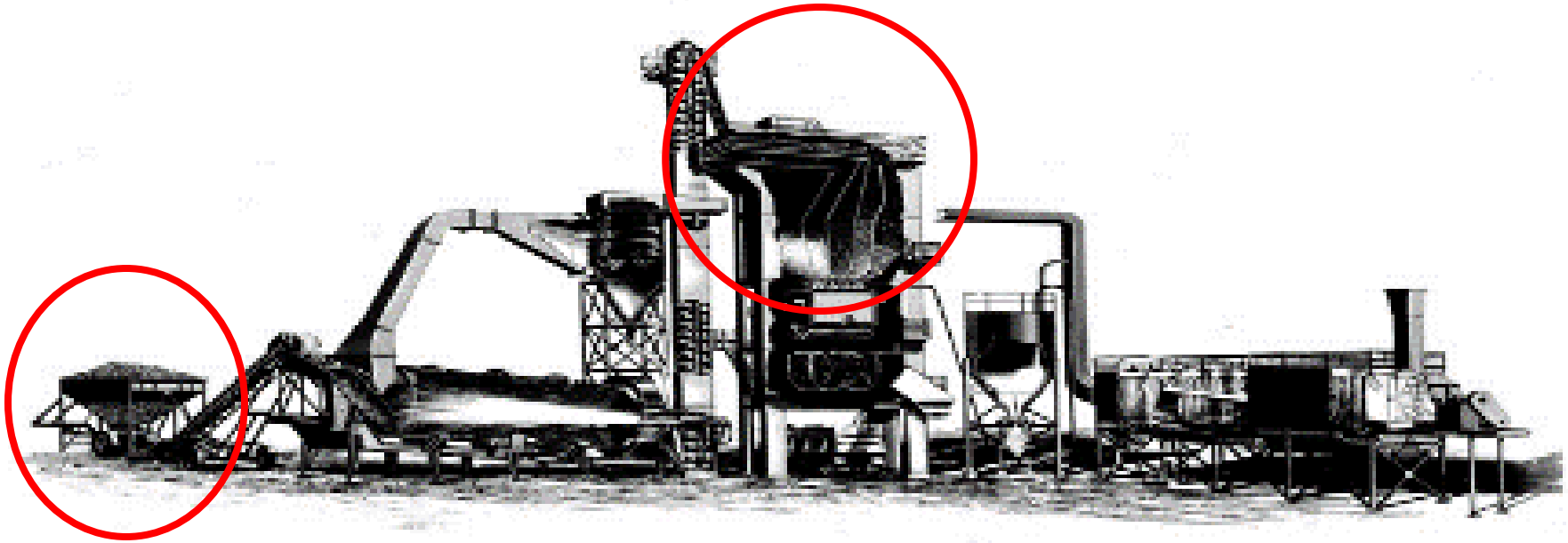
ADAPT, INNOVATE

Plant Innovation is also event driven

- **The batch plant was king for decades – why?**

Batch Plant

Aggregates were separated so they could be recombined



Aggregates from the quarry were all combined

BATCH PLANT

ONE BIN COLD FEED

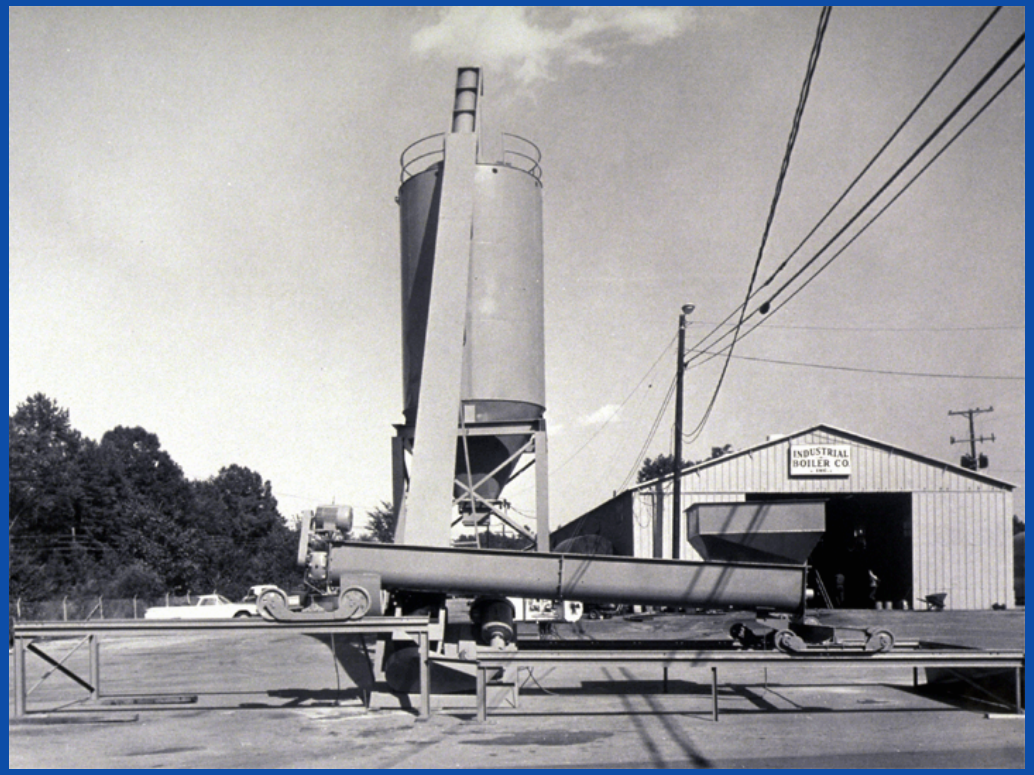
Plant Innovation is also **Event Driven**

- The batch plant was king for decades – why?
- **1973 Oil Embargo – gas lines – AC 4X cost overnight**
- **RAP (Reclaimed Asphalt Pavement) = inexpensive AC**
- **Milling technology made RAP economically available**
- **One problem: Batch plants struggle with RAP**

- **October 1973 Embargo begins.**
- **Oil price jumps from $3/bbl to $12/bbl.**

Plant Innovation

Keystone technology



1966

Plant Innovation

- The invention of the surge/storage silo made continuous plants viable –
  - Don Brock invented surge and storage silos in 1966
- **Continuous plants are very RAP friendly** – batch plants are not – steam "explosion"
- First continuous plants were parallel flow – could heat, dry, and coat in one drum – **low equipment cost**
- The industry (USA) quickly **changed from batch to continuous** technology
- **Cheap, portable, RAP friendly – Continuous technology**

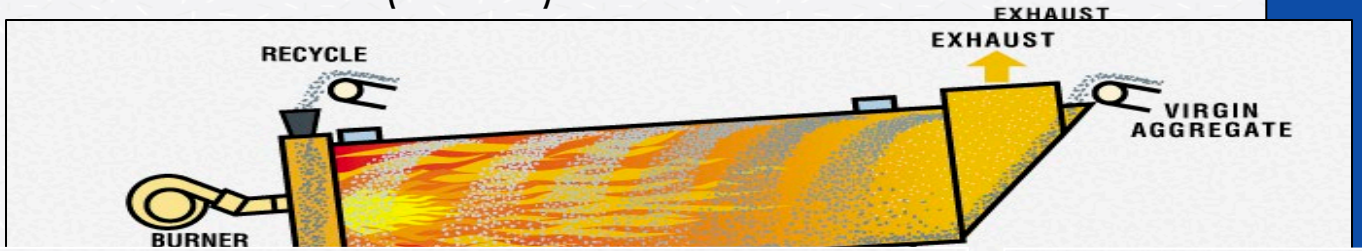
RAP and Plant Innovation

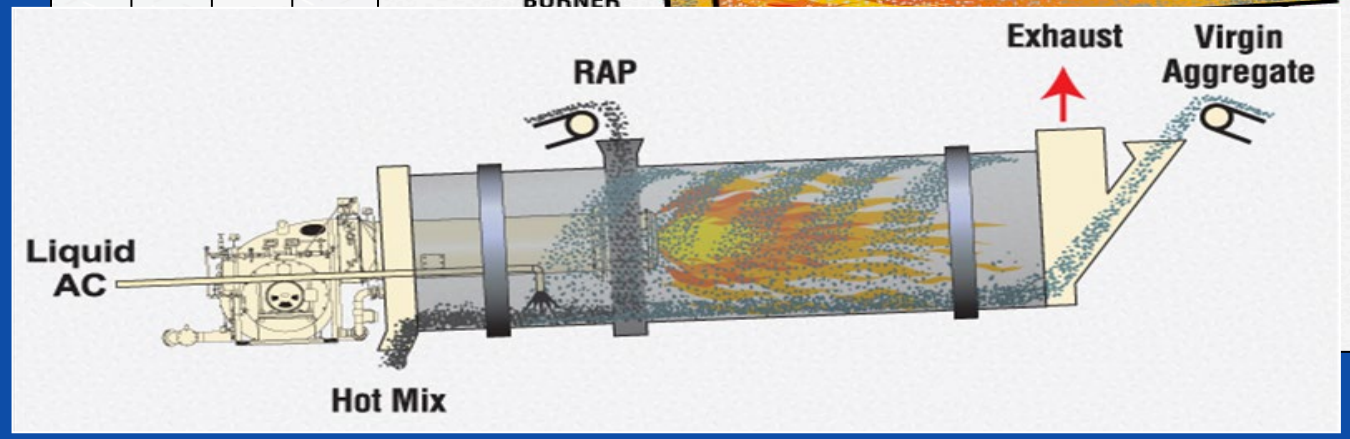
Original Parallel-Flow Drum Mixer (1970's)

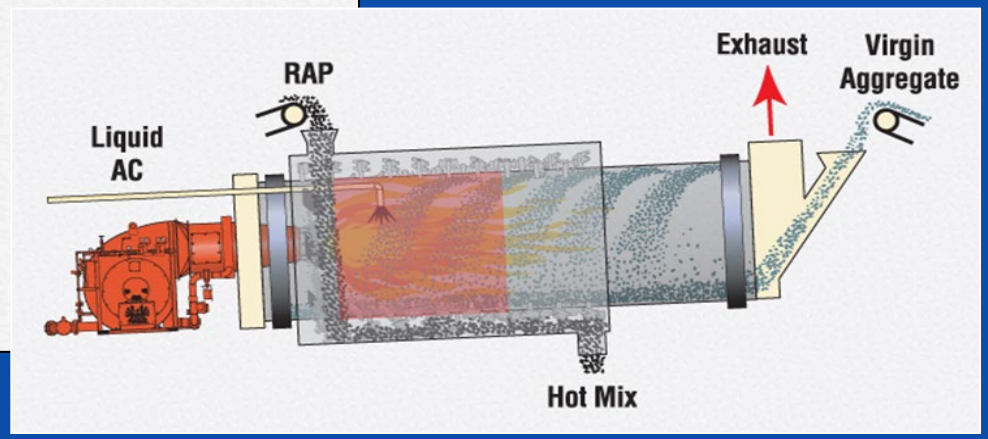
Drum Mixer with Center Inlet (1970's – 1980's)

Drum Mix Coater (1980's – 1987)

Drum Mix Coater II (1980's)

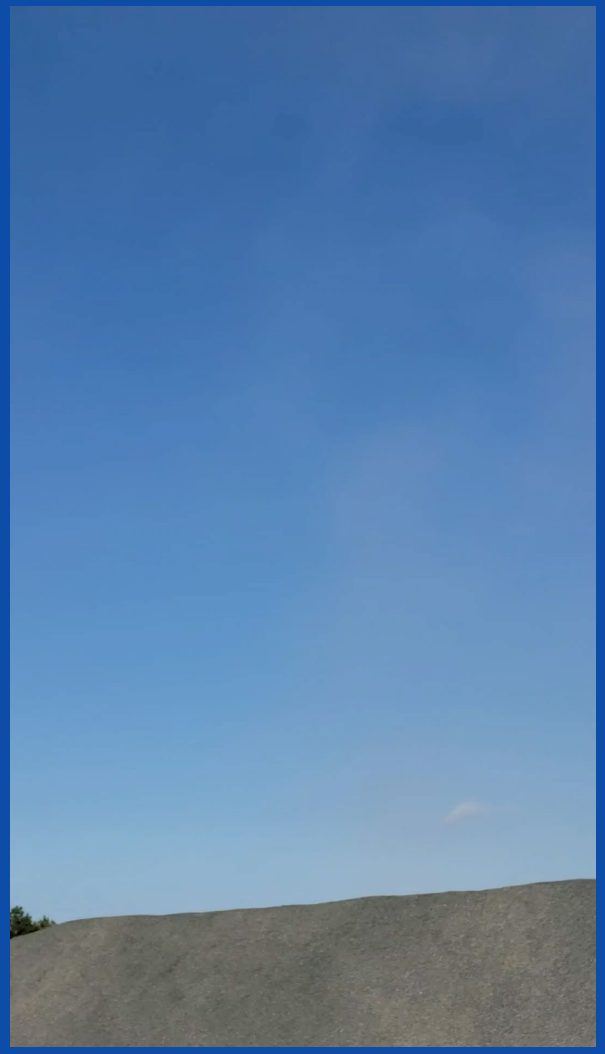






RAP has been a significant driver in plant innovation. The type of plant you have today is probably a result of the demand for RAP mixes decades ago.

Parallel Flow Blue Smoke Emissions



High RAP Processing Methodologies

“Direct” Method

- When the hot gases directly contact what is being heated.
- Finger over steam blowing out of steam kettle. **Ouch!**
- Aggregate in the dryer. Products of combustion contact the aggregate.
- Can cause high emissions with RAP.

“Indirect” Method

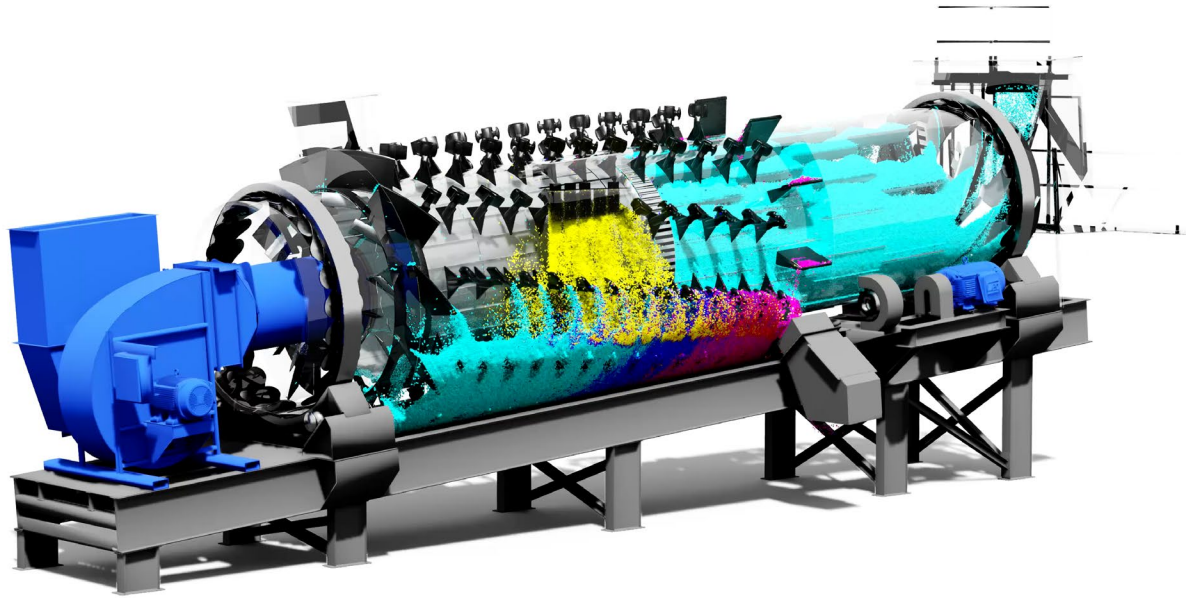
- When the hot gases do NOT directly contact what is being heated.
- Putting a hot fork in your mouth that has been sitting on the fajita plate. **Ouch!**
- The way RAP is heated in a continuous plant.

Indirect RAP Heating

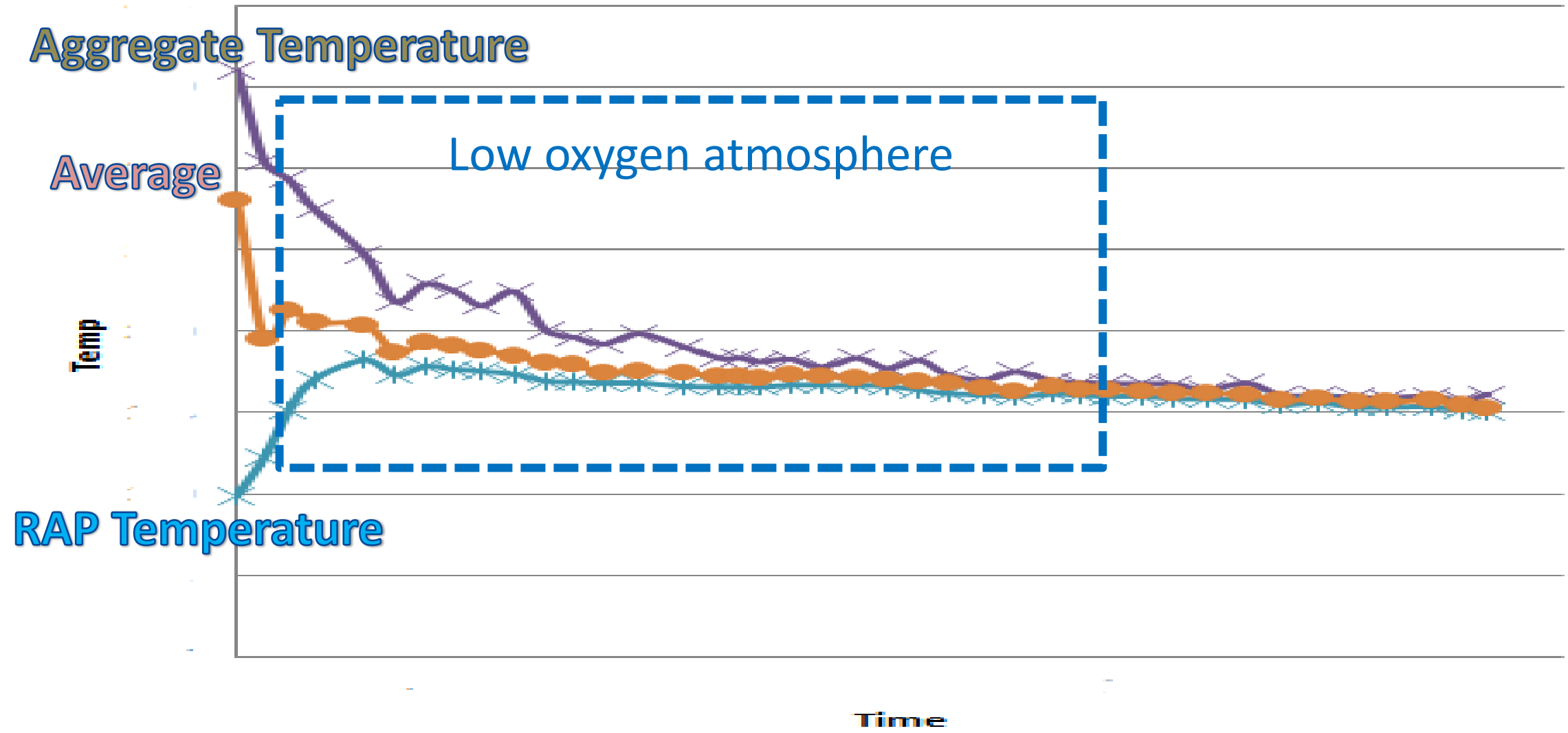
Cold Water
(Ambient Temp RAP)

Hot Water
(Above temp Agg)

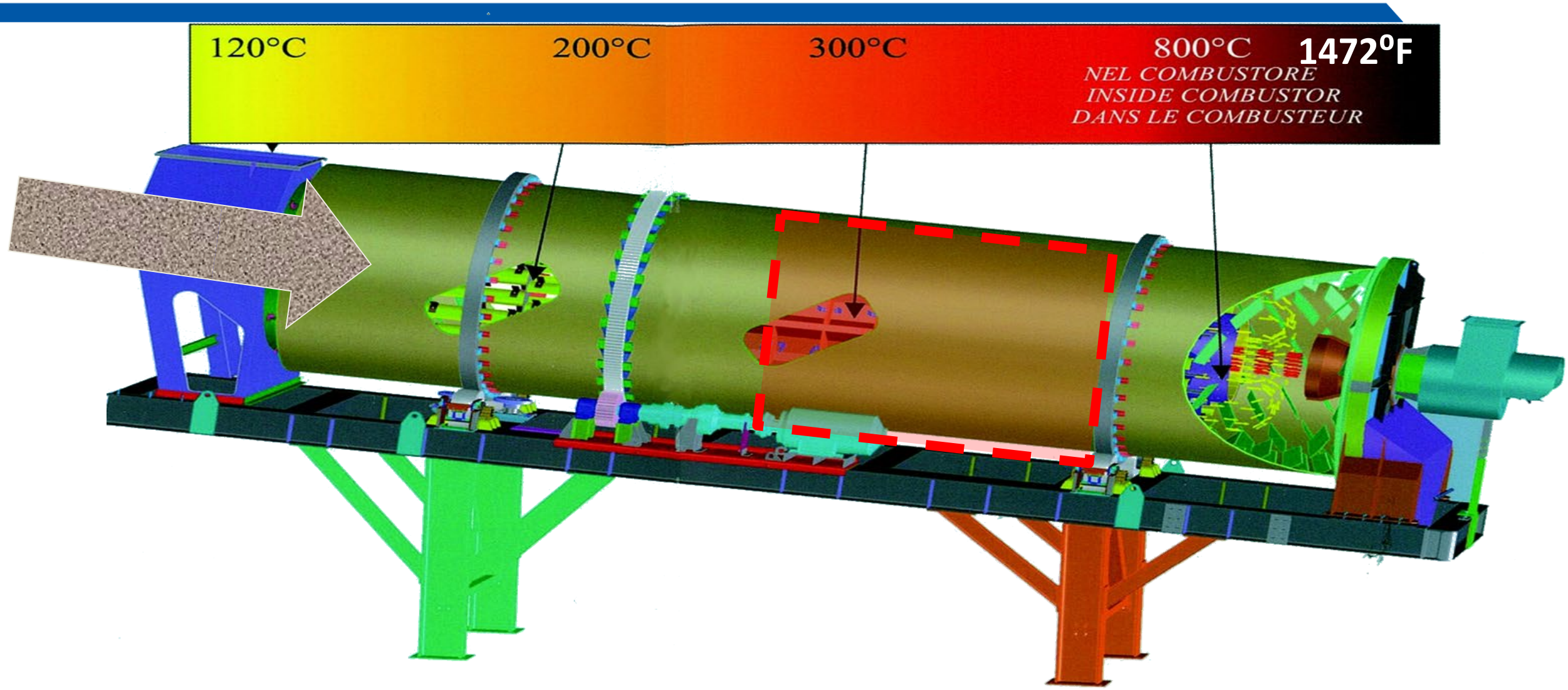
Warm Water
(Mix at correct temp)



“Indirect” Method Benefit: Time



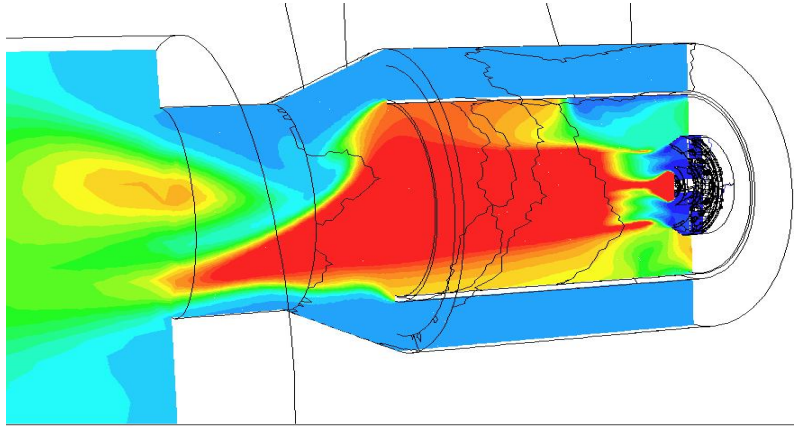
“Direct” Method – Hot, Hot Hot



RAP Pre-Dryer – Direct RAP Heating

Additional drum to dry and pre-heat RAP

- Heated with exhaust from aggregate drum
- Augmenter burner firing into a refractory for gentle heating of RAP



RAP European Style

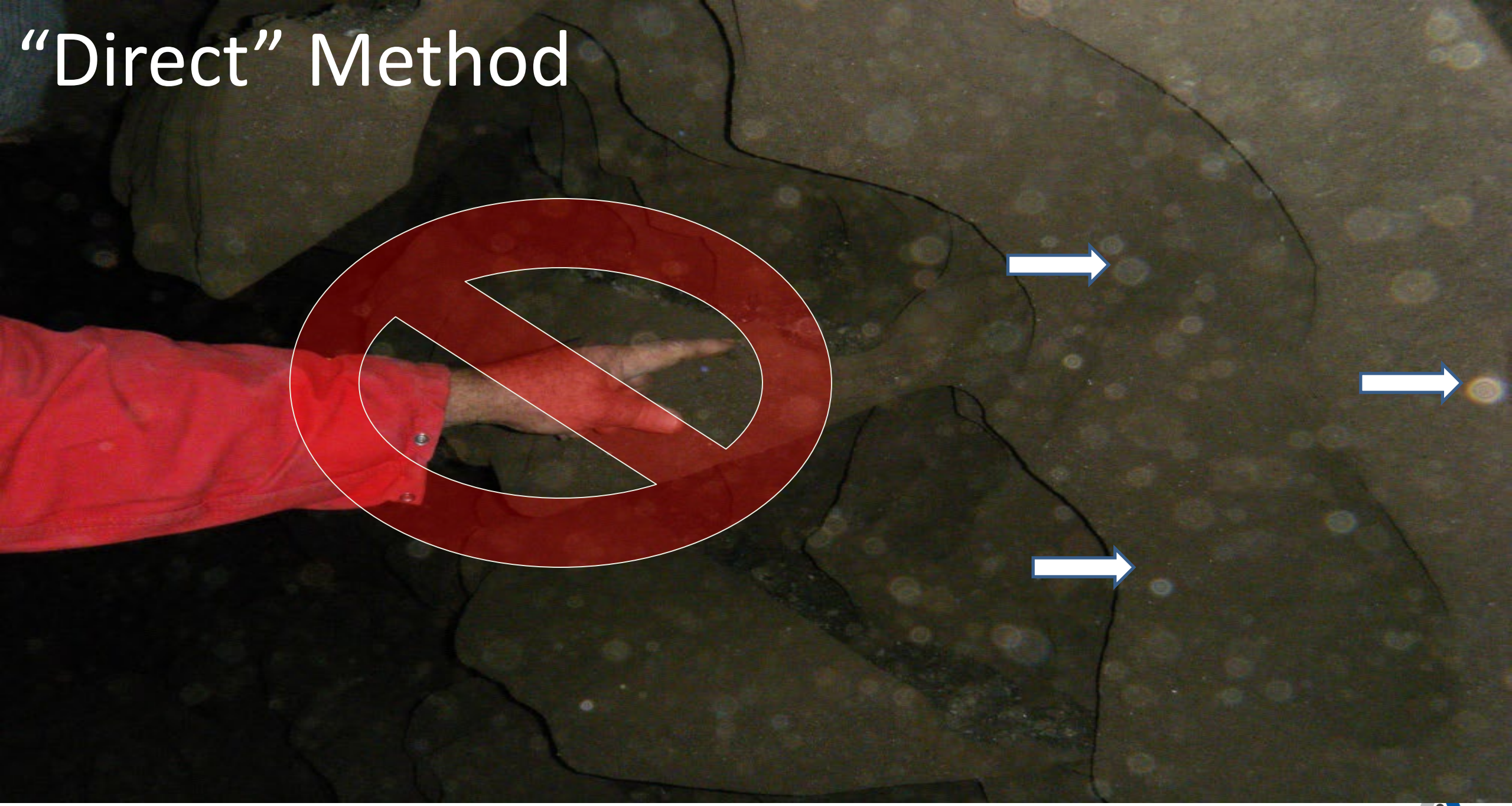
Parallel Flow shown

“Direct” Method – “Good” heat transfer, but….

There are drawbacks!

Screen heated material to remove chunks
Modified flight design
Hot rock scrub to remove buildup (every ~175k – 200k tons)

“Direct” Method



Video Inside a Direct RAP Dryer

3 Factors in Bitumen Oxidation…

H High Temperature

O Oxygen

T Time

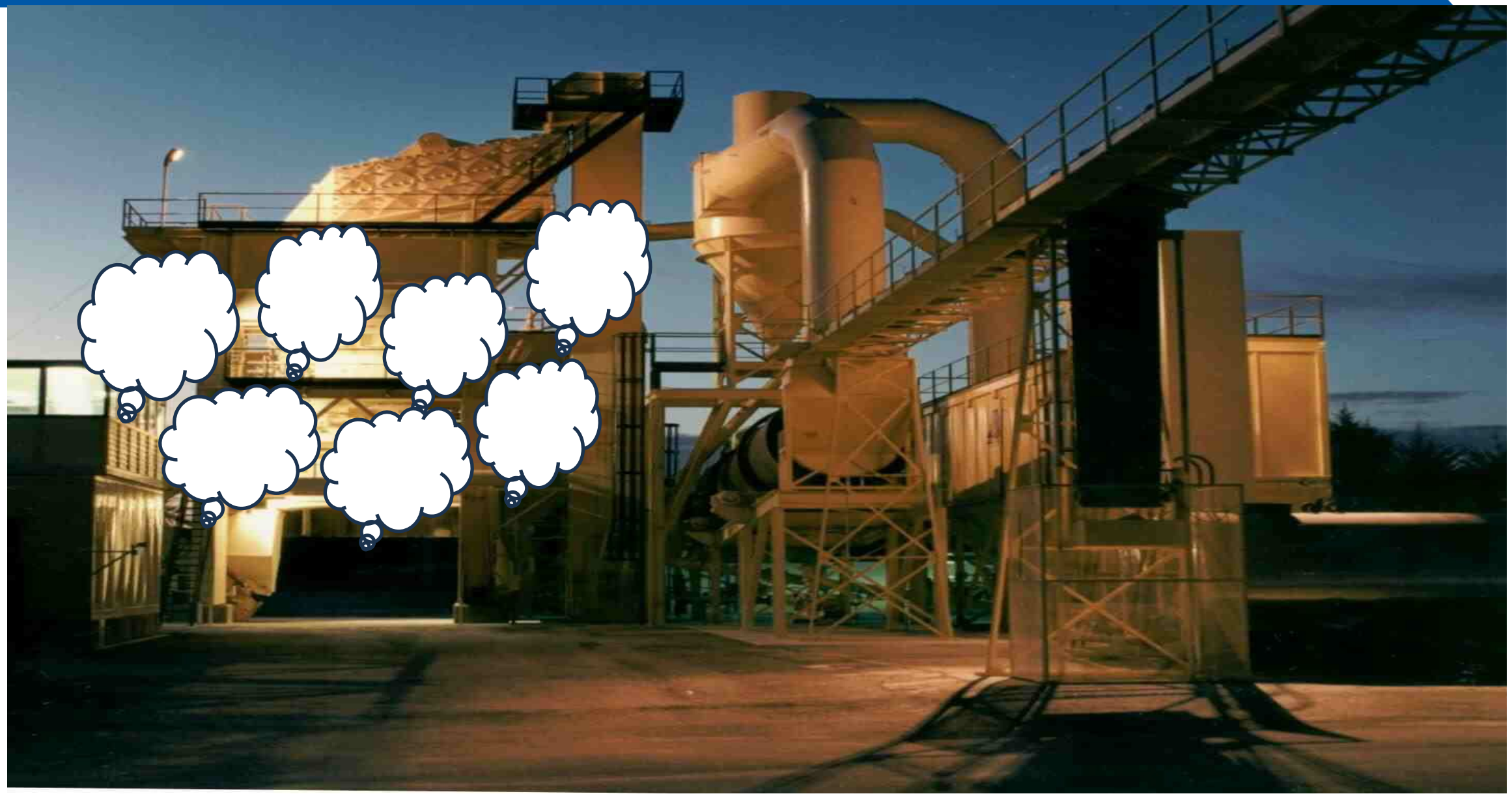
Direct RAP Dryer Limitations

- Recycle fines exposed to VERY HOT oxygen-rich gas
- Bitumen + High Heat + Oxygen + Time --> Oxidation
- Bitumen + High Heat + Oxygen + Time --> Carbon Monoxide
- High Heat + Bitumen --> Volatile Organic Compounds
- Oxidation requires binder modification ($)
- Emissions may require specialized equipment and fuel ($$)

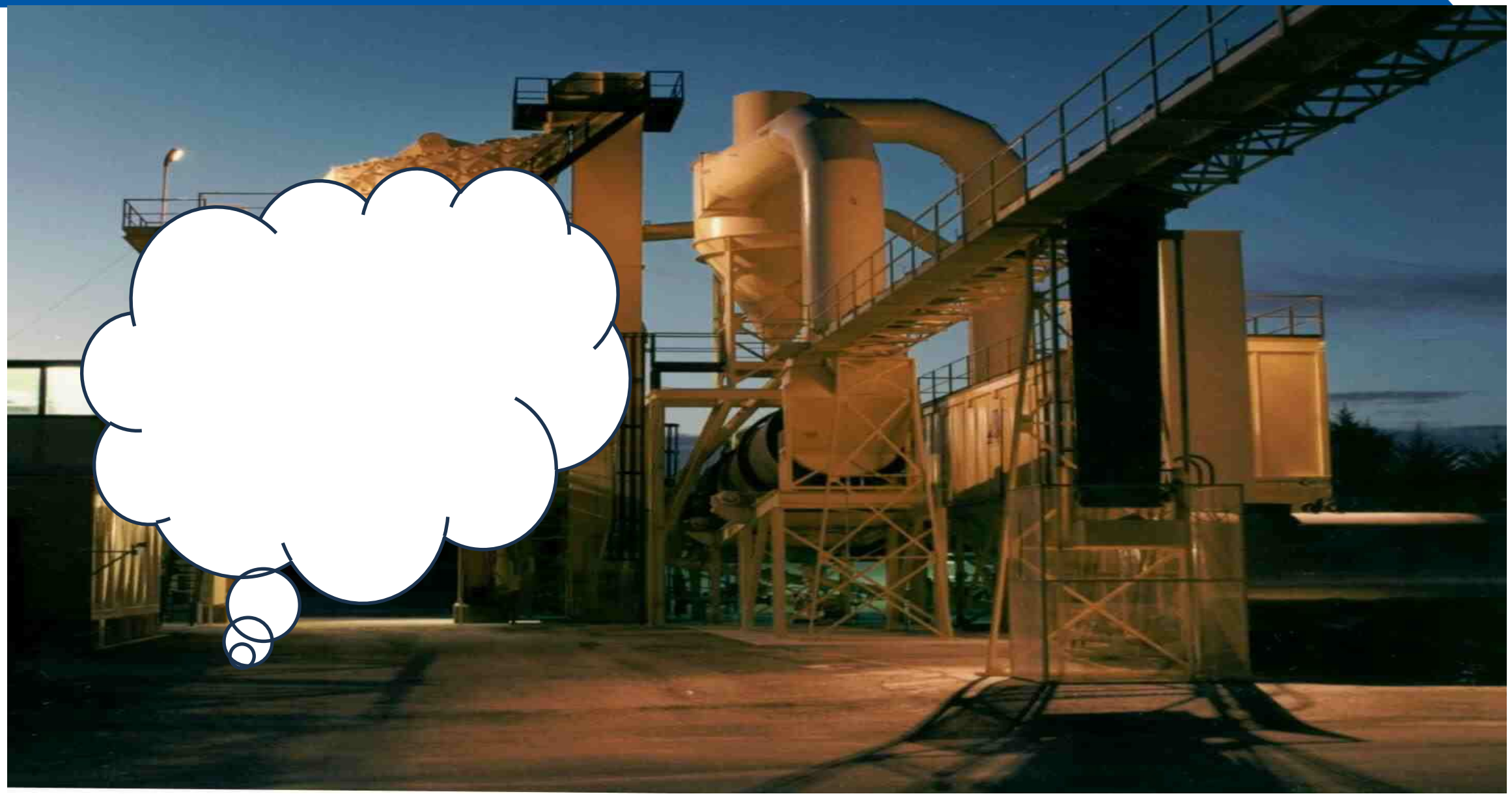
Which is worse at 50% RAP at 5% moisture?

- **1472°F (800°C): convection in oxygen-high environment?**
- **855°F (457°C): conduction and steam convection with minimal oxygen?**

RAP Steam Release – Indirect RAP heating



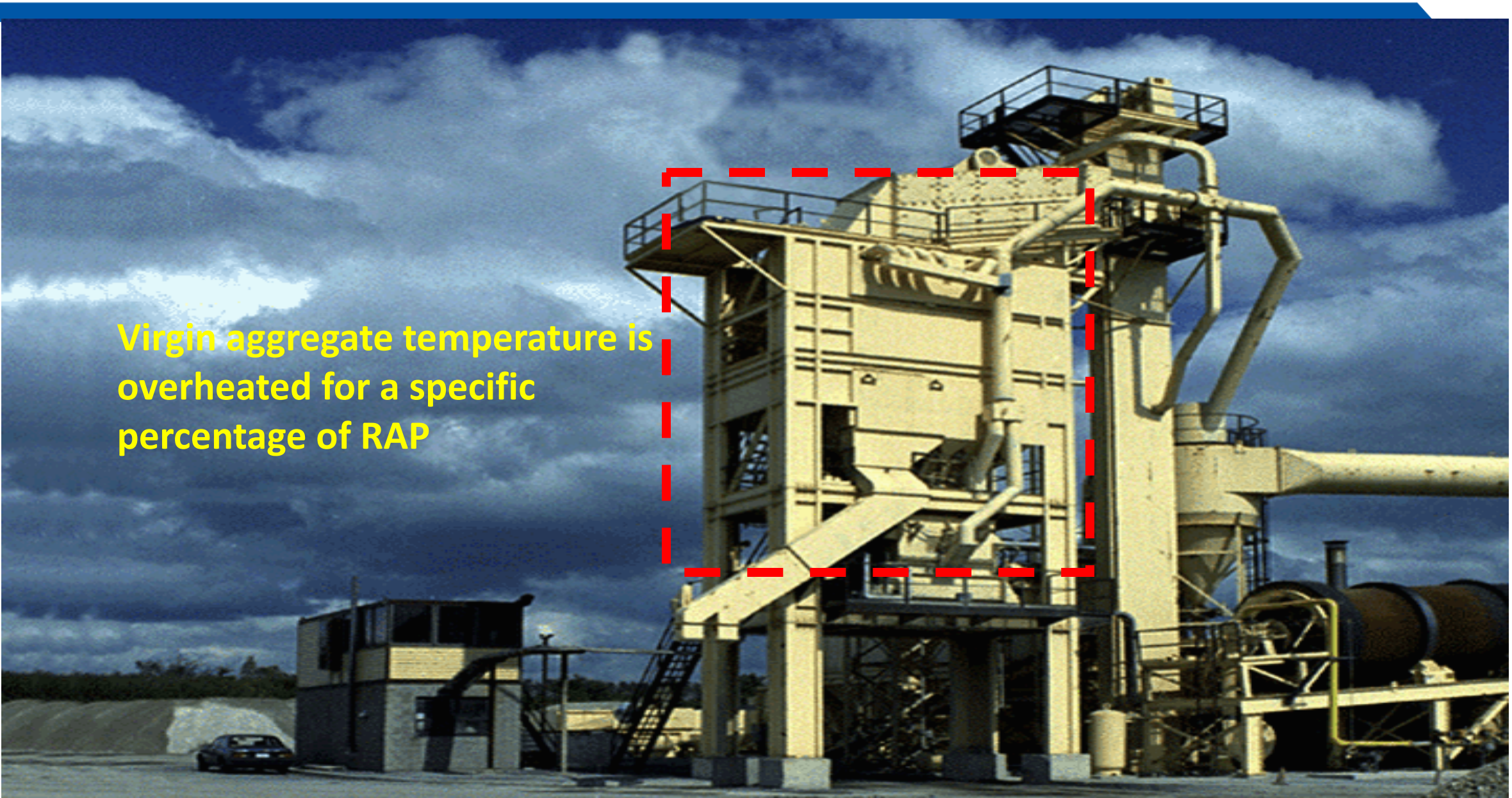
RAP Steam Release



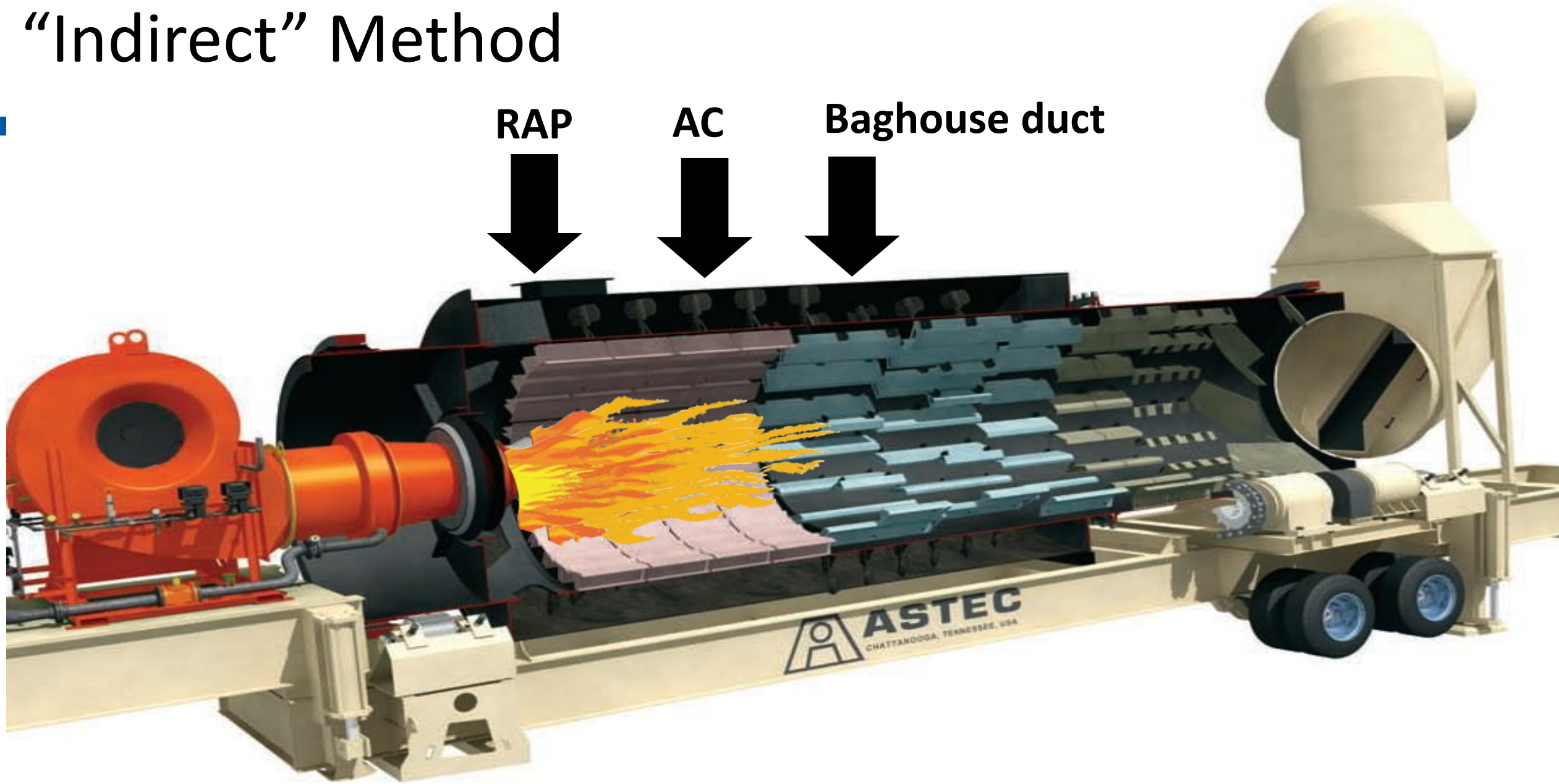
“Stationary” Batch, Northern United States (435 T/hr)

Batch Plant RAP System – USA Style

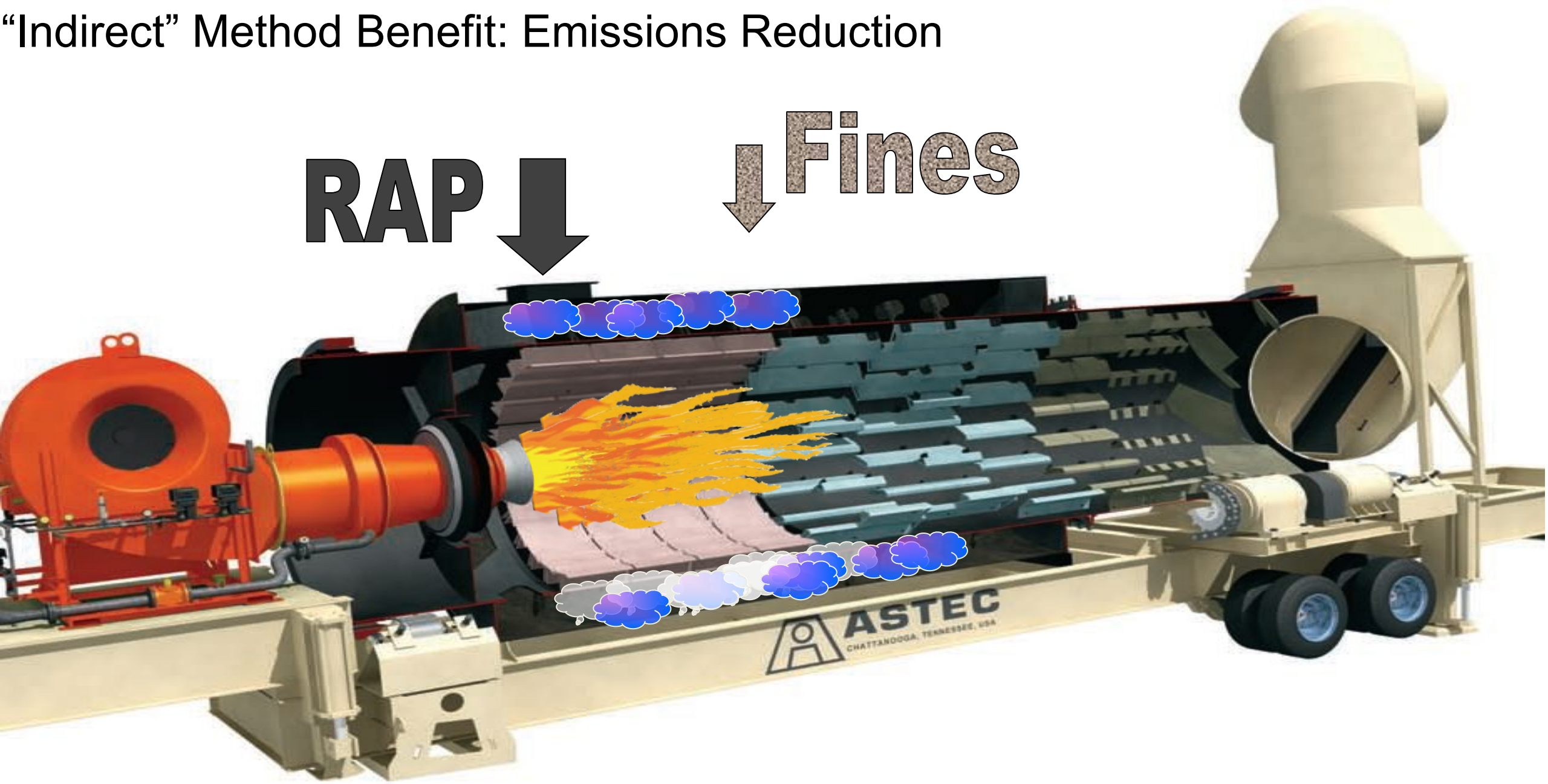
Aggregate Temperature



“Indirect” Method



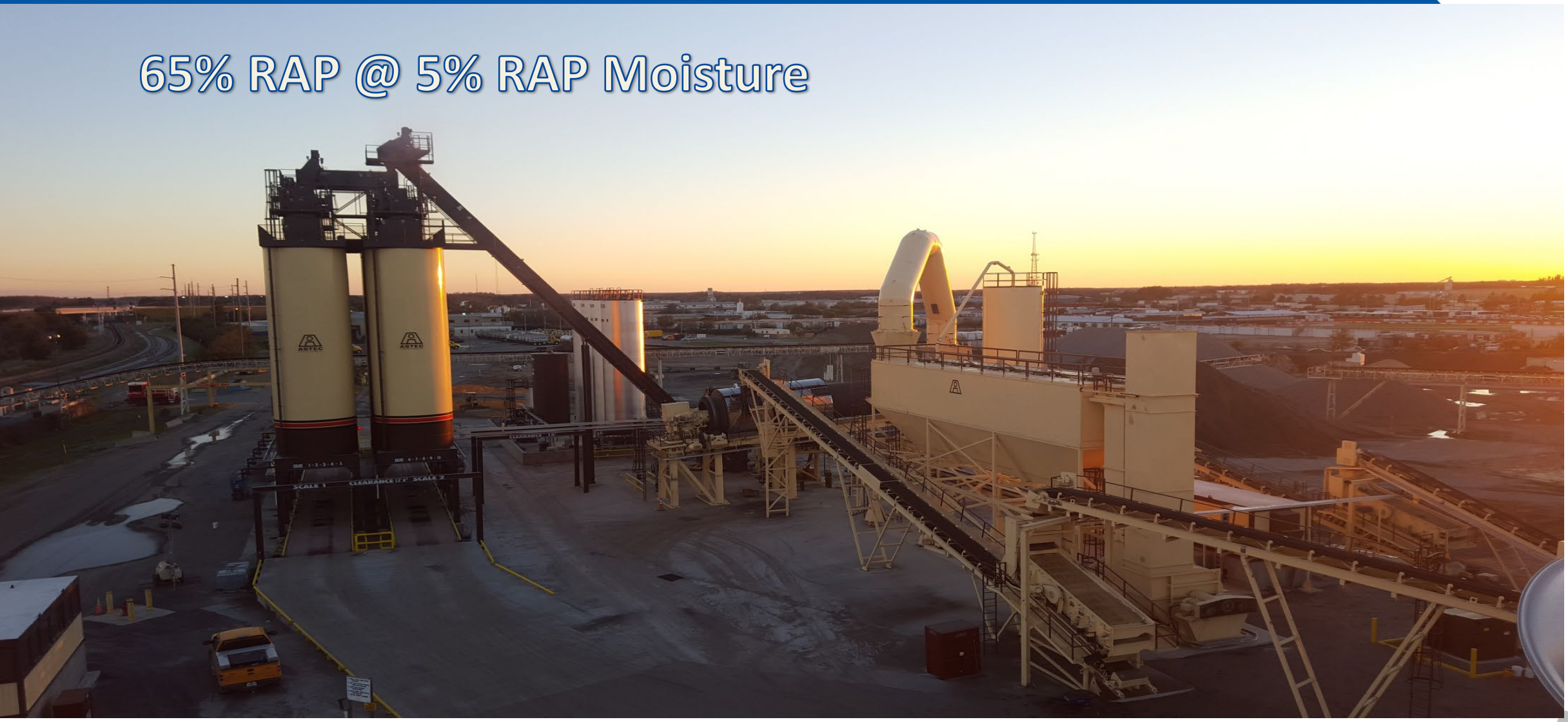
“Indirect” Method Benefit: Emissions Reduction



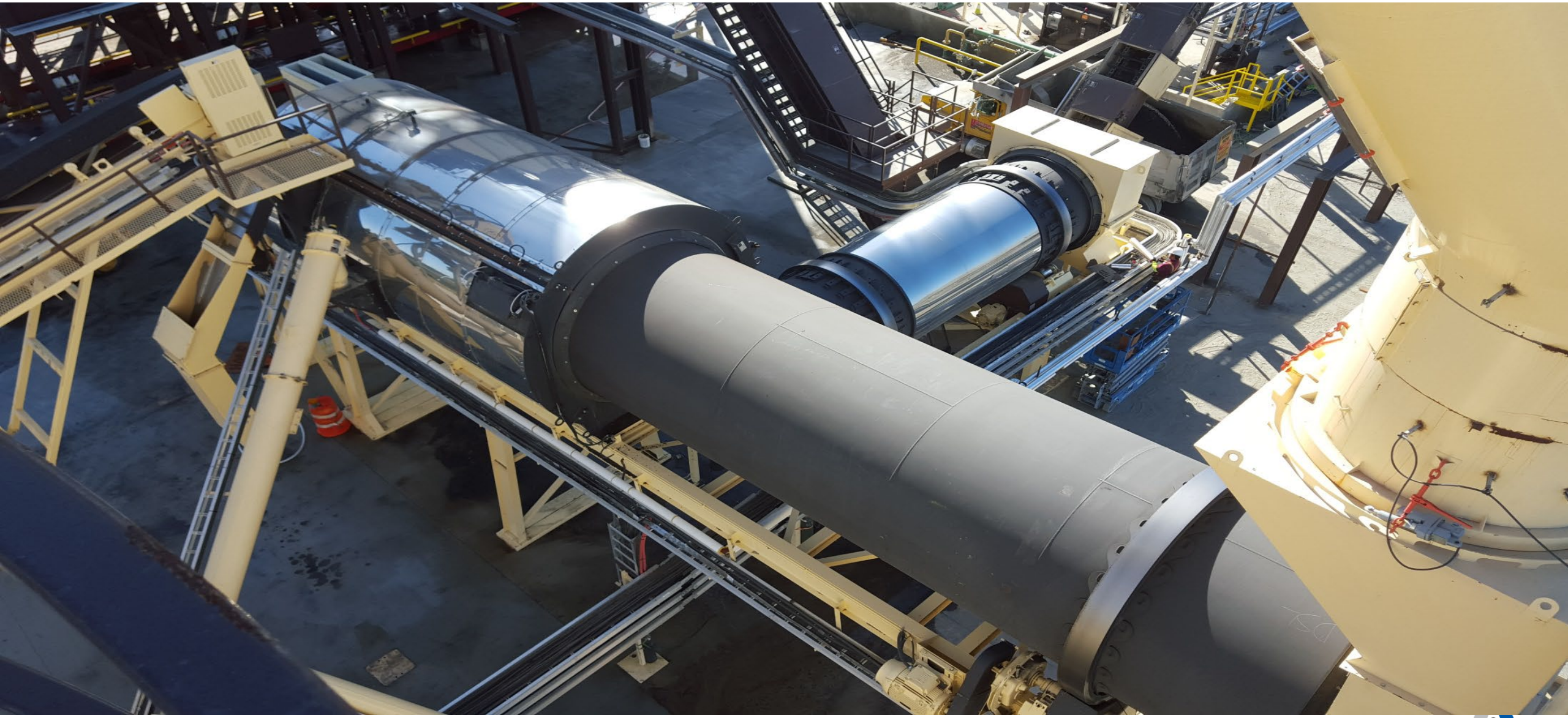
“Indirect” Method as the RAP percentage increases past 50%

As the RAP % increases the challenge is heat transfer
More RAP = less virgin aggregate
Virgin aggregate carries all of the heat

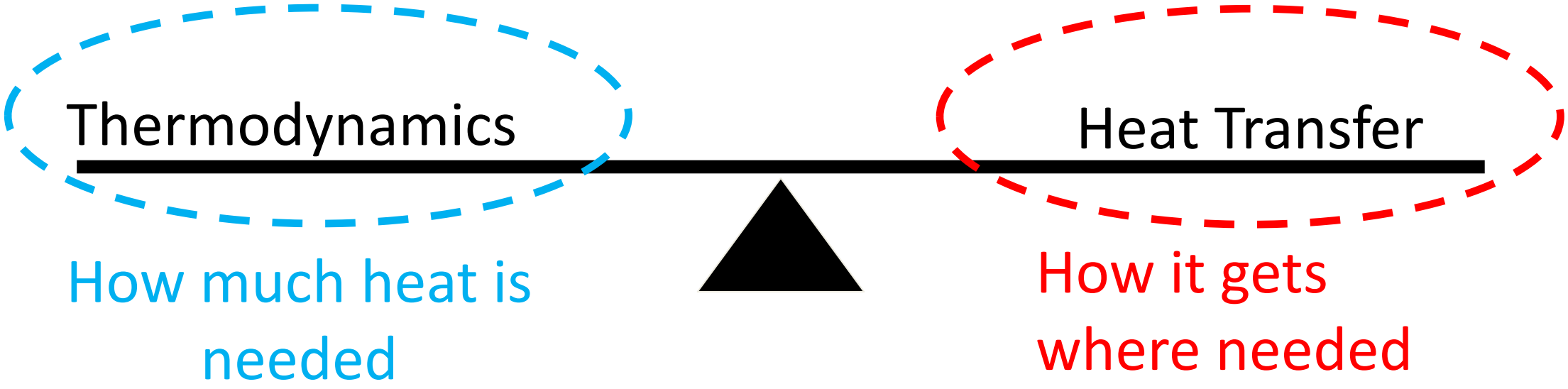
65% RAP @ 5% RAP Moisture



Double Barrel XHR®

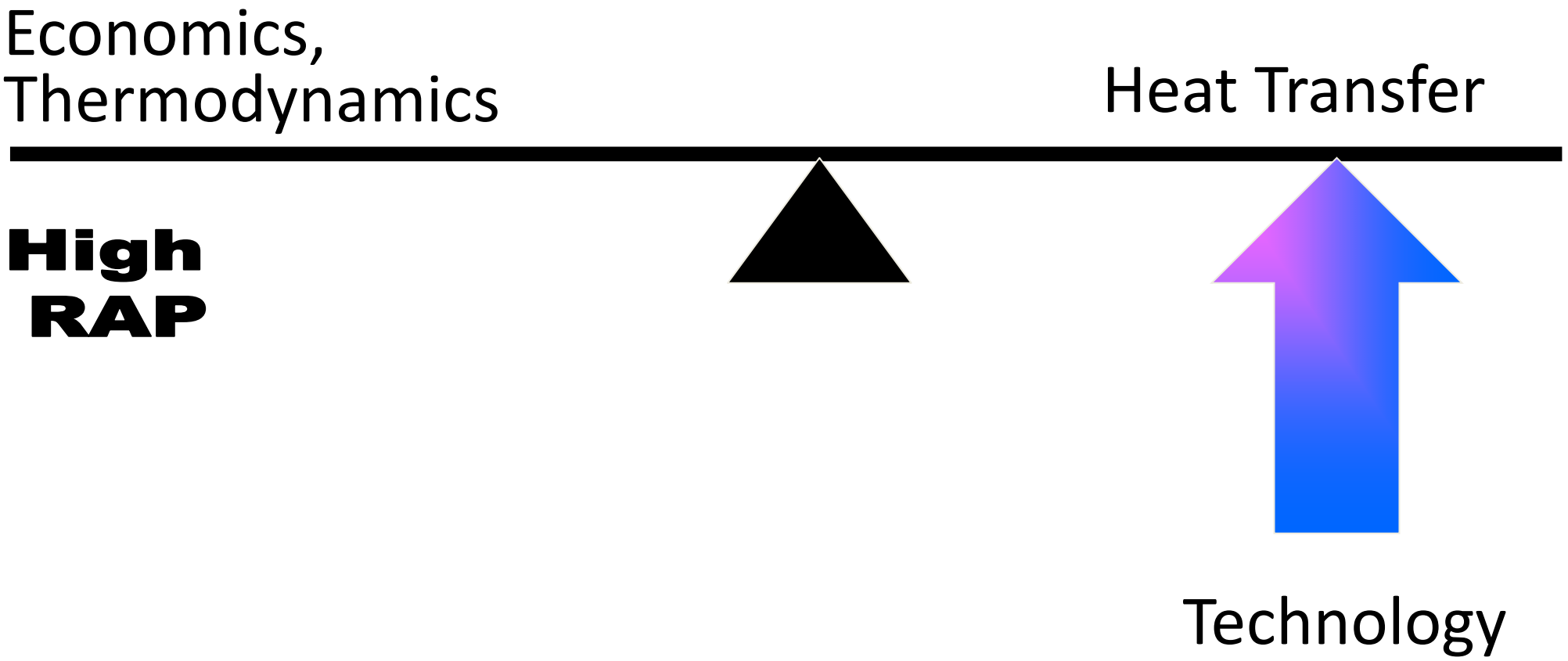


Thermodynamics vs. Heat Transfer…

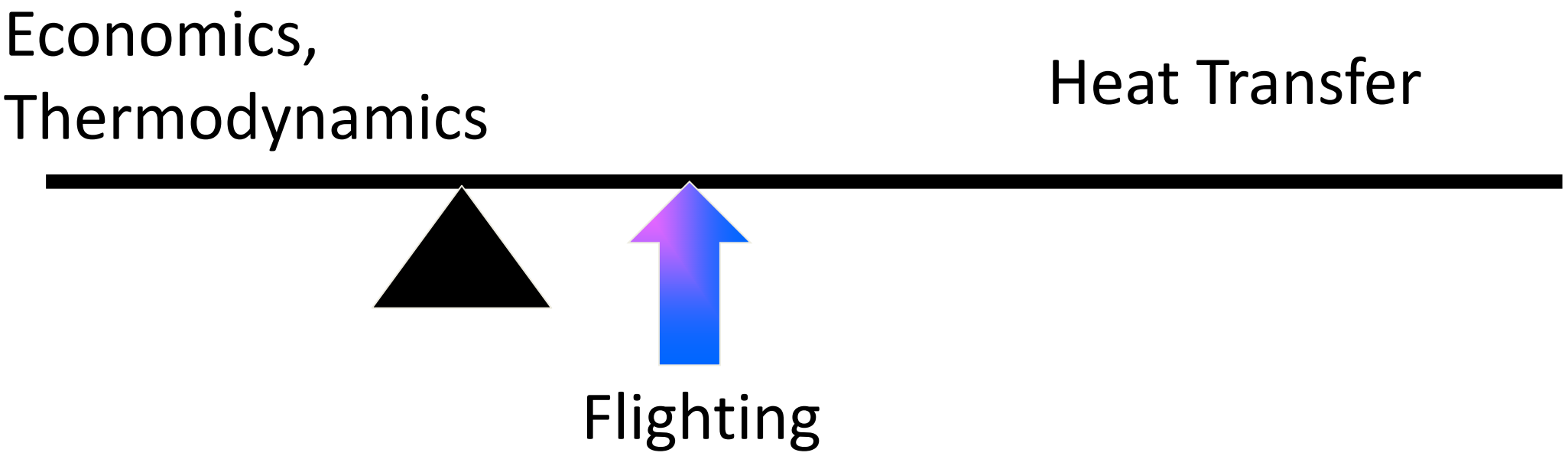


Heat transfer is ALWAYS the challenge

Overcoming the Physics Disadvantage

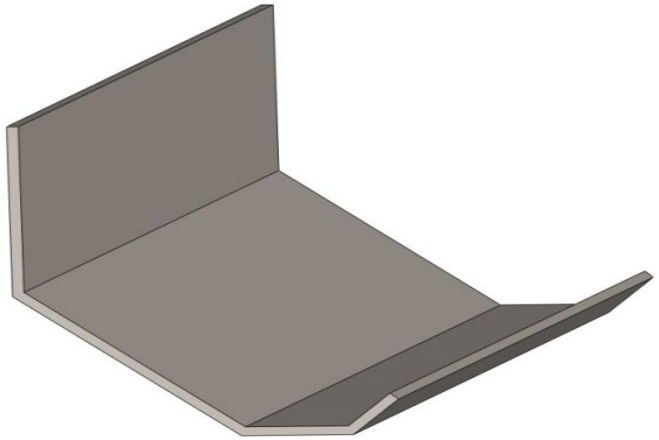


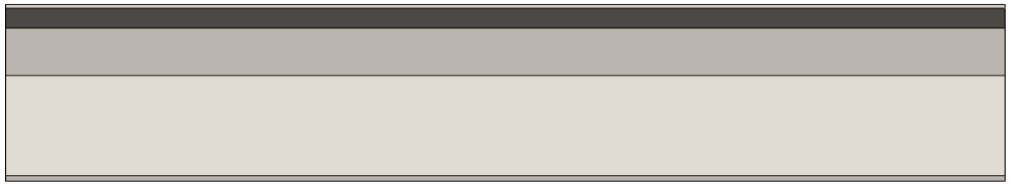
Dryer Flighting Technology



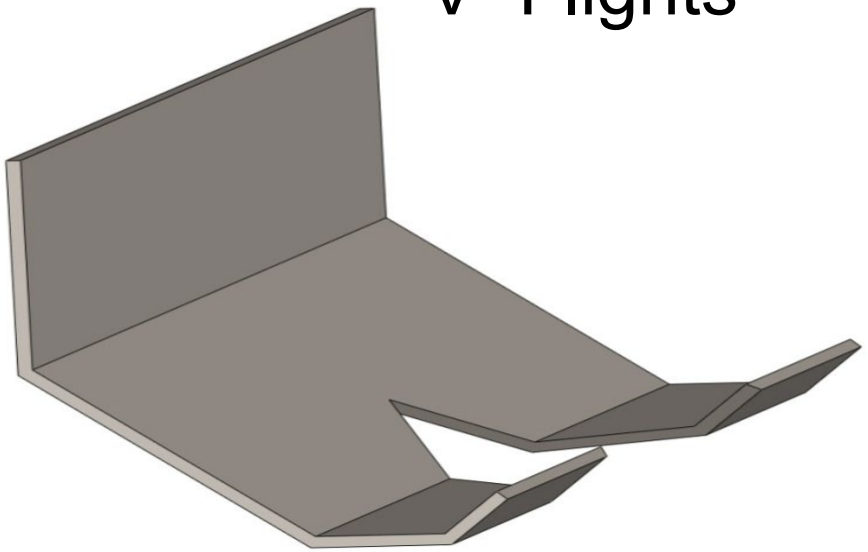
Flighting Technology

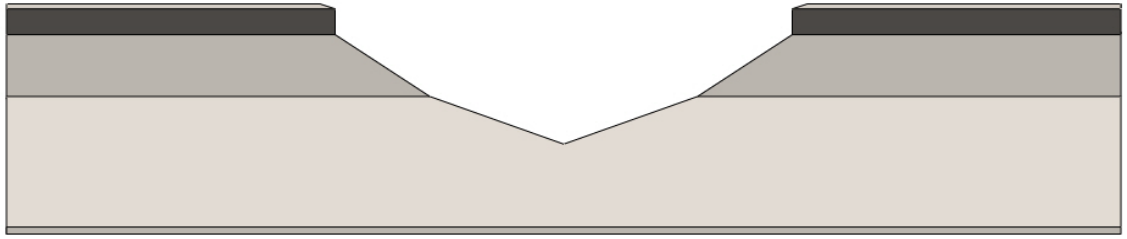
Typical Flights





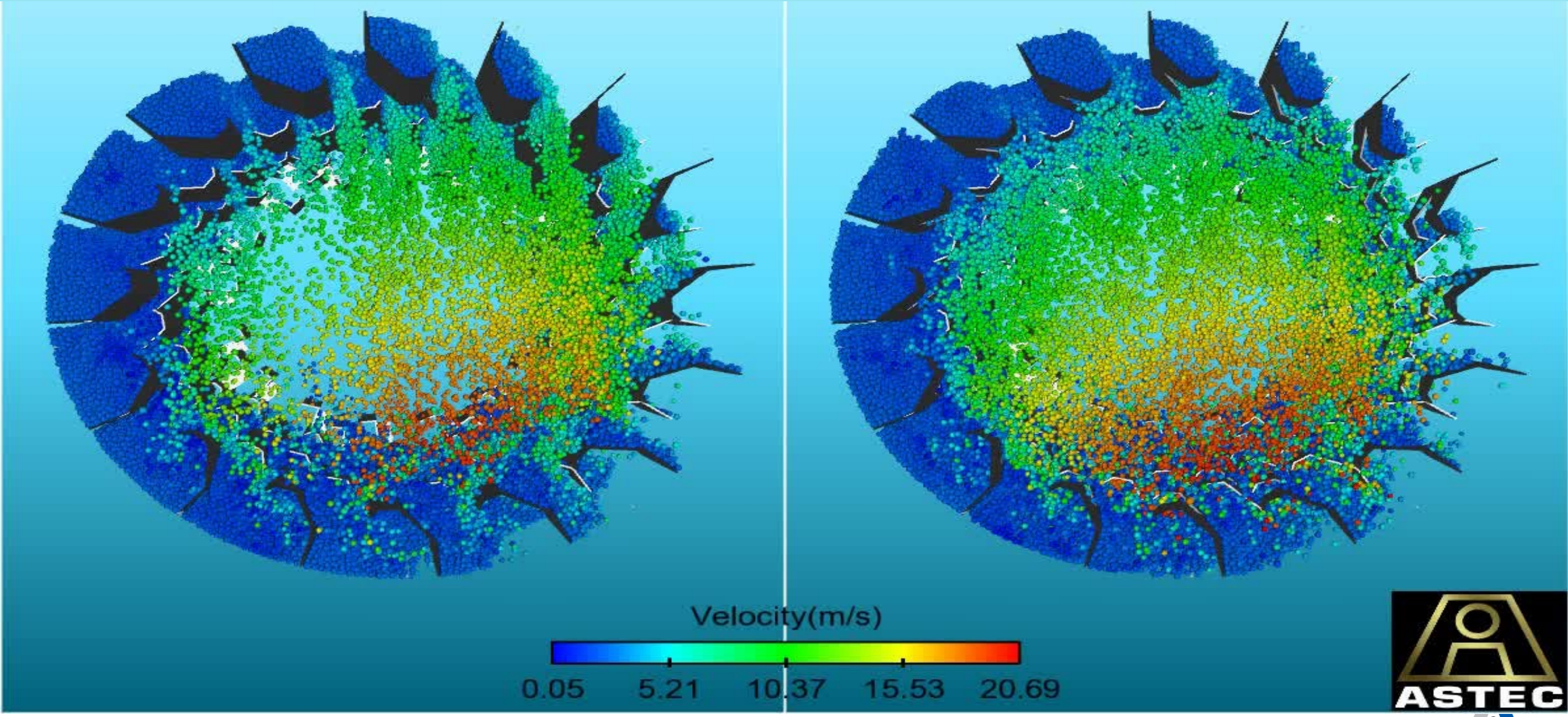
V- Flights



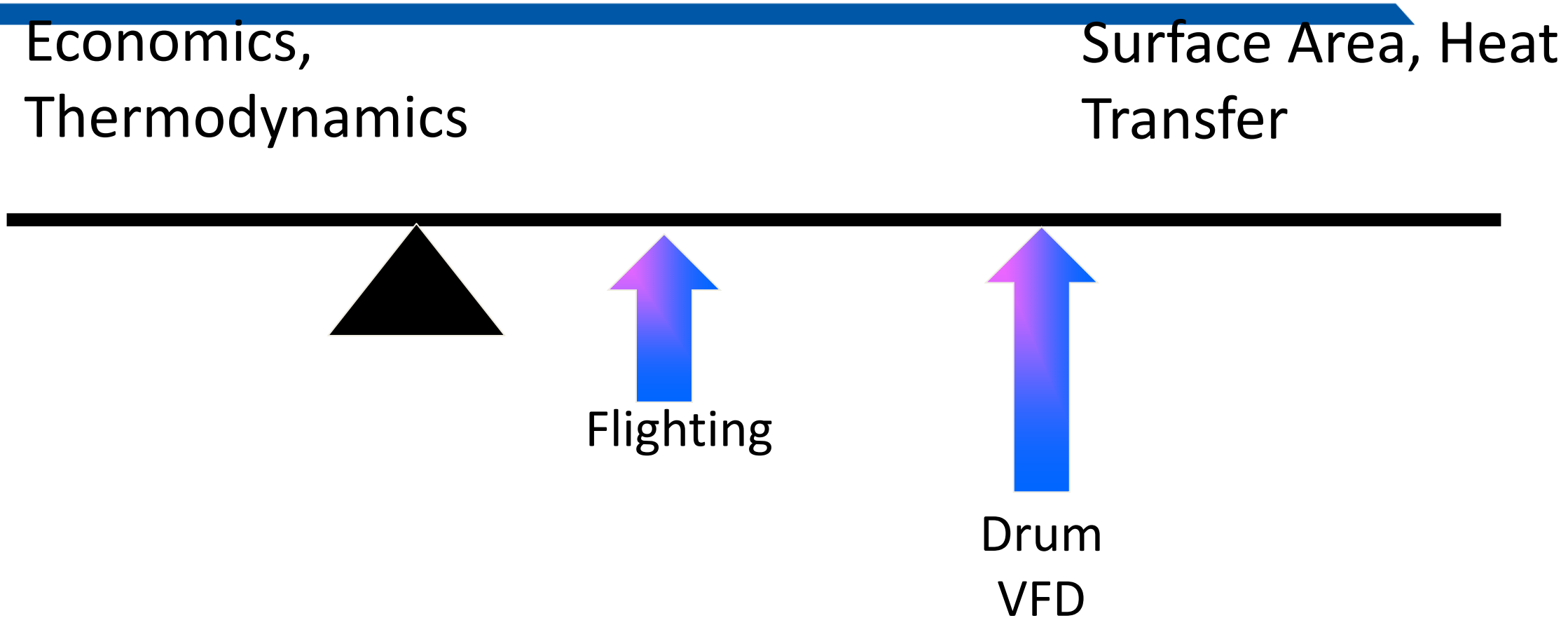


Typical Flights

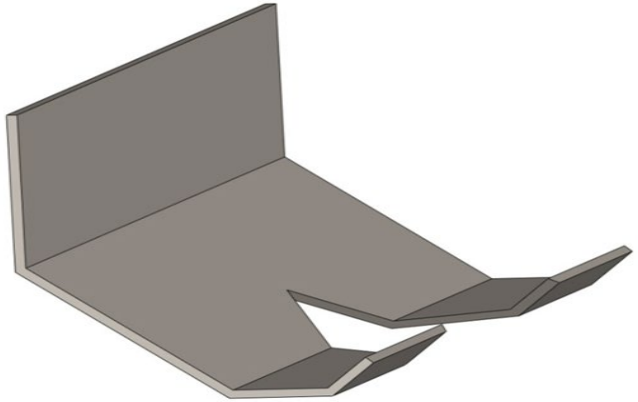
V-Flights



In the balance…drum speed multiplies SA exposure

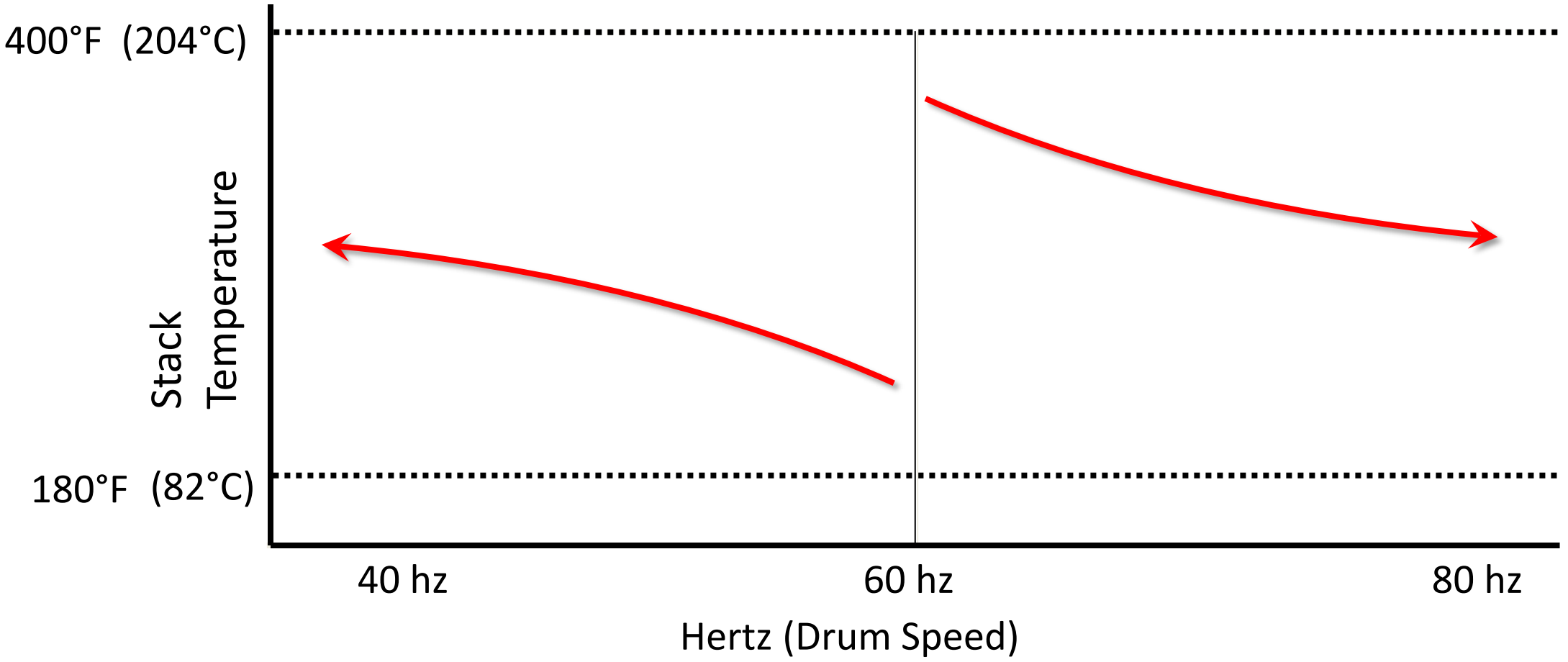


V-PAC™ Stack Temperature Control

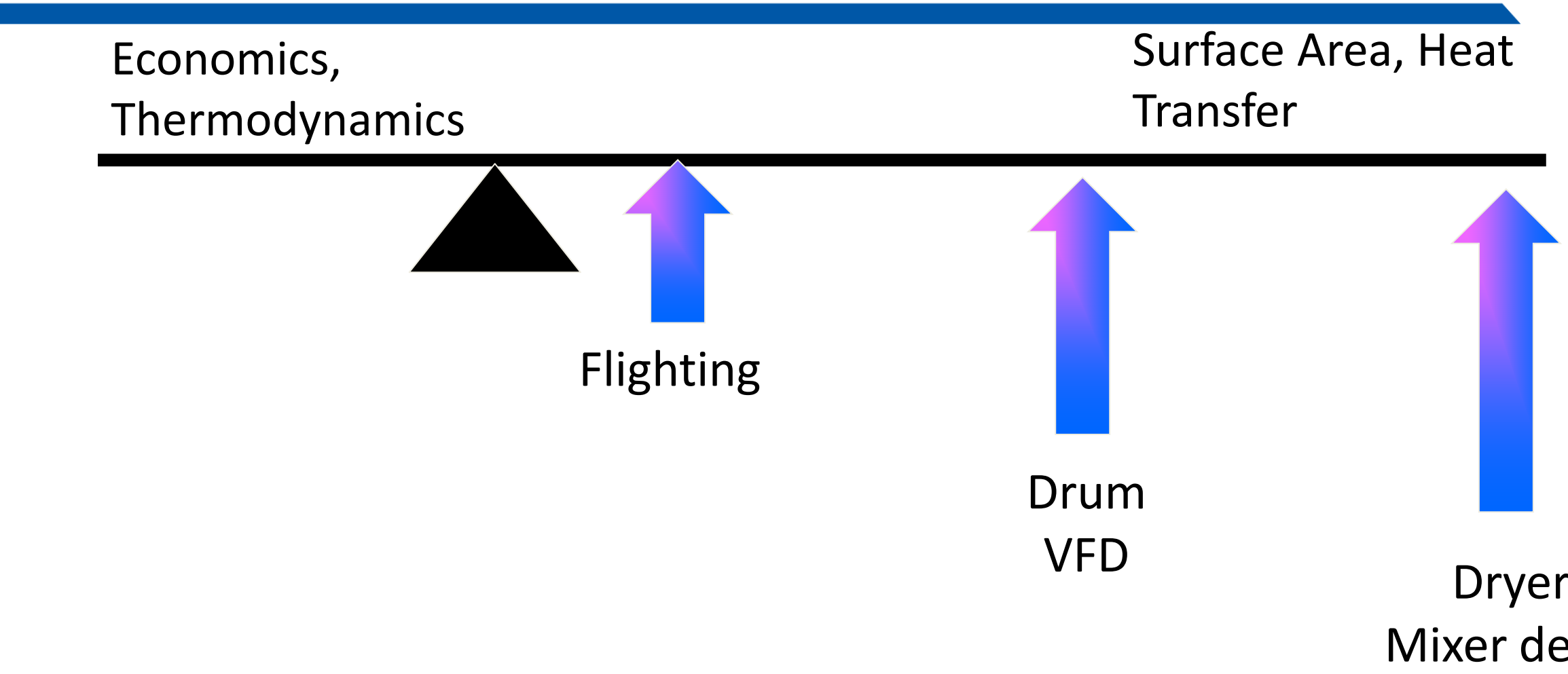


Control Logic

V-PAC™ Stack Temperature Control



Balance…capable dryer and mixer



Double Barrel XHR®

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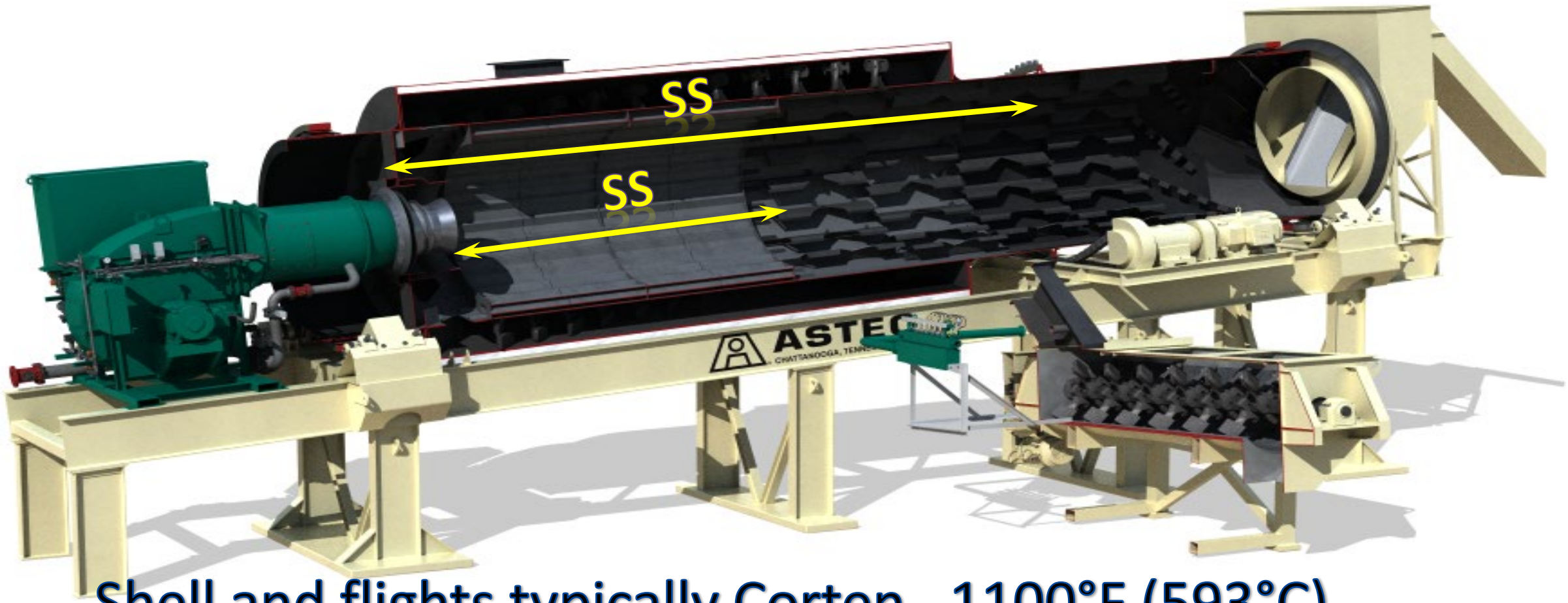
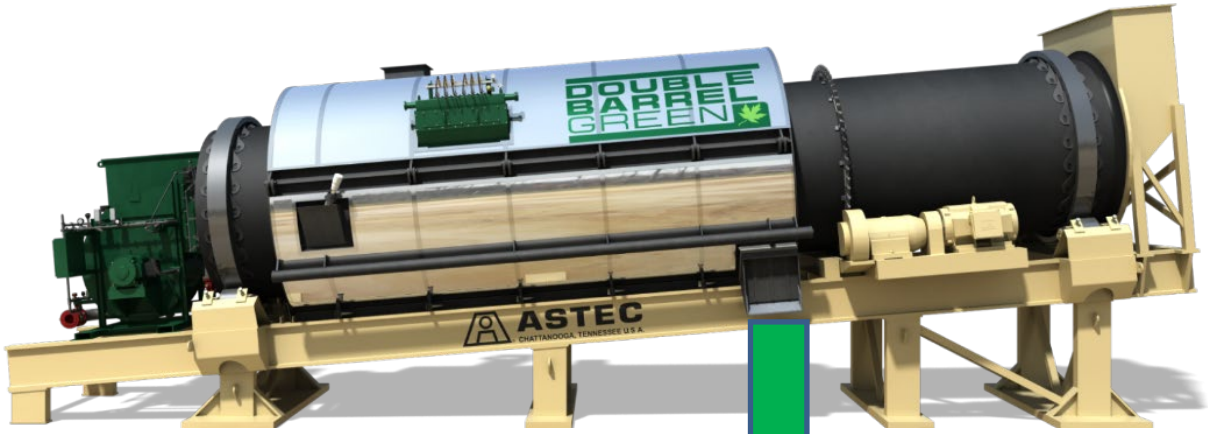
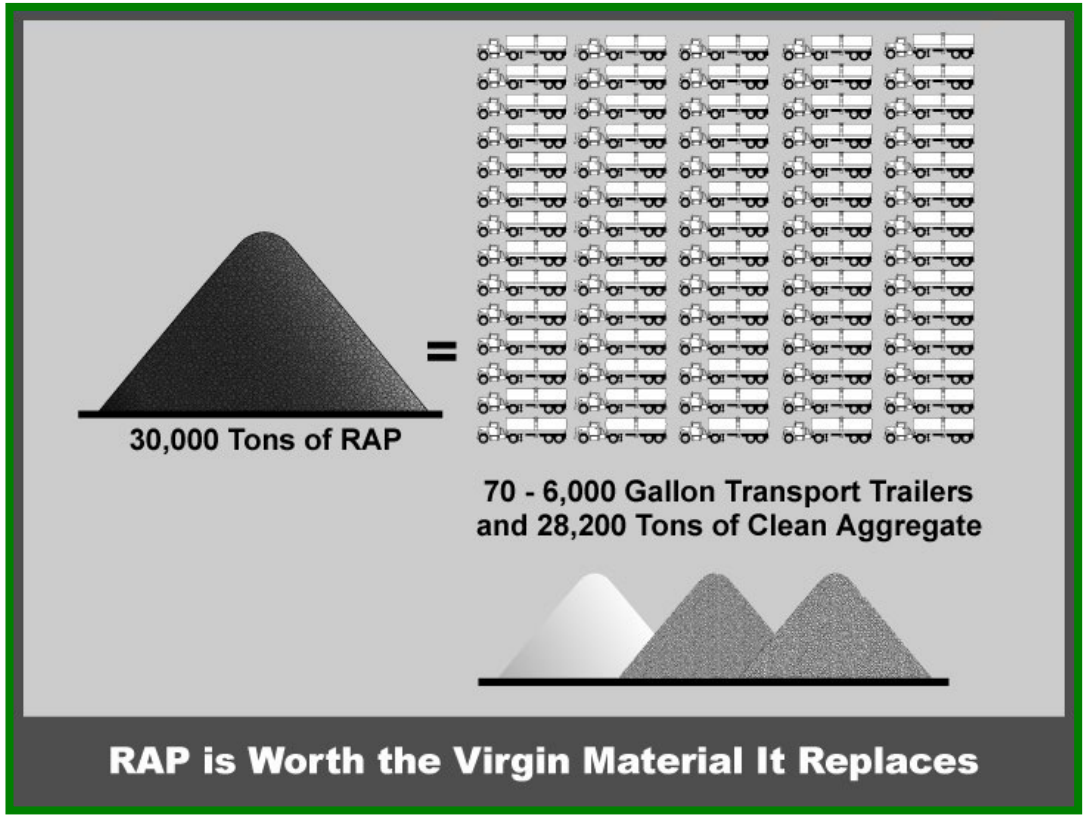


Shell and flights typically Corten, 1100°F (593°C)
Stainless, **1800°F (982°C)** minimal oxidation

RAP is important for several reasons





RAPANOMICS

RAP IS WORTH WHAT IT REPLACES

AGGREGATE .....0.95 X $25.00 = $23.75 /ton TON

ASPHALT .....0.05 X $600.00 = $30.00 / ton

TOTAL ..... = **$53.75 / ton**

MILLING .....= $ 4.00 / ton

TRUCKING ..... = $ 4.00 / ton

PROCESSING ..... = $ 4.00 / ton

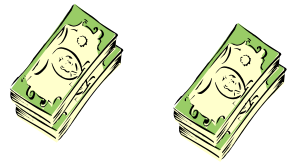
COST..... = $12.00/ ton

RAP VALUE ..... = **$41.75/ton**

RAPANOMICS – Show me the money!

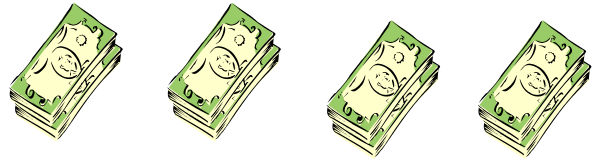
10% RAP… 0.1 X $41.75/TON = $4.17 / ton

20% RAP… 0.2 X $41.75/TON = $8.34 / ton



30% RAP… 0.3 X $41.75/TON = $12.51 / ton

40% RAP … 0.4 X $41.75/TON = $16.68 / ton



50% RAP … 0.5 X $41.75/TON = $20.85 / ton

RAP ECONOMICS

RAP IS WORTH WHAT IT REPLACES.
AGGREGATE ……..0.95 X $25.00 = $23.75 / TON
ASPHALT ……0.05 X $600.00 = $30.00 / TON
TOTAL …… = **$53.75 / TON**

MILLING ……= $ 4.00 / TON
TRUCKING …… = $ 4.00 / TON
PROCESSING …… = $ 4.00 / TON
COST…….. = $12.00/ TON
RAP VALUE …… = **$41.75/TON**
ADDITIONAL PROFIT
10% RAP… 0.1 X $41.75/TON = $4.18 / TON

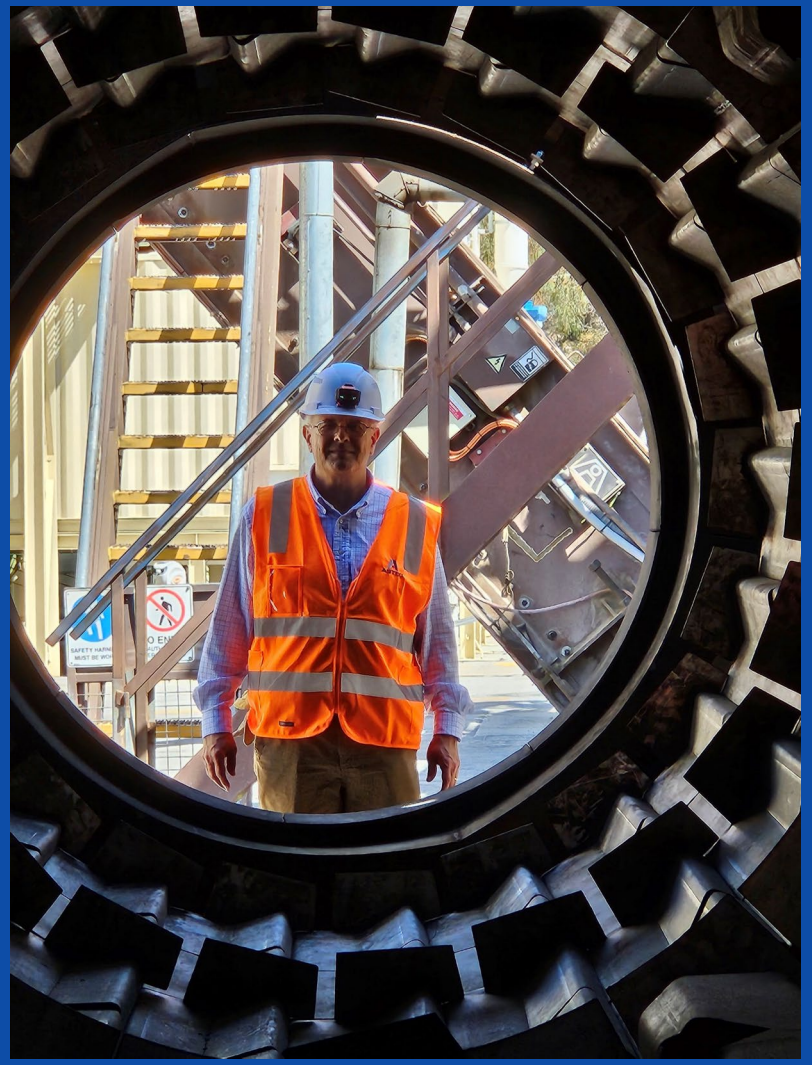
20% RAP… **$8.36 / TON**

30% RAP… **$12.54 / TON**

40% RAP … **$16.72 / TON**

50% RAP … **$20.90 / TON**

Thank You!



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