

Cement Manufacturing Process

- What is Cement?
- History
- Overview of the Cement Manufacturing Process
- Brief Overview of Kiln Operations
- Why Burn Wastes?

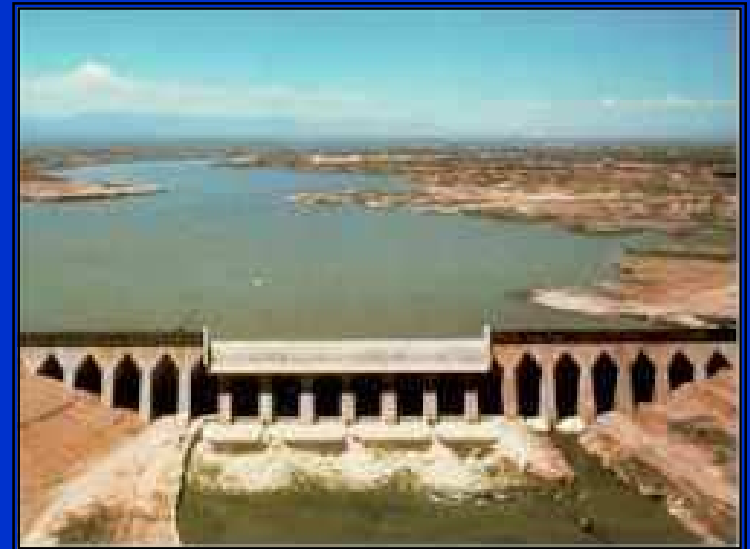


Portland Cement

- A hydraulic cement made by finely pulverizing the clinker produced by calcining to incipient fusion a mixture of argillaceous and calcareous materials
- Portland cement is the fine gray powder that is the active ingredient in concrete

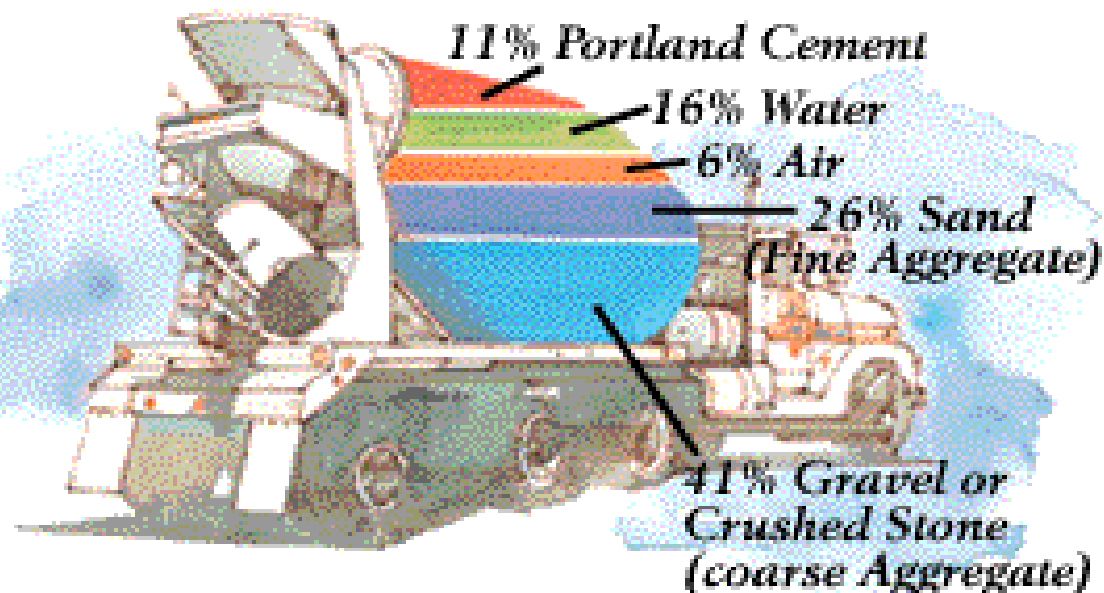
Concrete

- One Shovel Powder.....Portland Cement
- Two Shovels Sand.....Mineral Aggregate
- Three Shovels Rock.....Mineral Aggregate
- Add water & mix
- Binds & sets to a solid mass



Concrete

Concrete components: Cement is the key ingredient of concrete, but makes up just 11% of the mix.



Concrete

- Mixture of ingredients into a paste & triggers a chemical reaction - hydration
- Reaction forms a gel which coats & fills spaces between the stone/sand;
- Hardens into a solid mass that gets stronger & stronger



Concrete

- The world's most widely used building material
- Global production is 5 billion cubic yards per year (using approximately 1.25 billion tons of cement)

Concrete owes its strength and durability to one essential ingredient - Portland Cement



Portland Cement

- Limestone + Shale/Clay + Heat = Clinker + CKD + Exit Gas
- Material Temperatures Exceed 2700 °F
- Pulverized Clinker + Gypsum = Portland Cement
- Cement is powder so fine that one pound contains 150 billion grains

Portland Cement (cont'd)

- Basic Chemical Components of Portland Cement:
 - Calcium (Ca)
 - Silicon (Si)
 - Aluminum (Al)
 - Iron (Fe)
- Typical Raw Materials:
 - Limestone (CaCO_3)
 - Sand (SiO_2)
 - Shale, Clay (SiO_2 , Al_2O_3 , Fe_2O_3)
 - Iron Ore/Mill Scale (Fe_2O_3)

Portland Cement (cont'd)

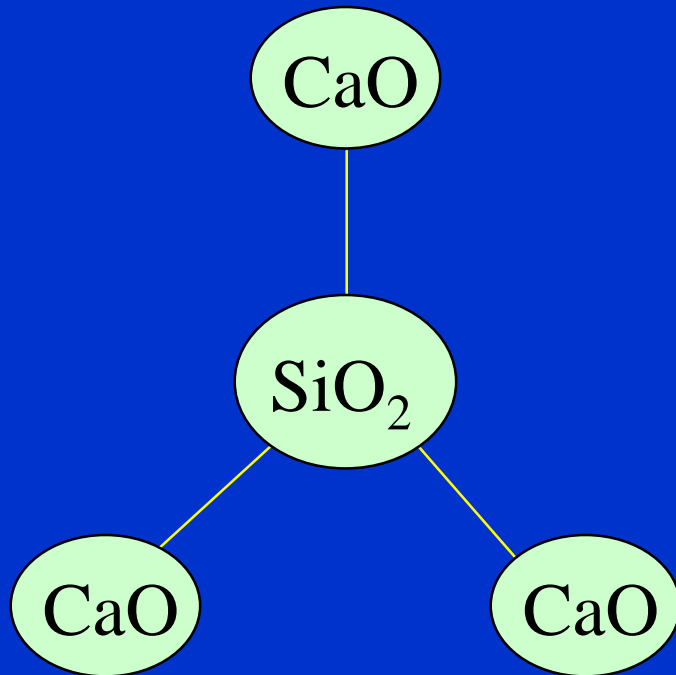
- Calcareous Component (providing Lime - CaO)
 - limestone
 - marly limestone
 - chalk
 - coral limestone
 - marble
 - lime-sand
 - shell deposits
 - lime sludge
- Argillaceous Component (SiO_2 , Al_2O_3 , and Fe_2O_3)
 - clay
 - shale
 - calcareous marl
 - marl
 - marly clay
 - tuff, ash
 - phyllite, slate
 - glass

Portland Cement (cont'd)

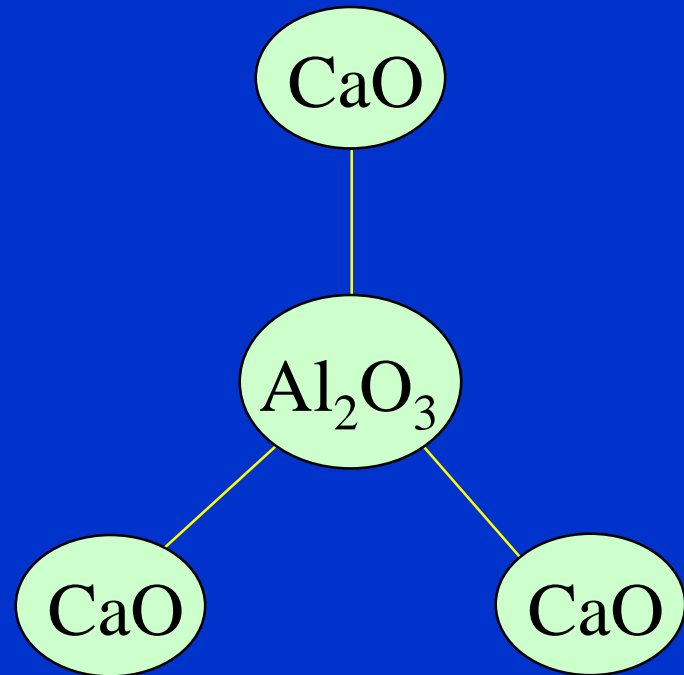
- Clinker Chemistry
 - Tricalcium silicate ($3\text{CaO}\cdot\text{SiO}_2$), (50-70%)
 - Dicalcium silicate ($2\text{CaO}\cdot\text{SiO}_2$), (15-30%)
 - Tricalcium aluminate ($3\text{CaO}\cdot\text{Al}_2\text{O}_3$), (5-10%)
 - Tetracalcium aluminoferrite ($4\text{CaO}\cdot\text{Al}_2\text{O}_3\cdot\text{Fe}_2\text{O}_3$), (5-15%)

Portland Cement (cont'd)

Tricalcium Silicate

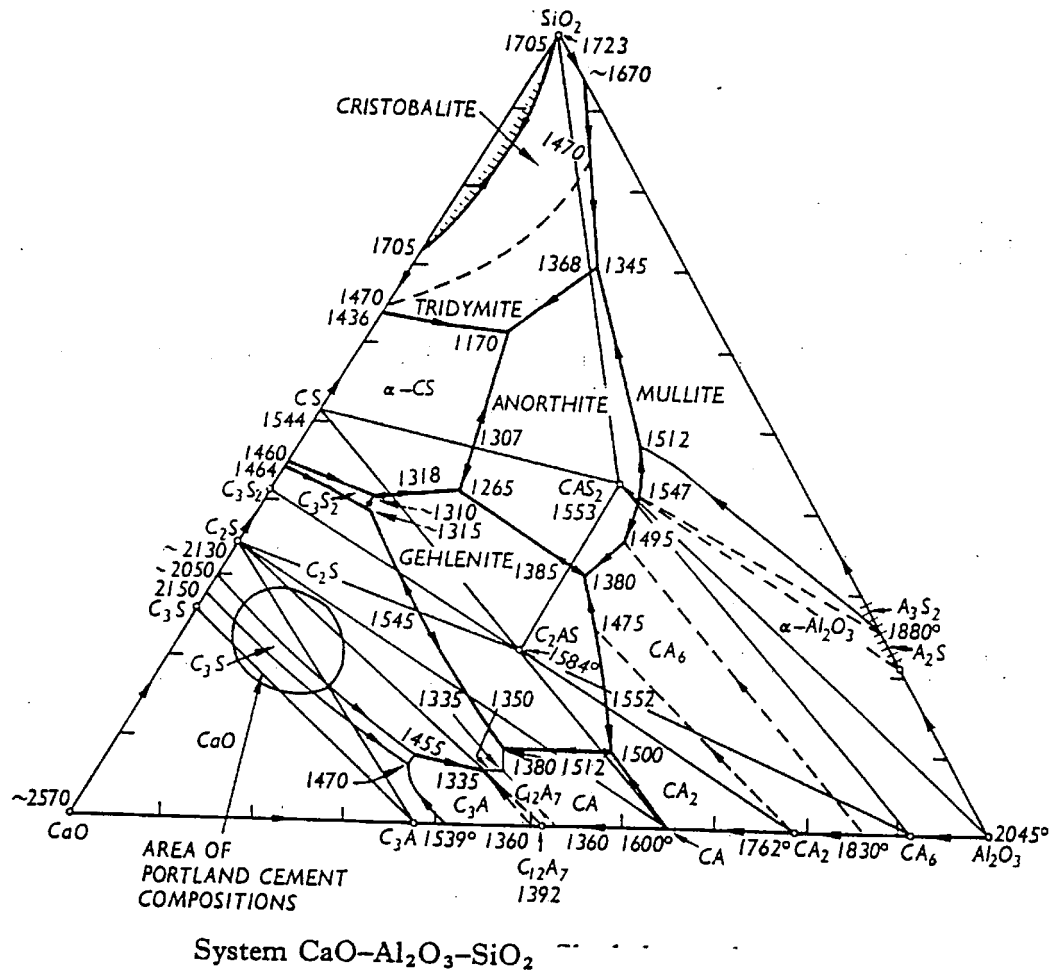


Tricalcium Aluminate



Portland Cement (cont'd)

Phase Diagram



History of Portland Cement



- First cements produced by early Greeks and Romans from volcanic ash mixed with slaked lime
- This art was lost during the Middle Ages
- Portland cement developed in England by bricklayer Joseph Aspdin in early 1800's
- Called "Portland" because concrete made with it resembled natural stone from the Isle of Portland

History of Portland Cement



- First rotary kiln designed to produce Portland cement patented in 1885 by Frederick Ransome
- First economical U.S. kilns developed by Atlas Cement Company in 1895
- Thomas A. Edison first developed long kilns (150 feet compared to 60 to 80 feet)

Energy/Capital Intensive Industry

- Requires 80 separate & continuous operations
- 1990 - 6th in the nation for energy usage
- 18,700,000 tons of coal burned in the U.S. (value of \$748,000,000)
- 1,398,400,000 kW of power used (value of \$700,000,000)
- A one million ton plant requires approximately \$175 million in capital

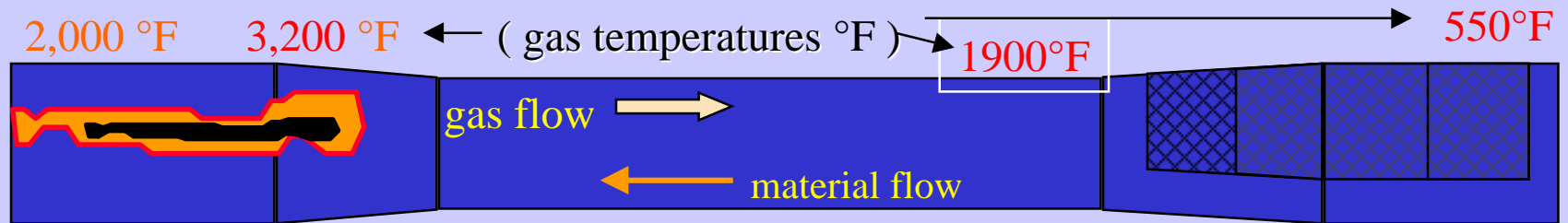
Types of Cement Processes

- Wet Process
- Dry Process - 74% of cement produced
- Preheater/Precalciner Process

Evolution of the Cement Process

- Wet process easiest to control chemistry & better for moist raw materials
- Wet process high fuel requirements - fuel needed to evaporate 30+% slurry water
- Dry process kilns less fuel requirements
- Preheater/precalciners further enhance fuel efficiency & allow for high production rates

The Wet Cement Kiln

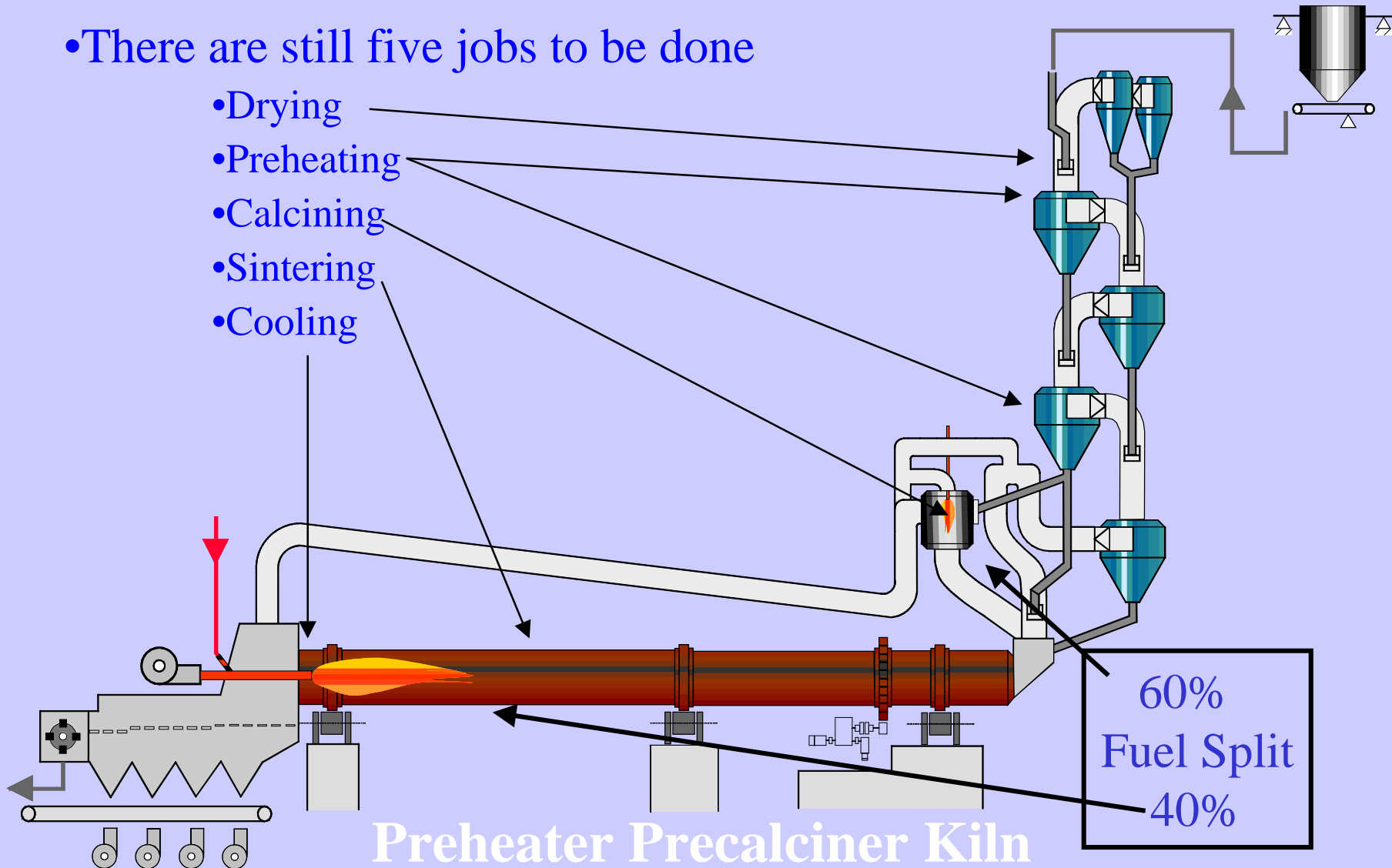


- ◆ The kiln is a continuous stream process vessel in which feed and fuel are held in dynamic balance
- ◆ 5 distinct process functions are performed in the kiln:
 - ◆ Dry
 - ◆ Preheat
 - ◆ Calcine
 - ◆ Sinter
 - ◆ Cool

Dry Process Preheater/Precalciner System

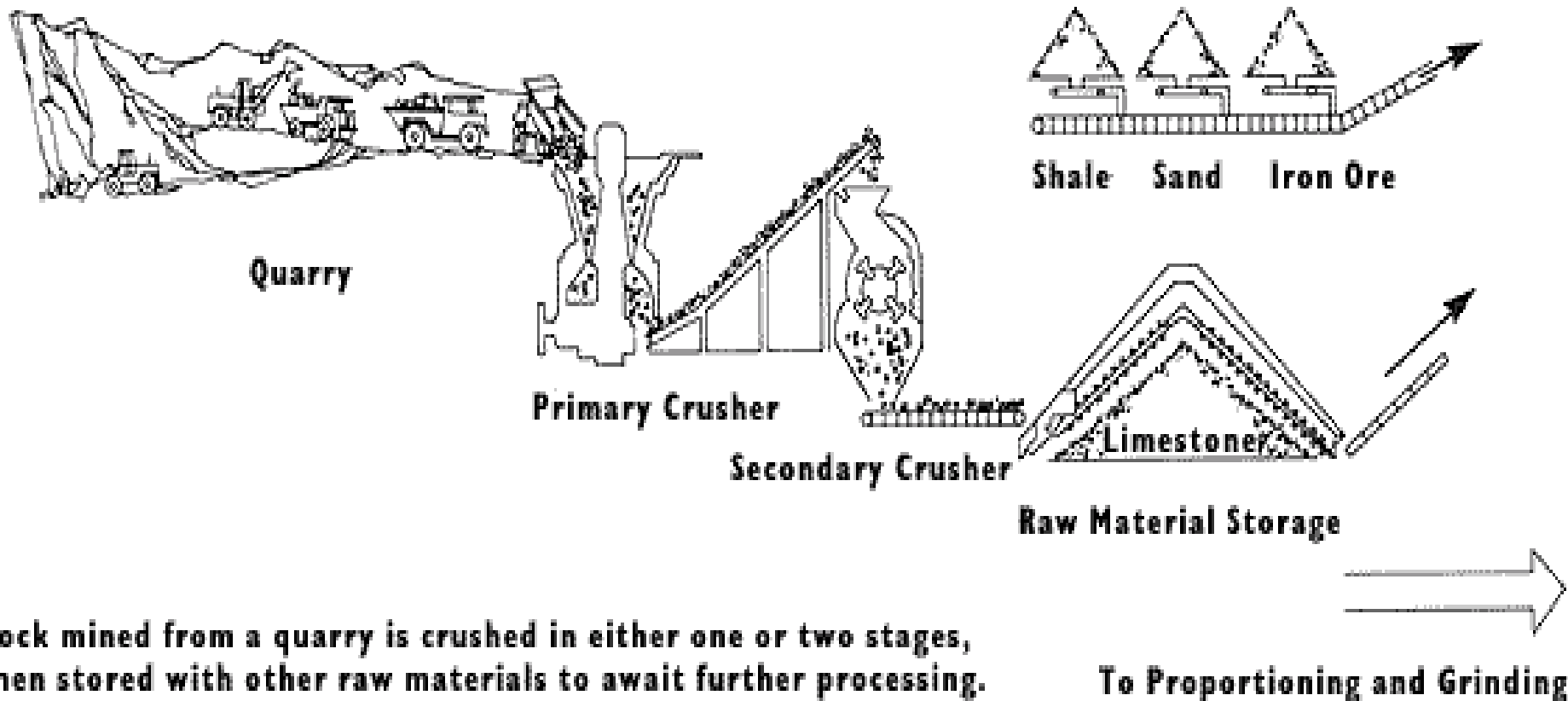
• There are still five jobs to be done

- Drying
- Preheating
- Calcining
- Sintering
- Cooling



Preheater Precalciner Kiln

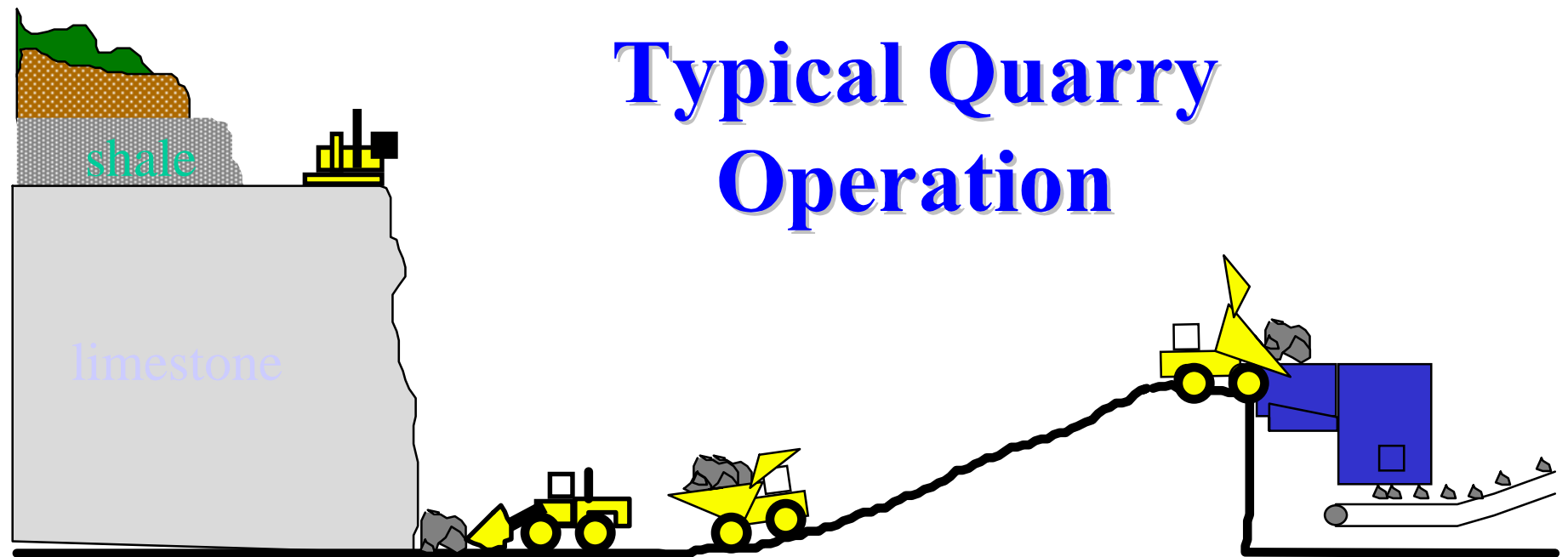
Steps in the Manufacture of Portland Cement



Rock mined from a quarry is crushed in either one or two stages, then stored with other raw materials to await further processing.

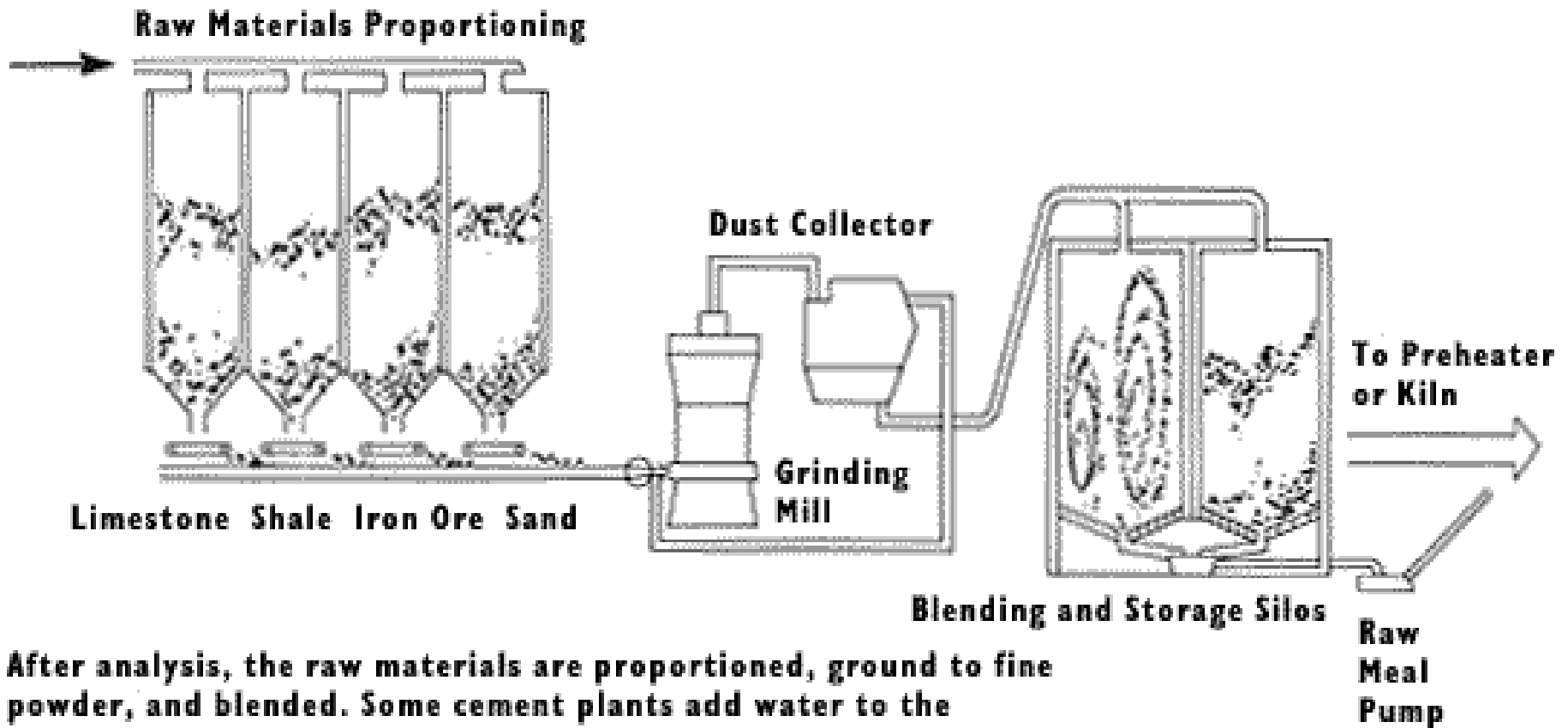
To Proportioning and Grinding

Typical Quarry Operation



- ◆ Typically shale provides the argillaceous components:
 - ◆ Silica (SiO_2 , Aluminum(Al_2O_3) & Iron (Fe_2O_3))
- ◆ Limestone provides the calcareous component:
 - ◆ Calcium Carbonate (CaCO_3)
- ◆ Raw materials may vary in both composition and morphology.

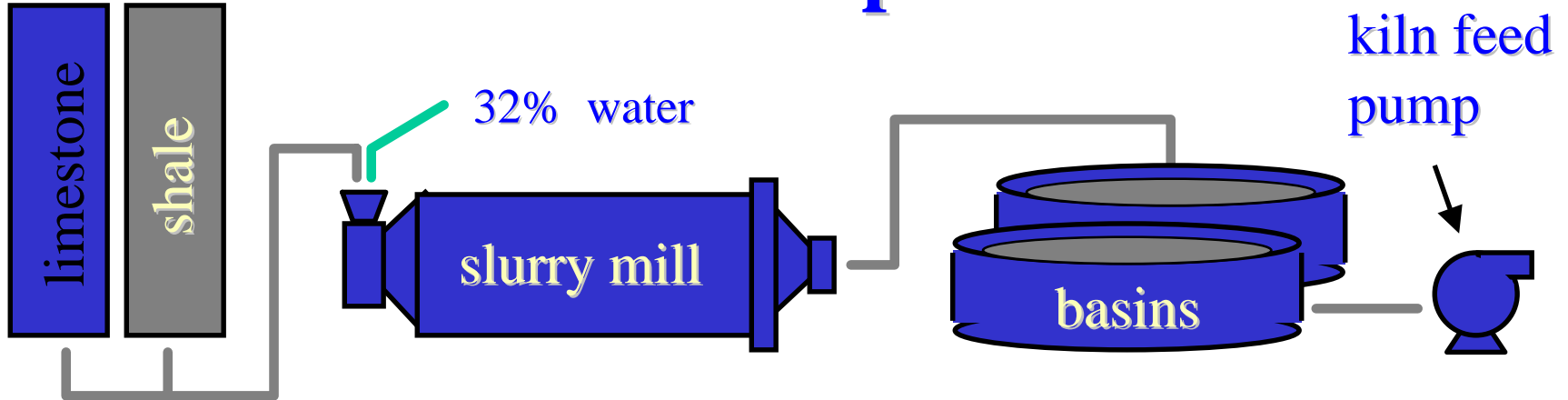
Steps in the Manufacture of Portland Cement



After analysis, the raw materials are proportioned, ground to fine powder, and blended. Some cement plants add water to the material during grinding, then blend and store it as a slurry.

70% 30%

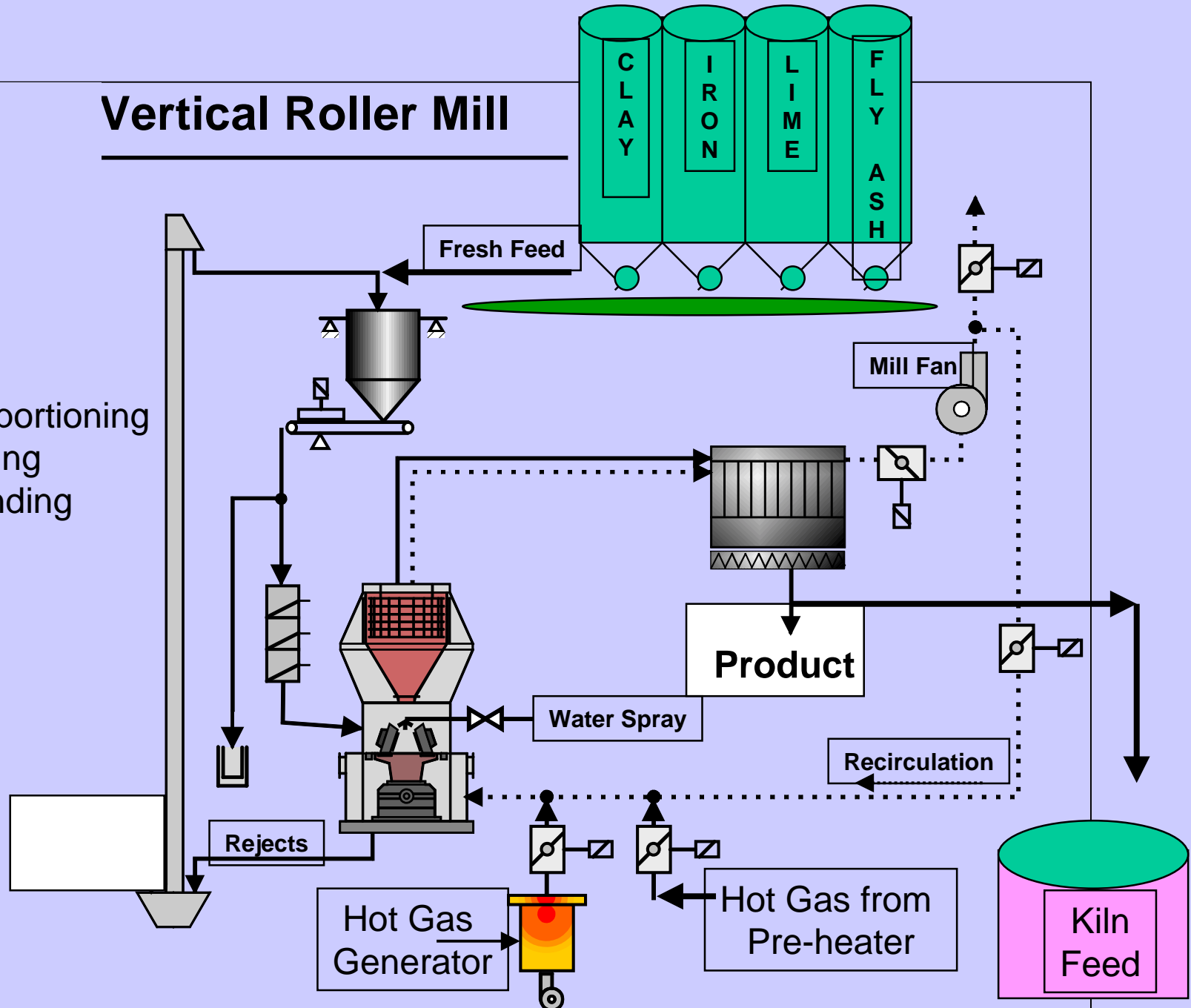
Kiln Feed Preparation



- ◆ Proportioning of feed stock.
- ◆ Size reduction to $< 125\mu$.
- ◆ Control of moisture.
- ◆ Blending to reduce standard deviation.
- ◆ Uniform delivery rate of feed to the Kiln.

Vertical Roller Mill

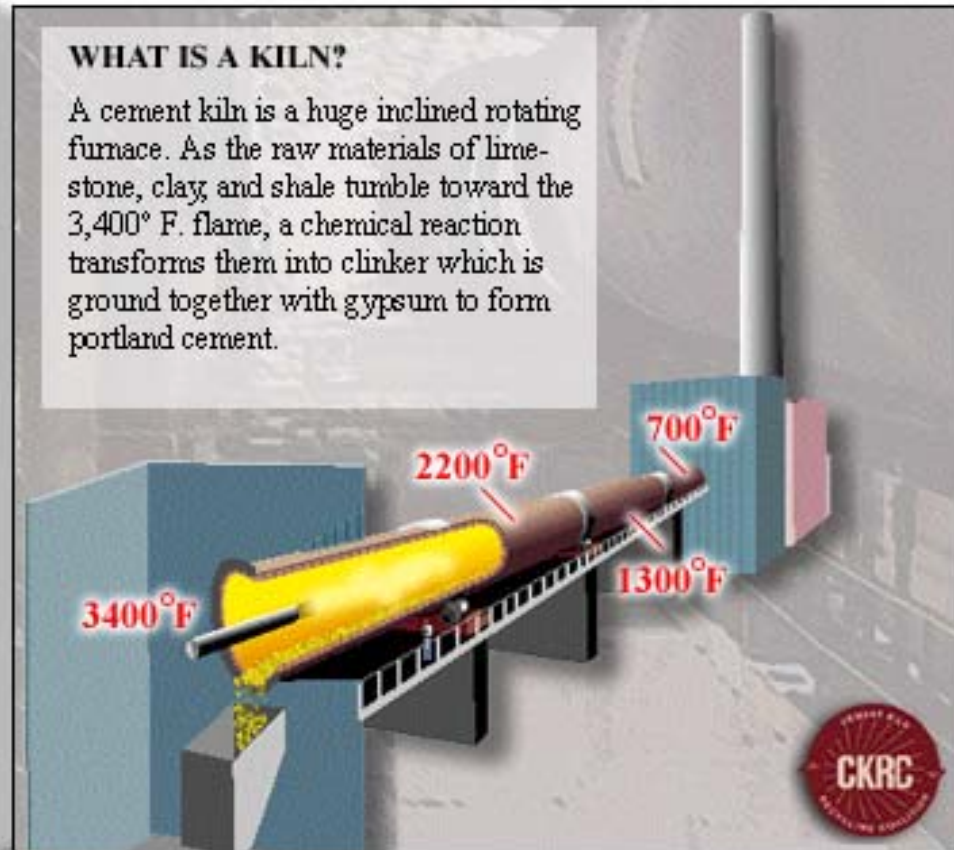
- Proportioning
- Drying
- Grinding



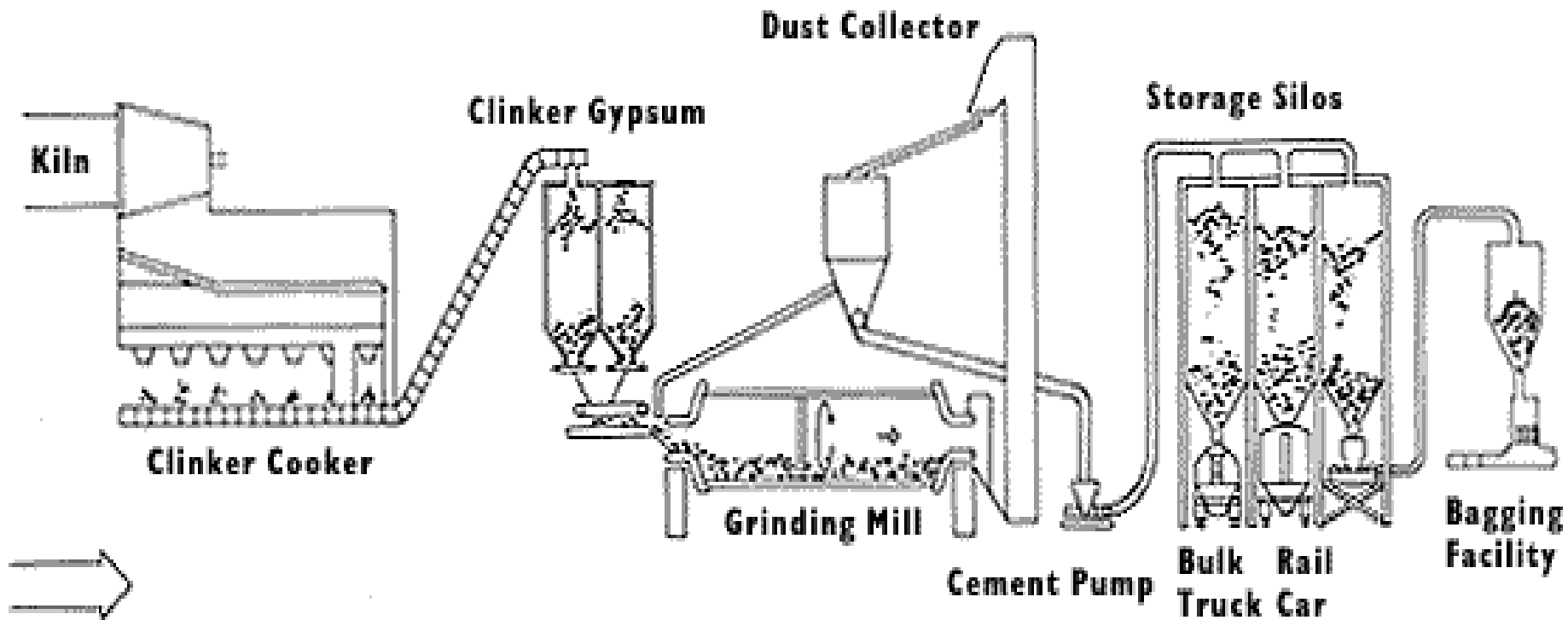
Steps in the Manufacture of Portland Cement

WHAT IS A KILN?

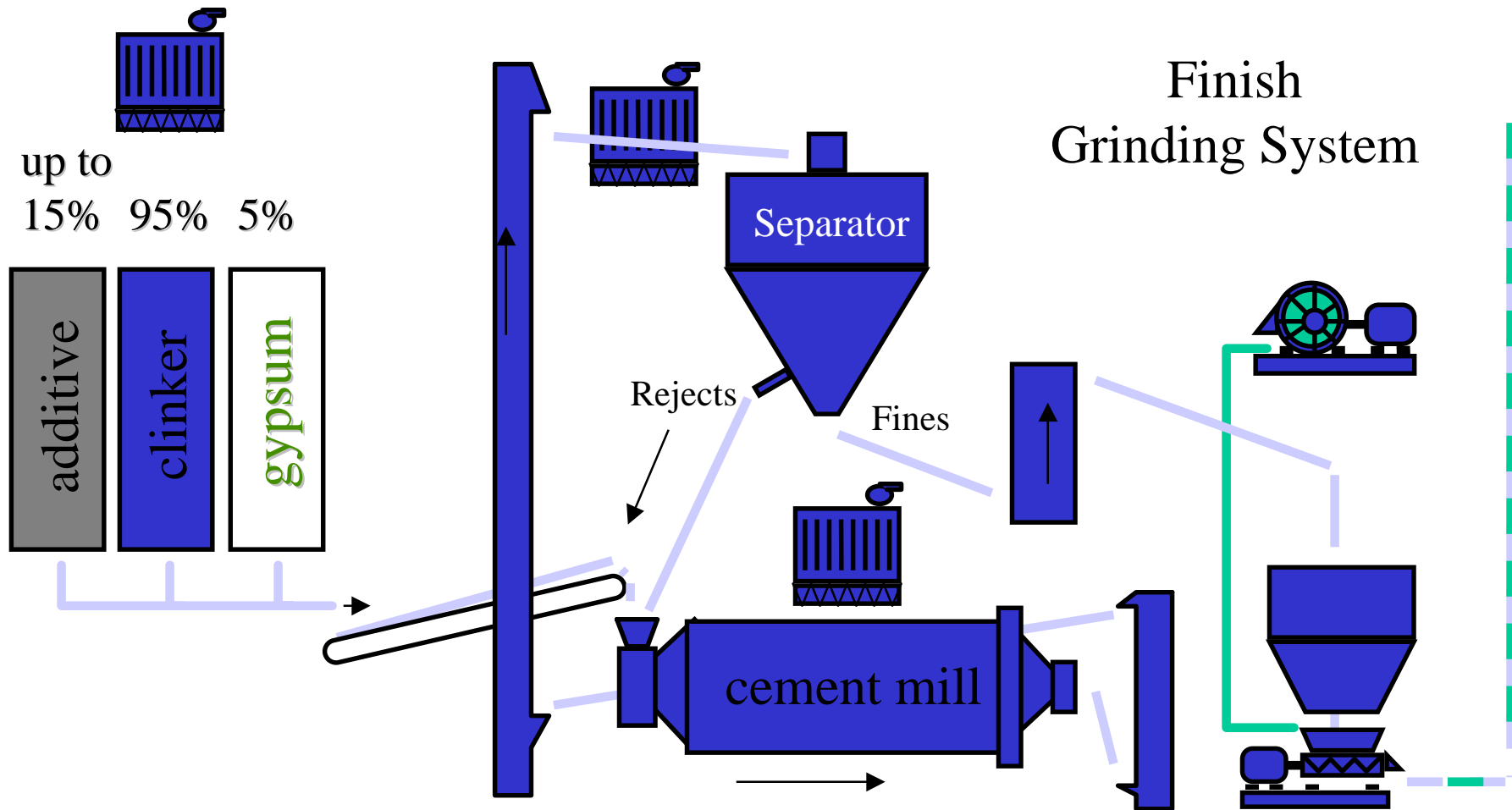
A cement kiln is a huge inclined rotating furnace. As the raw materials of limestone, clay and shale tumble toward the 3,400° F. flame, a chemical reaction transforms them into clinker which is ground together with gypsum to form portland cement.



Steps in the Manufacture of Portland Cement



Once cooled, the clinker is ground with a small amount of gypsum.
It's now portland cement-ready to be bagged or shipped in bulk.



- Clinker, gypsum, and optional additives are weighed to proper proportions and ground in the cement mills.
- Additives may include: Fly-ash, Limestone.....

Cement Kiln

the Largest Moving Equipment in any
Manufacturing Operation



And the Hottest

Cement Kilns

- High temperature
- Long residence time
- Natural alkaline environment
- CKD is only by-product of the process
- Thermal stability

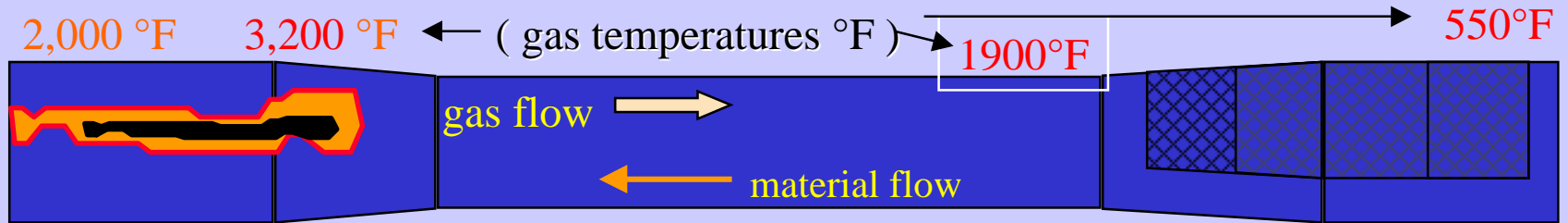


Kiln Process Control

- Critical Parameters: Fuel, Feed, Kiln Speed, Gas Flow
- Kiln Temperatures - Burning Zone
- Kiln Stability
- Chemistry
- Instrumentation



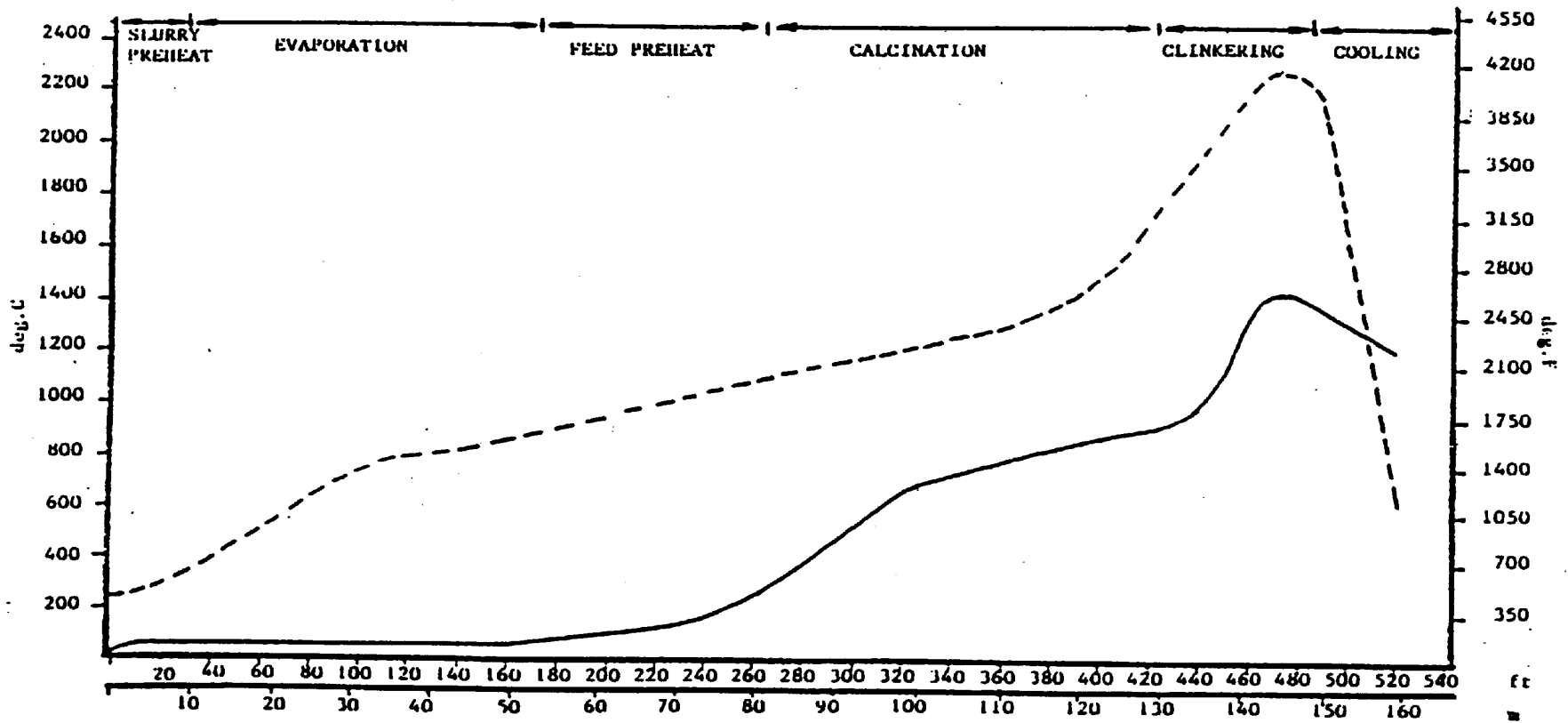
The Wet Cement Kiln



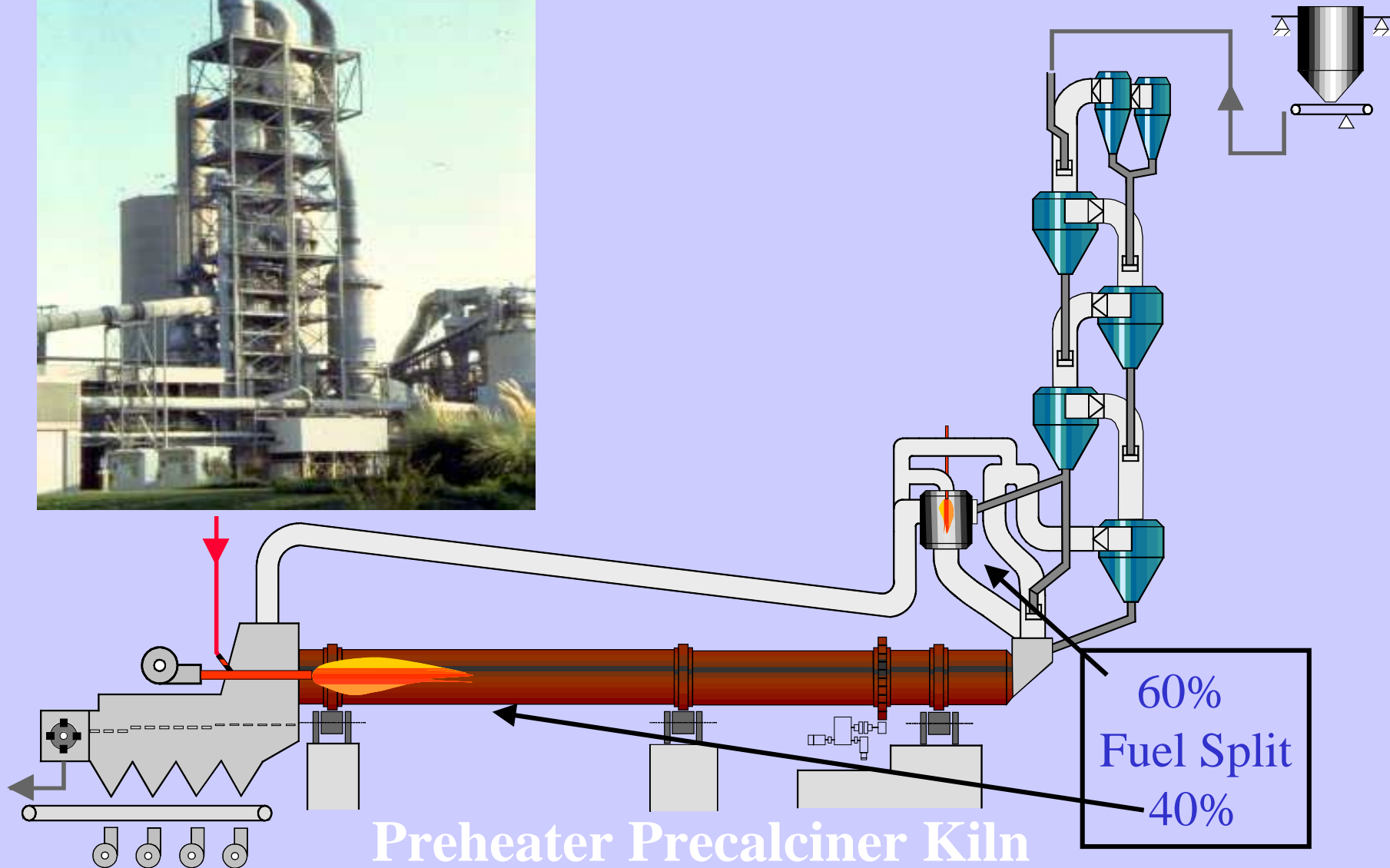
Critical Parameters: Fuel, Feed, Kiln Speed, Gas Flow
Kiln Temperatures



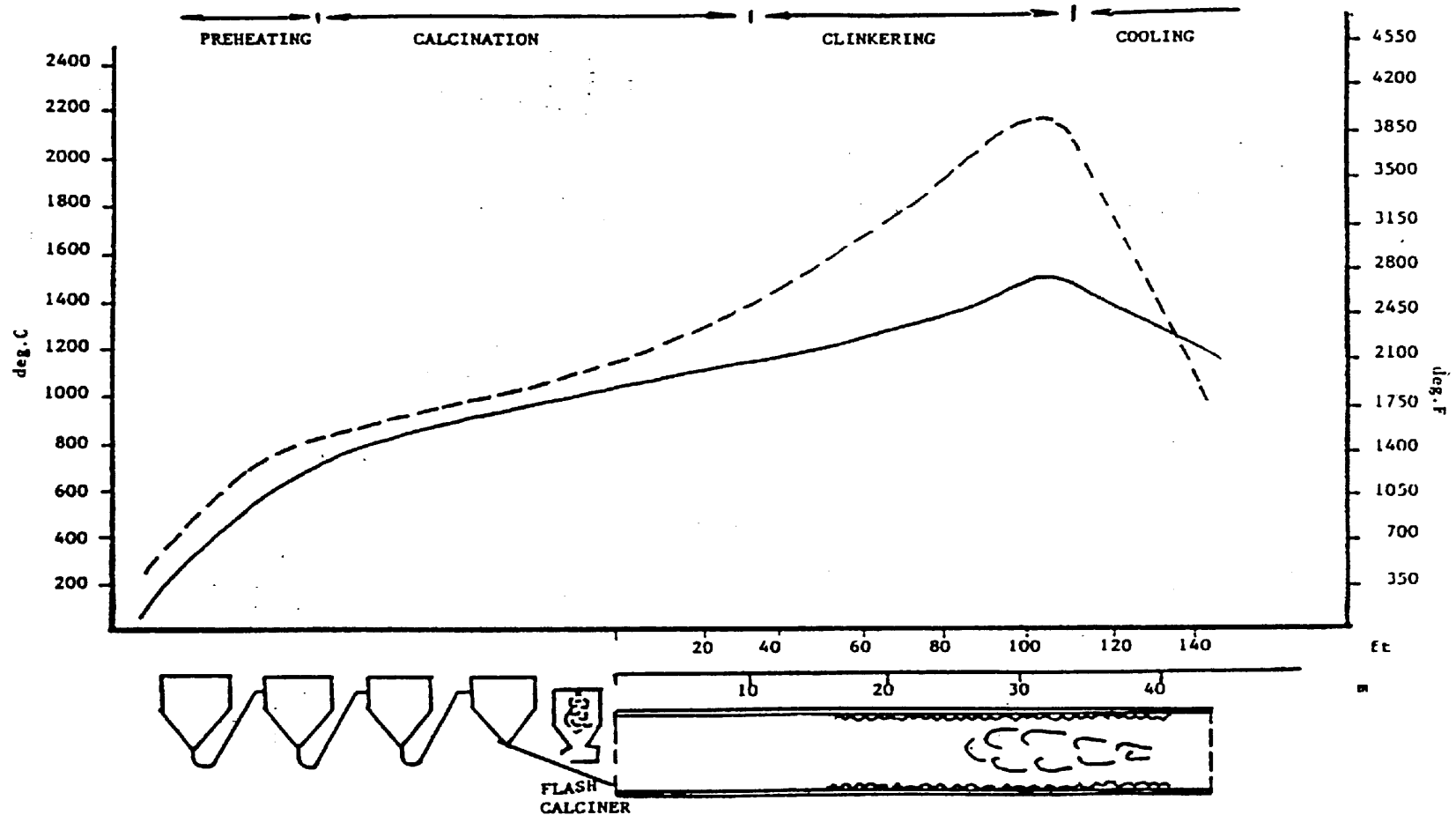
Wet Kiln Process Material and Gas Temperatures



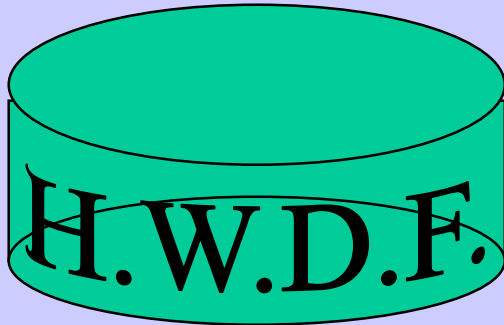
Dry Process Preheater/Precalciner System



Dry Kiln Process Material and Gas Temperatures

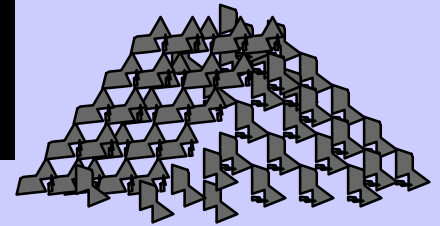


Kiln Fuels



Coal
&
Pet Coke

T.D.F.



Alternate
Fuels

A typical wet kiln burns about 400# of fuel to make a ton of clinker (5.0 mmBtu/ton of clinker)

Fuels can be any combustible hydrocarbon such as:

- ◆ coal, coke, natural gas, used motor oil, wood, tires, cellulose others.

Why Burn Wastes?

A cement kiln is a proven technology for recycling by beneficial REUSE of solid and hazardous wastes

The benefits are:

- energy recovery
- material recovery
- economics
- environmental preservation

Federal & State Established Priorities for Industrial Waste Disposal

- Reduction at the source
- Recycling
- Energy recovery
- Incineration
- Stabilization
- Landfill

Benefits of a Recycling Program

- Allows for reuse of waste materials
- Conserves virgin fuels & raw materials
- Regulated stringently for environmental protection

Waste Recycling Process

- Waste fuels are destroyed, releasing heat, water and carbon dioxide
- Solid materials are physically and chemically combined in the clinker product

Cement Kilns - Excellent Environment for Destroying & Recycling Wastes

A Cement Kiln Provides:

- 3,000°F + Flame
- Long retention times of gasses and materials
- Stability of a large dependable industrial process
- Many inherent safeguards

A Cement Kiln Is A Proven Technology For Beneficial REUSE of Otherwise Waste Materials

The Benefits are:

- Energy Recovery
- Material Recovery

Recycling Programs

Energy Replacement for Coal/Coke

- Liquid fuels
- Solid fuels

Material Replacement for Raw Materials (Limestone, Shale and Sand)

- Solids/sludge slightly contaminated with metals
- Solids/sludge slightly contaminated with organics

From Quarry...to Kiln...to Construction Site



Thank You !