Petuum

Petuum Optimum for Clinker Coolers

Reach operational excellence with artificial intelligence forecasting and optimization models.

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 of air passing through a specific section of the clinker bed during a specific time period), 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.

The operator must analyze all of the above-mentioned variables to ensure the optimal production of cement. In addition, the operator needs to comply with the equipment and operational constraints and consider the other connected assets in the production process.

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.

Solution

Petuum 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 CO2 being released into the atmosphere.

Petuum Optimum empowers cement producers to operate safely and consistently beyond conventional methods. Petuum leverages AI to predict, prescribe, and operate in supervised-steer mode while adhering to constraints and safety guidelines.

Petuum

Petuum Optimum is personalized based on your business goals and constraints. The following is a standard configuration for clinker cooler objectives, constraints, and the resulting AI prescriptions:

Objectives

- Maximize secondary air temperature
- Maximize tertiary air temperature
- Minimize clinker temperature
- Stabilize the cooler operation (undergrate pressure or grate speed or cooler main drive amps)

Constraints

- Undergrate pressure
- Cooler stroke speed for each fan (1 -> n)
- Cooler fans amps/pressure
- Grates plates temperature
- Grates plates pressure
- Cooler main drive amps
- Cooler vent air temperature
- Exit clinker temperature
- Cooler clinker exit transport (e.g., bucket elevator, conveyor) amps

Prescriptions

- Fan flow (speed) for each fan (1 > n)
- Undergrate pressure or grate speed
- Water pump speed (if water is used to reduce cooler vent fan temperature)

Results

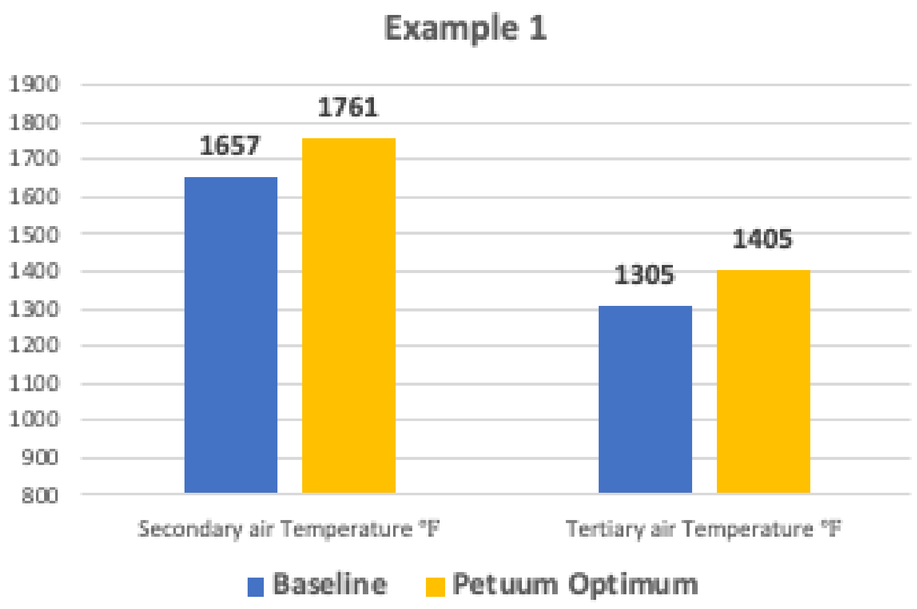
For this use case, we compared the operational efficiency and potential benefits of one clinker cooler with and without Petuum Optimum over multiple weeks. During each test period, the asset experienced lower to higher feed rates to cover a range of possible operating conditions.

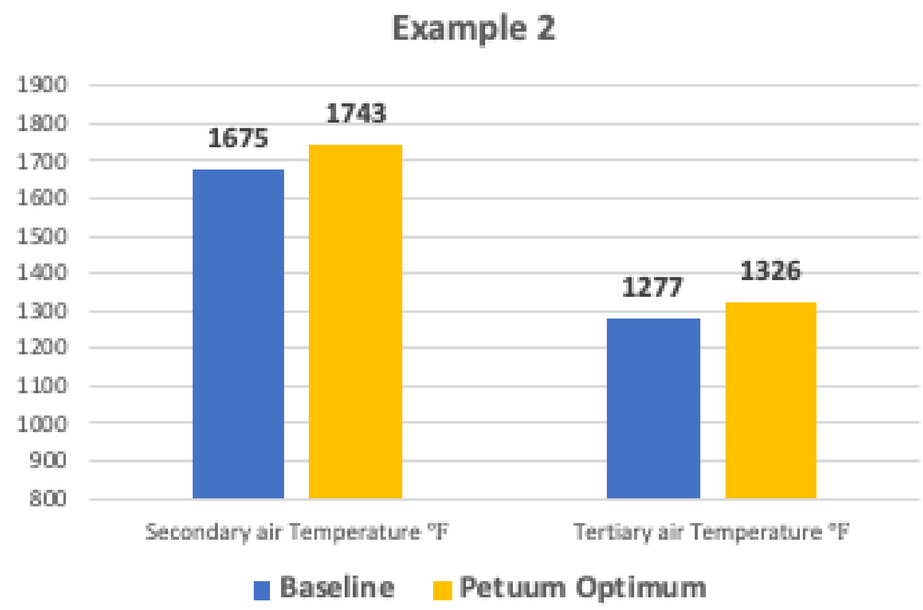
Energy efficiency for the clinker cooler was measured indirectly by two key variables: tertiary and secondary air temperature. Furthermore, we analyzed and reported the operation stability, potential thermal energy recovery, energy savings, CO2 reduction, and production increase allowance from the release capacity.

Below are the averaged results for each test period based on a 3,000 tons per day kiln and a thermodynamic analysis of the cooler.

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*

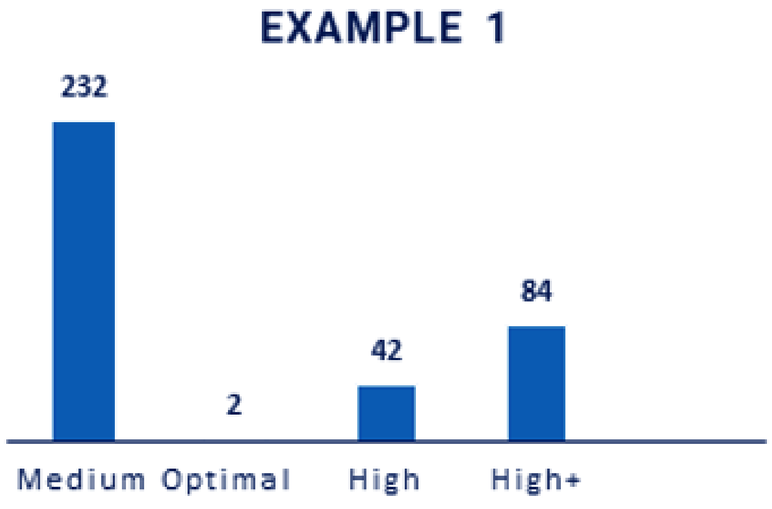




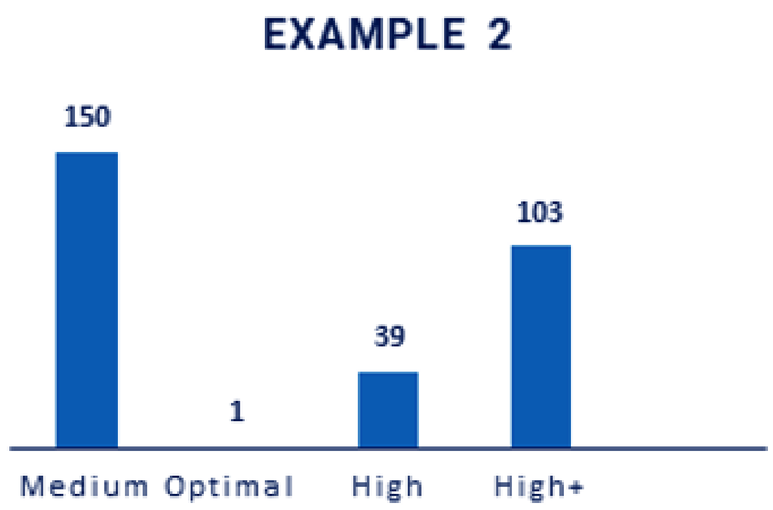
Graph 1 & 2. *Improvement in Average SAT & TAT with and without Petuum Optimum*

Both examples show that Petuum Optimum achieved higher secondary and tertiary air temperatures to satisfy the objective for increased heat recovery and improved fuel efficiency compared to a conventional non-AI operation.

Taking a closer look at the energy recovery gains, available during different operating conditions in Graph 3 and 4, you will observe that Petuum Optimum provides the most opportunity for optimization while the asset capacity is above or slightly below the optimal feed rate.



FEED RATE		
271-281	95-100%	High+
261-270	92-95%	High
241-260	85-92%	Optimal
200-240	70-85%	Medium
0-199	70%>	Low



Graph 1 & 2. *Secondary Air Temp Increase* $^{\circ}F$ *with Petuum Optimum for Different Production Levels*

These operational gains provide the resulting savings and benefits, as calculated in Table 2. Depending on your operational priorities, it is always possible to tune the objective weight factors in the Petuum Optimum product configuration for a different prescription and optimization of process variables.

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*

Petuum Optimum results will vary for each unique configuration of objectives, constraints, and operating conditions. Additionally, the benefits will differ based on the previous efficiency levels, the production capacity, the AI prescription utilization rate, among other factors.

On average, **we observe energy savings of up to 5% and yield increase up to 2% with Petuum Optimum**. CEMEX, one of our global customers say:

> **“On top of getting better heat recovery, we’re getting additional yield. The higher the production rate across each site, the higher the benefits. Once you factor in this, the numbers multiply very fast and this will be a big path for CEMEX.”**

With Petuum Optimum, operators of all experience levels are enabled to reach operational excellence and have their best golden day of operations, every day.

Petuum, Inc. Office Locations

Pittsburgh, PA
2555 Smallman Street, Suite 120
Pittsburgh, Pennsylvania 15222
USA

Sunnyvale, CA
150 Mathilda Place, Suite 650
Sunnyvale, California 94086
USA

Phone: 408.721.1137
Email: business@petuum.com