

JDC | PHOSPHATE

The Improved Hard Process: Current Status and Next Steps



The JDC Fort Meade, Florida Demonstration Plant

JDC Phosphate's Improved Hard Process

A patented, transformational technology for phosphoric acid production

- 10,000 ton per year facility built in 2013 near Fort Meade
- Key aspects of technology have been demonstrated

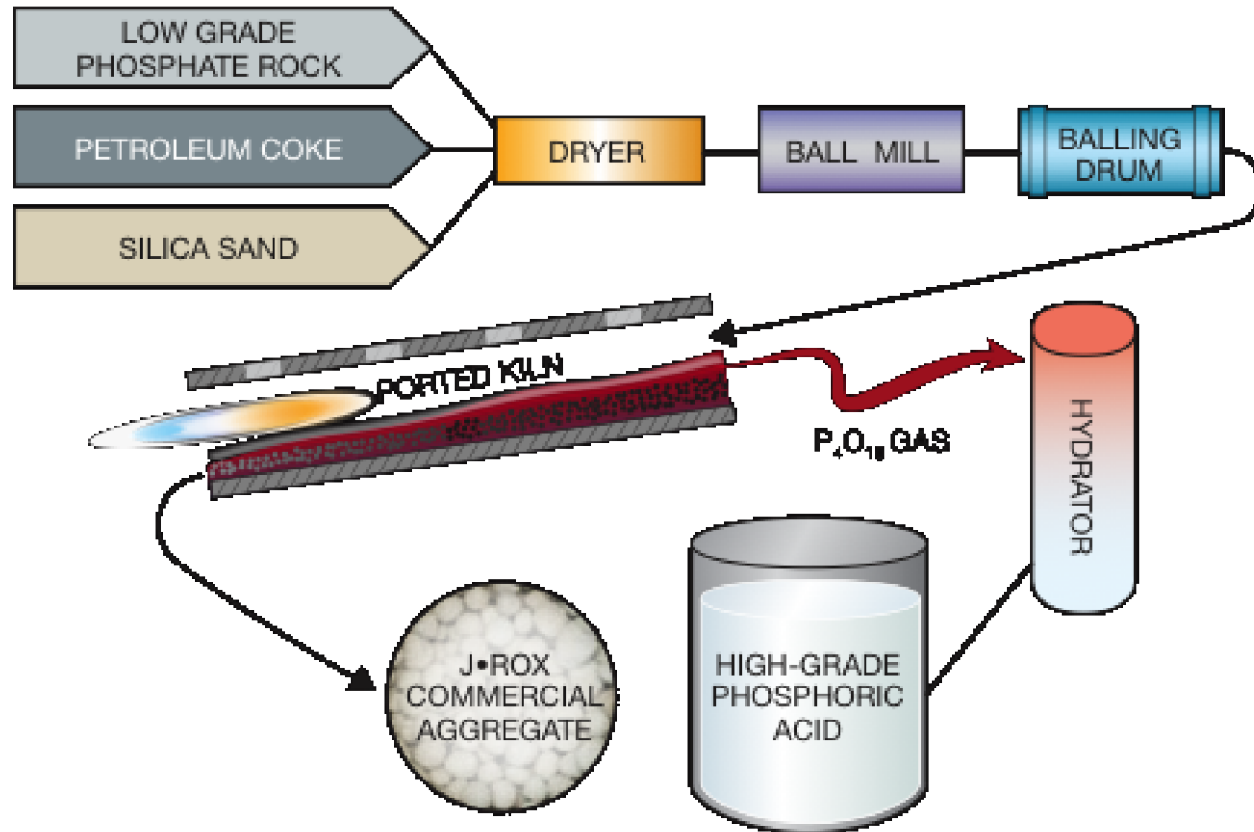
IHP provides advantages across the value chain

- Uses low grade, higher impurity rock that expands reserves
- Lower Capex and Opex per ton of product than existing technology
- Produces higher quality super phosphoric acid
- IHP co-product is a useful aggregate (no phosphogypsum)

JDC Phosphate Fort Meade, FL Demo Plant



IHP as Originally Envisioned



Key Technological Innovations that Make IHP Commercial

- **Chemistry control to avoid melting of feed stock in kiln and to lower reduction reaction temperatures**
- **Heat treatment process that produces a hardened, low dust and higher purity agglomerate to the reduction kiln**
- **Grind size control to improve reaction kinetics and heat treatment properties**
- **A rotary kiln designed to achieve high phosphorus yields with a high temperature reduction zone and a controlled oxidation zone**
- **Kiln heat capture opportunities**

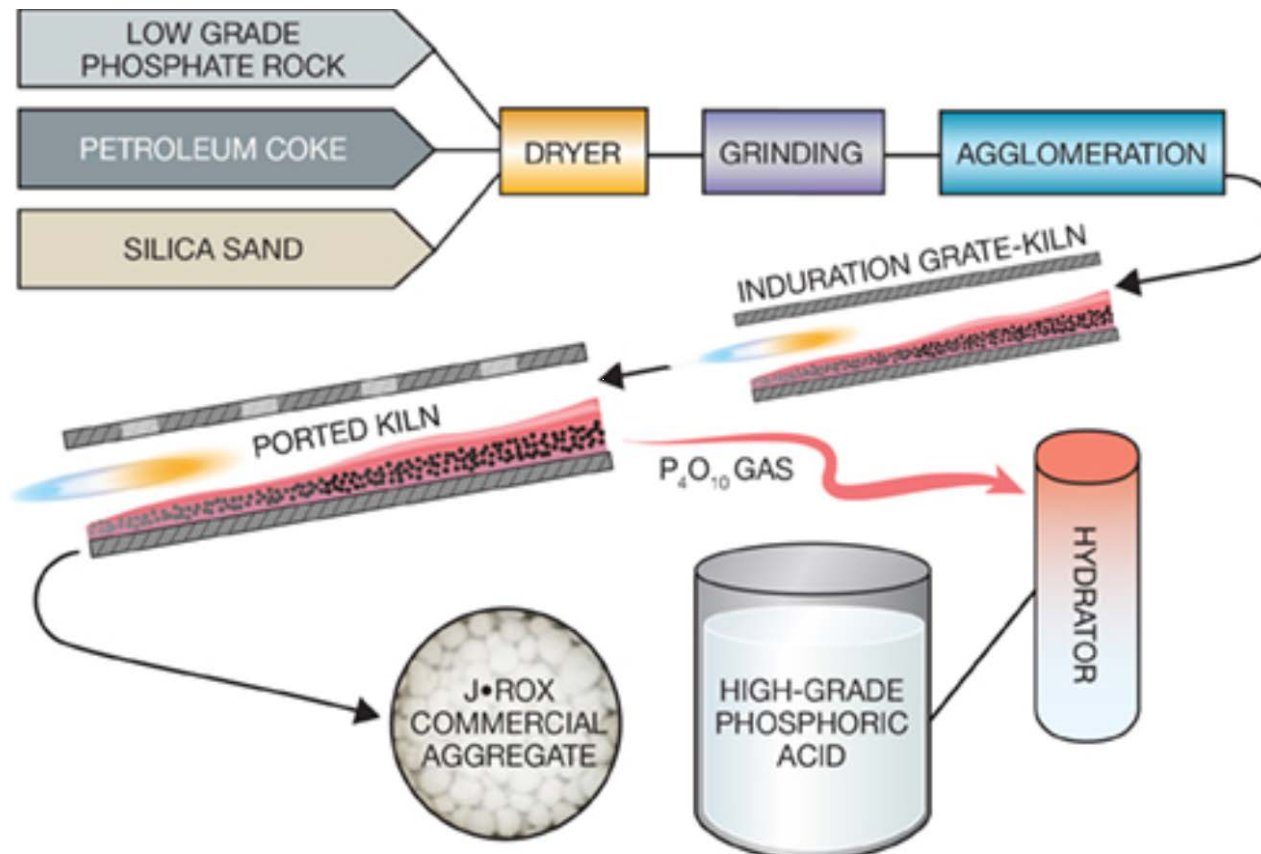
Key Elements of Initial Flowsheet Demonstrated

- Control of feedstock melting at high temperatures
- Release of phosphorous gas in reduction zone
- Oxidation to phosphate (P_4O_{10}) within ported kiln
- Demonstrated ability to absorb P_4O_{10}
- Temperature control in reduction kiln via controlled oxidation

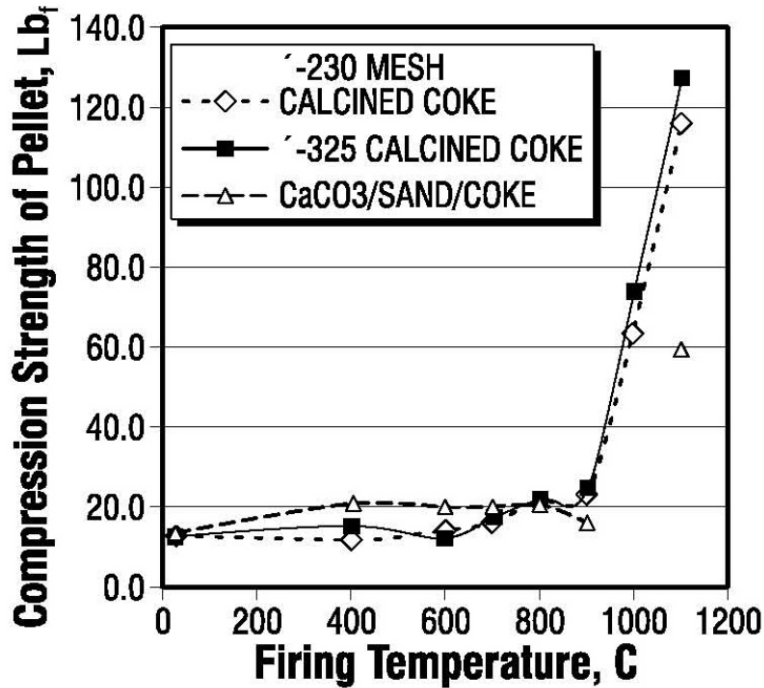
Single Kiln Operational Setback and Solution

- Reduced kiln operating times due to excess dust formation
- Patented process to pre-treat agglomerates
 - ▶ Achieving ~10-20x strength improvement
 - ▶ Drives off other impurities to improve acid quality
 - ▶ Demonstrated multiple times at 10,000 TPY scale kiln
- Other Lab Developments
 - ▶ Refinement of grind sizes to improve
 - Low temperature yields
 - Pre treatment strength
 - ▶ Understanding of fluorine evolution dependencies during reduction
 - ▶ Successfully tested 5 ore sources from different geographies

IHP Flowsheet with Pre-Treatment Kiln



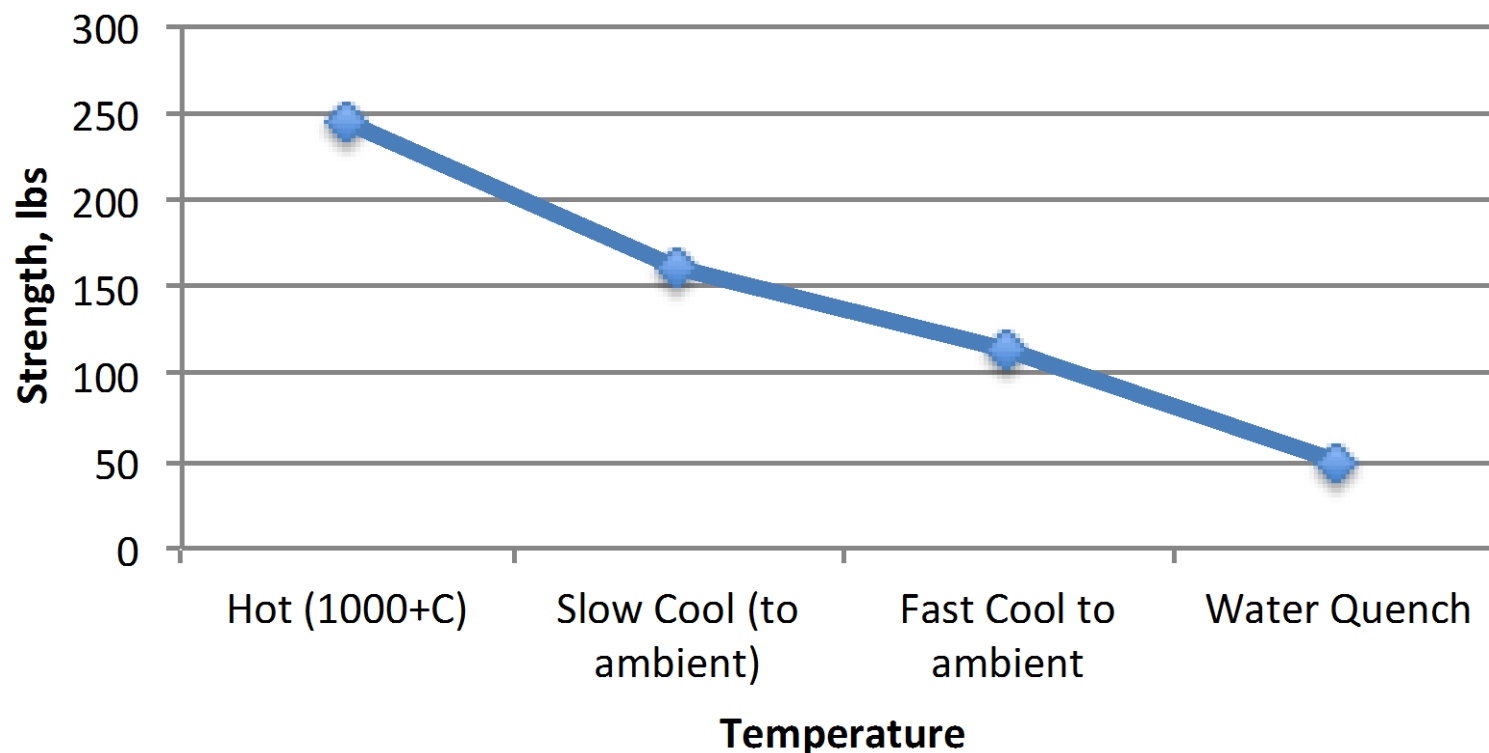
Heat Treatment to Reduce Dust Potential in Kiln



- ~10-20x hardening of agglomerates
- Occurs at temperatures below reduction
- Finer grind size improves strength
- Impurities are removed during the heat treatment
- Achieved at demo plant scale multiple times

Indurated Ball Strength vs. Cooling

Ball Strength vs Temperature



Indurated agglomerates are strongest directly after induration and at hottest point
No signs of sticky or molten state

Demo Plant Data: Induration Impurity Removal

| | <u>Pre-Induration*</u> | <u>Post-Induration*</u> | <u>% Reduction</u> |
|-----------------|-------------------------------|--------------------------------|---------------------------|
| Aluminum | 7,053 | 2,800 | 60 |
| Arsenic | 6.1 | 2.3 | 62 |
| Cadmium | 2.2 | 0.2 | 91 |
| Lead | 6.0 | 0.2 | 97 |
| Chloride | 7,192 | 345 | 95 |

** These relative % reductions have been repeated multiple times with different ore sources.

Summary

- JDC has demonstrated the key IHP technical elements
 - ▶ Silica and melt control
 - ▶ Carbo-thermal reduction of phosphorous
 - ▶ Downstream oxidation in same vessel
 - ▶ Ability to absorb phosphorous gases in acid plant

- JDC has patented new technology to solve key issue
 - ▶ Addition of pre-treating kiln to harden agglomerates 10 fold
 - ▶ Further impurity removal in pre-treating kiln to improve acid quality
 - ▶ Demonstrated on semi-continuous basis with large 93 foot kiln
 - ▶ Additional heat capture opportunity with two kiln operation
 - ▶ Grind size impacts to yield and pre-treatment

Path Forward

- Achieving financing to build scaled down pilot plant
 - ▶ Continuous operation with good operating times
 - ▶ Two kiln flowsheet with appropriate burners and porting systems
 - ▶ Grinding and feed stock mixing flexibility
 - ▶ Full Acid plant with HF removal circuit
 - ▶ Indirect cooler to preserve co-product “J-Rox” stream
 - ▶ Heat capture system on first kiln
 - ▶ Sized with ability to scale up
 - ▶ Ability to test other ore sources

- Design larger scale IHP plants based on pilot plant data