Optimum - The Deep Learning AI/ML Platform for Clinker Cooler Optimization

Overview:

Optimum enables complex manufacturing operations to achieve optimum results – creating millions of incremental operational dollars by driving higher yields, lower energy use, and reducing carbon emissions

Patented IP Platform allows scalability from single units to multiple unit process optimization and plant optimization (RTO)

Unit and product templates enable faster implementation

Leverages standard industrial communication protocols (e.g., OPC) and meets the rigorous security requirements to operate on the PCN

Benefits over existing APC and RTO technologies:

- **Improved model accuracy** by capturing process dynamics accurately using deep learning technology
- **Improve productivity** by operating units to the unit capacity while respecting safety, quality and energy constraints
- **Stable in all plant regimes** with the ability to operate efficiently under different unit regimes
- **True objective function** optimized using a genetic algorithms without any linearization
- **Flexible optimization function** that can be modified "on the fly"
- **Able to implement large problems** which are easier to scale and standardize, no MV/DV limits
- **Includes a tool set** for APC engineers to de develop their own applications

Optimum empowers cement producers to operate safely and consistently beyond conventional methods.

The Clinker Cooler Optimization Challenge

The main function of the clinker cooler is to cool down clinker and transfer the thermal energy back to the kiln to be reused. The efficiency of the heat transfer depends on air flow (volume flow rate of air passing through a specific section of the clinker bed), the pressure of the air (undergrate pressure), the clinker bed height, the clinker nodules size, and the clinker temperature. Some of these variables are not easily measurable or digitized.

Optimum for clinker coolers is an AI-driven asset prediction & optimization solution for enhanced energy recovery, emissions reduction, and operational stability. Optimum improves overall clinker cooler performance and stability by increasing thermal energy recuperation and optimizing fan airflow. Intelligent energy optimization provides a double positive effect: cost savings as a result of reducing energy consumption and decreasing the amount of carbon dioxide being released into the atmosphere.

This is a highly variable and complex workflow that is difficult to regulate without the proper tools and techniques. Depending on the operator experience, process automation, and available decision aiding tools, the clinker cooler inputs can have an array of impact on the product quality, energy efficiency, and overall safety of the operation

Optimum Overview

oPRO.ai's patented Optimum software platform enables complex manufacturing operations to achieve higher optima than traditional linear APC technologies including higher yields, lower energy use, and reduced emissions.
Delivered on-premise and deployed at the edge on the PCN, Optimum integrates seamlessly within current operator dashboards for ease of use and adoption.

AI Operational Gains over Conventional Operation	Example 1	Example 2
Delta Secondary Air Temperature (°F)	104	68
Secondary Air Temperature Increase	6%	4%
Delta Tertiary Air Temperature (°F)	100	48
Tertiary Air Temperature Increase	8%	4%

Table 1. AI operational gains over conventional operation

oPRO.ai Deep Learning AI/ML Platform accelerates the optimization of Clinker Coolers

Optimum for Clinker Cooler Optimization includes:

- **Multivariable deep learning optimizer:** More than 10 manipulated variables and 25 controlled variables.
- **Sub-model architecture:** Deep learning models are used to predict properties and state variables. These predictors are trained as sub-models and assembled into a overall model, enabling easier and faster model maintenance.
- **Templatized approach:** oPRO.ai's proprietary platform allows the templatization of models so that they can be reused by similar assets, reducing implementation time.
- **HMI and dashboards:** Operators and engineers are provided with the tools required to operate and tune the optimizer.
- **Engineering Services:** APC and machine learning engineers provide the necessary services for the development and implementation of the application: data validation, correlation analysis, model training, software deployment, and commissioning.

Our optimization applications can be applied to any cooler configuration, enhancing the value of these assets.

AI Savings & Benefits over Conventional Operation	Example 1	Example 2
Secondary Air Temperature Coefficient of Variation (STDV/Avg)	2%	0.1%
Thermal Energy Recovery (kJ/Kg clinker) *Assuming 32,000 mj/t coke*	45.1	17.4
Energy Savings (USD per year) *Assuming 1 ton pet coke = $85 (material, logistics, drying) & 330 working days per year*	$71,341	$27,439
Reduction of CO2 (tons per year) *Assuming 1 lb of pet coke = 3.1 lbs of CO2 emissions*	3,930	1,516
Production increase available from release capacity *Production increase% = Thermal energy saving*wasted energy factor*100 / specific heat consumption*	13,352	5,151
Production increase available from release capacity (USD per year) *Assuming $30 per ton clinker*	$471,901	$181,969

Table 2. AI savings and benefits over conventional operation

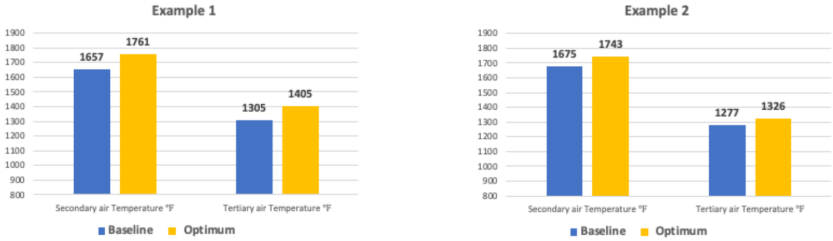

Figure 1. Improvement in Average SAT & TAT with and without Optimum

Figure 2. Secondary Air Temp Increase with Optimum for Different Production Levels

The optimizer includes dashboards to monitor the process and performance of the Deep Learning Optimization application including:

Process values, optimized targets and operational limits.

oPRO.ai

Email rob.christenson@opro.ai

Website www.opro.ai

Address 2923 Jackson Street,
Houston, Texas 77004
+1 713 829 2363 (Phone)

oPRO.ai