Lime Kiln Optimization for the Pulp & Paper Industry

INTRODUCTION
The lime kiln is an important unit operation in the production of pulp for paper manufacture. Used to supply reburned lime to the recausticizing operation, the lime kiln is the largest single energy consumer in the paper mill. The main objective of lime kiln operation is to produce uniform quality lime, while minimizing fuel consumption and complying with environmental emission regulations. Given the long process delays and interaction inherent to the lime kiln process, these objectives can be extremely difficult to achieve using traditional single loop kiln control.

Rising energy costs and tight environmental regulations have turned a greater focus on the lime kiln operation in recent times. The Invensys Lime Kiln Optimization solution is designed to fully optimize the calcining process. The application resides in a layer above the existing regulatory process control system and manipulates key process setpoints to their optimum position to deliver energy savings and improve product quality. The lime kiln optimization scheme is a multi-variable control scheme that uses a model of the kiln operation to describe the process dynamics and process variable interactions. The lime kiln optimizer reduces the variability in lime quality as well as reducing the operating costs of the kiln and reducing the risk of kiln damage which results from high temperature excursions.

SOLUTION FEATURES
The application is designed to fit most lime kiln processes and fully integrates with any automation system including the Foxboro® I/A Series® Distributed Control System.

Major features include:
- State-of-the-art Multi-variable Predictive Control (MPC)
- Kiln Economic Optimizer
- Lime Quality Controller
- Process model development for accurate representation of process behavior
- Unique adaptation capability to adjust process models online for changing process conditions
- Intuitive operator displays
- Comprehensive reporting package
- Complete set of documentation
STATE-OF-THE-ART MULTI-VARIABLE PREDICTIVE CONTROLLER

Through the use of Invensys MPC technology, the Lime Kiln Optimization solution uses a dynamic model of the kiln process to predict future responses and accurately react to disturbances. An accurate process model for the kiln is developed and verified using data analysis tools and modeling techniques. The MPC manipulates fuel flow, induced draft (ID) fan speed and other parameters to hold key control variables within operator set constraints. More than one process model may be used if process gains change significantly through the total operating range of the kiln. The Lime Kiln Optimization solution is capable of adapting and switching these models automatically online.

KILN ECONOMIC OPTIMIZER

The Kiln Economic Optimizer seeks to maximize the profitability of the lime kiln. The optimizer continuously drives process parameters to the lowest cost, highest profit operating point.

Within the structure or the controller, the relative costs of all the controlled and manipulated variables are declared. The optimizer seeks to locate an operating point that maximizes profit considering the process constraints and the steady-state relationships between the inputs and outputs of the process. For the lime kiln application, the fuel flow, mud flow, and mud density are assigned cost functions and are driven by the optimizer to maximize the profitability of the kiln.

LIME QUALITY CONTROLLER

The Lime Quality Controller is an optional feature, based on a fuzzy logic strategy, which employs a set of rules to manipulate the constraint limits on the front end temperature to optimize the residual carbonate. The controller uses the residual carbonate test and associated process data to determine which direction and how much to move the hot end constraint limits. Since the Lime Kiln Optimization solution is able to narrow the variability of the residual carbonate level, a shift to an optimum economic operating point can be achieved.
OPERATOR DISPLAYS
Lime Kiln optimization is available with a standard set of displays to give the operator maximum visibility and control.

Overview Display

REPORTS PACKAGE
A Microsoft Excel® application extracts historical data from the system and creates a shift report, which tracks key performance variables graphically and tabularly.

Kiln 03
Production and Energy Report

REPORTS PACKAGE
A Microsoft Excel® application extracts historical data from the system and creates a shift report, which tracks key performance variables graphically and tabularly.

ADVANCED CONTROL UTILIZATION REPORT
Advanced Control Utilization Report is displayed in a pie and bar chart format. This report gives a clear picture of how the operator utilizes the Lime Kiln Optimization solution.

Any of the archived reports can be viewed over the plant network in HTML format.
RESULTS
In one case, Invensys successfully implemented a three-tier advanced control solution with a unique combination of a multi-variable controller, economic optimizer, and fuzzy logic at a major pulp & paper facility in the southeastern United States.

Benefits included 6% fuel savings, 16% lime throughput increase, and a 56% reduction in product quality variability. Project payback was less than a year.

The facility faced the following challenges:

• Long dead time (~2hr residence time)
• Many process and emissions constraints
• Complex and interactive process dynamics
• Frequent Unmeasured Disturbances

Invensys installed a standard application solution, specifically designed to optimize the lime kiln process. First, the multi-variable predictive control application was used to stabilize the process and reduce variability. Next, a state-of-the-art economic optimizer drove production to a maximum while using the least amount of energy. Finally, a fuzzy logic controller evaluated residual carbonate test results and adjusted the product temperature to maintain optimum quality.

Connoisseur software has been successfully implemented at many sites, including Aracruz Celulose (now known as Fibria Celulose) and Georgia Pacific to achieve improved plant performance and increased profit on their kilns.