Vertimill Predictive Analytics

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Vertimill Predictive Analytics
Soda Ash 101

- Ciner Wyoming, LLC (pronounced jin-ner) is a natural soda ash producer in the Green River basin in Wyoming.
- We refine soda ash from a natural feedstock of sodium sesquicarbonate (Trona).
- Trona was deposited in the basin over a million year period when 4 million year old Lake Gosiute (\'gōˌshūt\') became closed off from a freshwater source and the alkali concentration increased.
- To produce soda ash, Trona is mined and calcined to remove water and CO$_2$ to convert the Trona ore to sodium carbonate aka Soda Ash:
  \[
  2(\text{Na}_2\text{CO}_3\cdot\text{NaHCO}_3\cdot2\text{H}_2\text{O}) \rightarrow 3\ \text{Na}_2\text{CO}_3 + \text{CO}_2 + 5\text{H}_2\text{O}
  \]
- Used in:
  - Glass – 49%
  - Chemicals – 27%
  - Soap and detergents – 11%
  - Flue gas treatment – 3%
  - Pulp and paper – 2%
  - Water treatment – 2%
  - Misc. – 6%
Problem Overview

- Continuous Drum Miners mine Trona ore
- Ore Grade varies throughout different areas in the beds
  - Low Ore Grade, below 83%, is referred to as “Bad Ore”
  - Variances in Ore Grade can lead to process upsets and unplanned downtime
- Lab analysis provides ore grade after the fact - no real time ore analysis
  - Process Operators are “blind” to sections of “Bad Ore”
Problem Overview in Detail

- Trona ore is calcined and then dissolved to separate the desired soda ash from the insoluble impurities
- Insoluble impurities are ground to recover any trapped soda ash and produce a PSD that generates a paste for disposal of the tailings
  - The amount and type of insolubles are a direct function of ore rate & grade
  - The Vertimill is capable of handling a fixed amount of insolubles
  - Variations in ore grade can send too many insolubles to the Vertimill
- The Vertimill can be overloaded when...
  - There is too high of an insoluble loading, and/or
  - Larger PSD of the insoluble, or
  - Inadequate loading of grinding media in the Vertimill
- ...reducing grinding effectiveness and ultimately spilling over the top of the Vertimill

*When the Vertimill is down 60% of total production is lost*
Problem Overview (2 hour processing time)
Existing Signals

- Existing real-time data showed that the process was affected by Bad Ore or the Vertimill was not properly loaded with grinding media prior to a process upset
  - 10 process data streams presented the best pre-upset visibility
- Patterns in the 10 data streams immediately around upset conditions were not consistent enough from upset to upset.
  - Varied in frequency, consistency, and magnitude

- Conventional analytics were not good as preventative warning
  - Time consuming application of statistical analytics to filter and refine the data did not work
  - Some other method or tool was needed…
Enlightenment

• By chance, we met Crick Waters from Falkonry at a regional OSIsoft event
  – Falkonry provides a Pattern Recognition software designed for use by frontline process experts or Subject Matter Experts (SME)
  – Trial run POV
    • 2 months to repeatable insightful patterns for all 10 data streams
  – Falkonry “crunched” our data streams
    • Similar operating conditions were grouped and color coded
    • No context…yet
Existing signals – New Tools & How They Work

- Adding context - time periods defined for Good and Bad Ore events or inadequate grinding media charge
  - Software found similar patterns to create Bad Ore or Media Charge prediction model
  - Ran multiple iterations and tests on the models to confirm validity
- Post validation, applied the model to real-time data flow
  - Ever improving predictive model
  - Able to be adjusted anytime there are new events
Combining Learned Models

- Best Solution? All 10 data streams in one model (pipeline)...
  - Expected to see Bad Ore move through the system in an hour or two...not the case...
- Broke 10 data streams into 3 like process pipelines
  - Dry-Burner/Calcining, Wet-Dissolving, and Grinding/Milling-Vertimill
  - Detectable Variations
- Insolubles from Bad Ore actually build up hours before Vertimill affected
  - Patterns show buildup of Bad Ore cascading from calcining to dissolving to the Vertimill
  - Plenty of time for corrective response versus reactive response
Operationalize

PI Coresight™ Dashboard

DCS Alarm

Alarm

3 Stage Alarm

Real time Ore Grade Prediction

Calculated Ore Rate

Calculated Ore Grade

First Warning Insol Saturation

Second Warning Insol Saturation

Final Warning Insol Saturation

Real time Ore Grade Prediction
Benefits

• Operations
  – Alarms provide visibility for operators where they were “blind” before
  – Confidence to make decisions regarding tonnage flow to run at optimal state

• Business
  – Reduce lost tons of production
  – Benefits are measurable and significant!

• Technical
  – No time spent teaching outside parties process details
    • Subject Matter Expert (SME) is directly involved
    • “Data science in software” significantly reduces time spent performing data analysis
  – Visual Pattern Recognition is relatable and easily interpreted
    • Models are easily modified to meet current conditions
  – Reduced development and deployment time leads to quicker realization of Revenue Growth and Cost Savings
Lessons Learned

• More than one problem may be revealed
• Iterative process requiring input from many areas of the process
• Opportunity is knocking…
# Predictions with the PI System and Falkonry's Pattern Recognition

## COMPANY and GOAL
Ciner Resources is a leading natural soda ash producer, and wanted to **predict and reduce** process downtime.

## CHALLENGE
Difficult to find patterns to use for alarms when combining multiple data sources.

## SOLUTION
Required a more advanced pattern recognition solution.

- Recognized upset using PI Coresight
- Unable to capture all instances using tools in PI Asset Framework
- Leveraged Falkonry with PI to identify meaningful patterns

## RESULTS
More detailed insight into current operation conditions.

- Detect Bad Ore Grade, Mechanical issues and Process Anomalies
- Generated Calculators using PI AF Analytics based on new insights
- Justified hypothesis around abnormal events
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Questions

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