OPTIMITIVE

EFFICIENCY THINKING

South Korea Pyro Process

CASE STUDY

Case 1: Kiln Optimization

Location	South Korea
N° of assets	1 Kiln
Type of kiln	Dry process with precalciner
Production	1.8 M. Tons Clinker
Fuels	- Coal - AF: Waste oil, solid mix (plastics, tires, wood) and sludge
Substitution rate	55% (in weight)
Control System	OPC-DA Server/DCS&SCDA

Alternative fuels

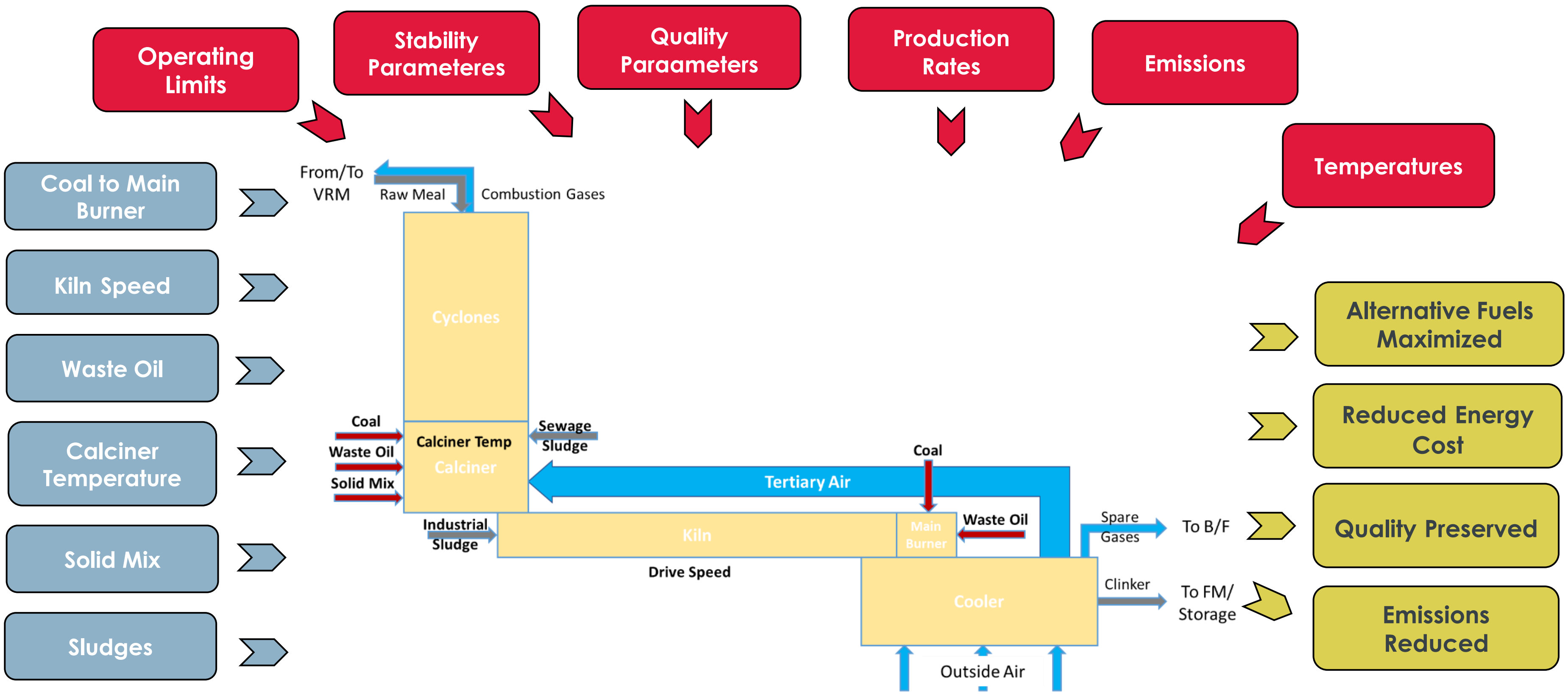
Fuel	Injection point	NCV (kcal/kg)	Flow rate (t/h)	Price	Comments
Coal	MB Calciner	6210	21	+	
Waste oil	MB Calciner	4060	5	+	• Viscosity fluctuation. • Associated with clogging in tertiary air duct.
Plastic.	Calciner	3.800	7.5	-	• Mix composition constant. • Frequent blockages in dosage pipe.
Tires chips.	Calciner	6.350	1.5	+	
Wood chips	Calciner	3.000	1.5	-	
Industrial sludge	Backend	0	2	-	• 0 NCV. • High content of water. • Cooling down the process.
Sewage sludge	Calciner	0	9	-	

Project Objective and Challenges

- **Project objective:** Minimize Specific Energy Cost by optimizing fuel mix and fulfilling with Quality and Environment standards.

- **Project challenges:**
  - Mix of operational, quality and environmental constraints:
    - Operational: Kiln power consumption, Tertiary Air Temperature and CO at preheater exit.
    - Quality: Free lime and Chlorine at clinker.
    - Environmental: NOx emission.
  - There are some operational set points (Kiln Feed, ID Fan, Cooler Operation) that are out of the optimization strategy due to customer requirement.
  - No consistent supply of Alternative Fuels.
  - Non consistent flow of AF.
  - Not fully automize Plant:
    - Clinker testing frequency 4 hours (2 hours if Free Lime above 2.5%).
    - No availability of kiln inlet gas analyzer.
  - Unstable process key parameters: precalciner output temperature and torque.

Kiln Optimization



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Solution - KILN

Operational variables

KILN

- Coal to Main Burner
- Waste Oil to Main Burner
- Drive Speed
- Industrial Sludge to Main Burner

CALCINER

- Calciner Temperature
- Waste Oil to Calciner
- Solid Mix to Calciner
- Sewage Sludge to Main Burner

Disturbance variables

- LSF
- Kiln Feed
- Cyclone 5 Temp
- Exhaust Fan

Predictable Output variables

Quality

- Freelime
- Chlorine

Stability

- Freelime
- Torque
- Tertiary Air Temperature
- Coal to Calciner

Emissions

- NOx
- CO

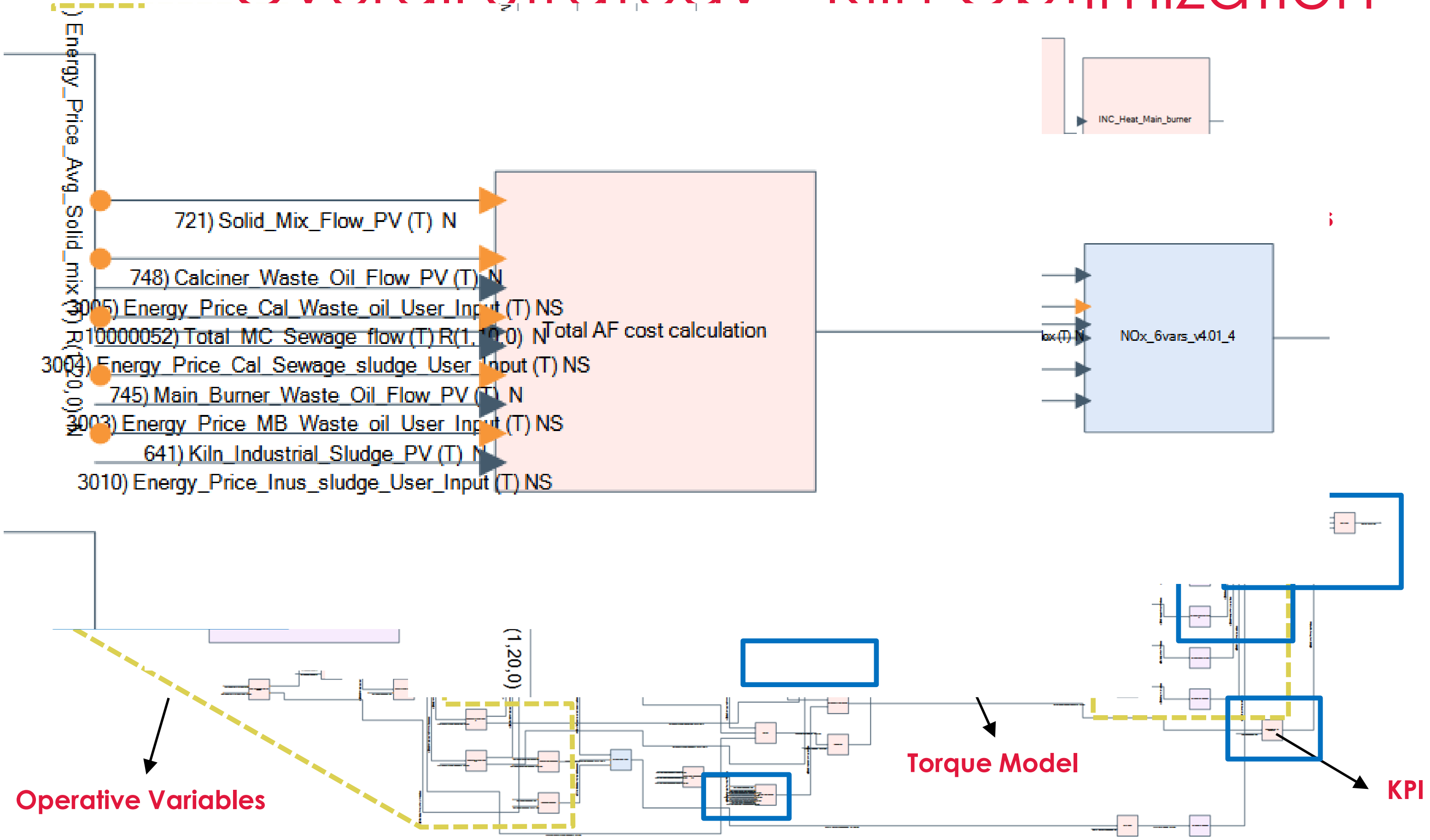
Main Constraints

- Freelime
- Chlorine
- TAT
- Torque
- NOx
- CO

Target function

- Minimize Energy Cost
- Maximize Alt Fuel Usage

Overall Strategy - Kiln Optimization



Kiln Optimization-Balance between variables

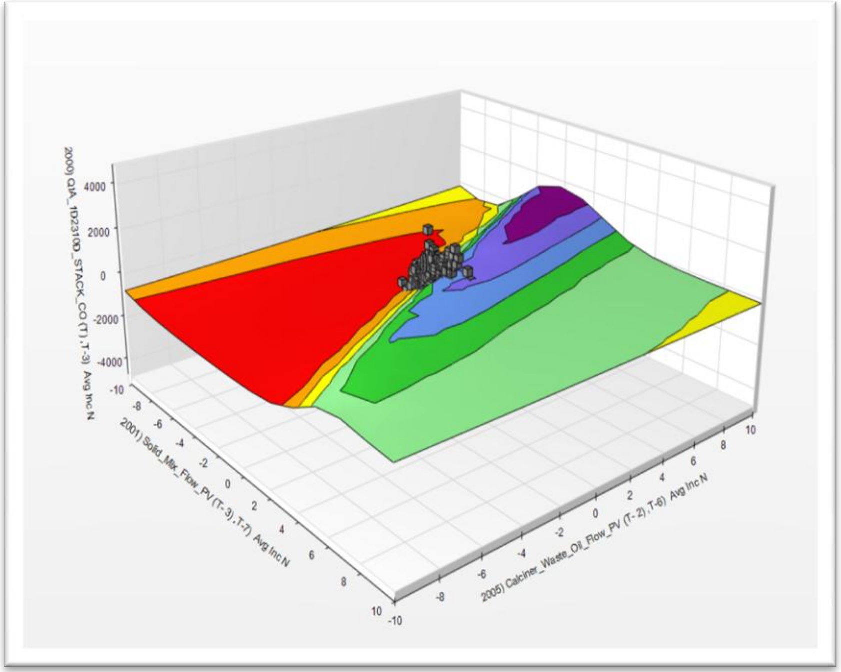
There are operative variables that impact in more than one constraint and influence as well in the Specific Energy Cost.

OPTIBAT® calculates and recommends the optimum values for those operative variables with the following priorities:

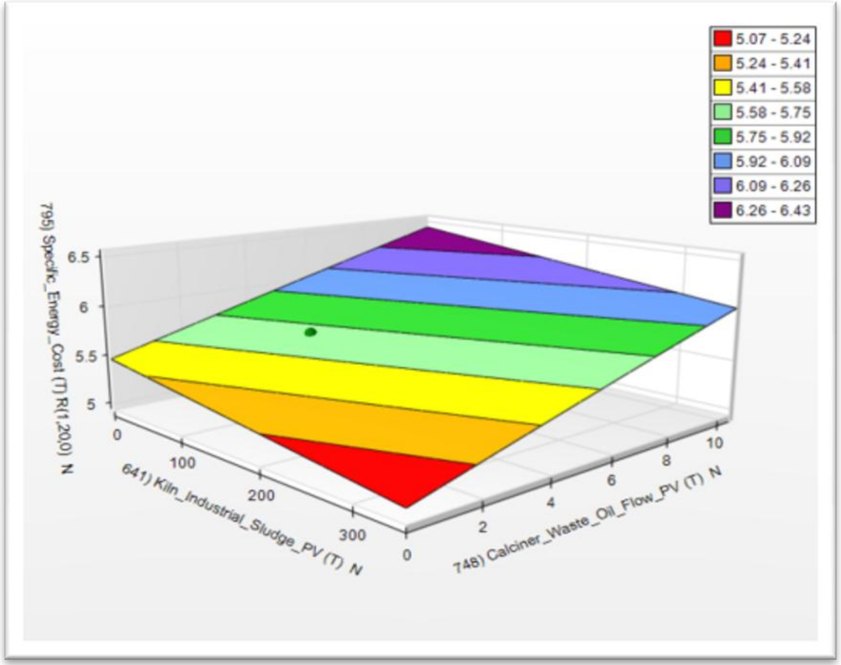
1. Constraint's fulfilment.
2. Minimize Specific Energy Cost.

	Free Lime	NOx	Tertiary Air Temperature	Torque	Chlorine	CO	SEC
MB Coal	↓		↑	↑	↓		↑ ↑
MB Waste oil	↓		↑	↑	↓		↑
Drive Speed				↑			
Industrial Sludge	↑		↑	↓	↓		↓
Precalciner Temperature	↓		↑	↑	↓		
Precalciner Waste Oil	↓	↑		↑		↑	↑
Solid Mix		↑		↑	↑	↑	↓ ↓
Sewage Sludge		↑					↓ ↓

Kiln Optimization-Balance between variables



Example: Relation between CO, Solid Mix and Waste Oil

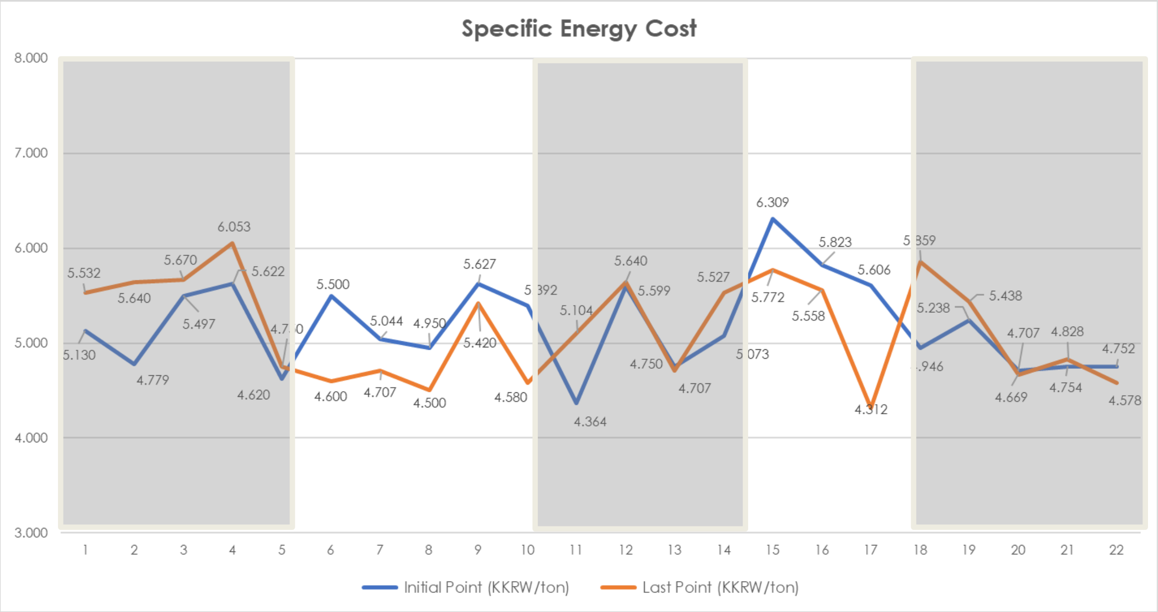


Example: Relation between Industrial Sludge, Calciner Waste Oil and Specific Energy Cost

Results

Results obtained in Business Case performed by client (21 days):

- Average Specific Energy Cost: -2.15%
  - Coal -3%.
  - Solid Mix -0.5%
  - Waste oil +7.12%
  - Industrial sludge +3.21%
  - Sewage sludge +2.67%
- Specific Energy Cost with all constraints within limits: -13.71%.
- Constrains Improved: 84.21% of the time



Areas not fulfilling constrains.

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Conclusions

- OPTIBAT® can meet quality and environmental requirements, despite the existing level of automation (clinker frequency testing and not availability of backend analyzer).
- OPTIBAT® brings Constraints within their limits (84.21%) and improves process stability. On top of this, the Specific Energy Cost is consistently improved by 2.15%.
- An improvement of 13% can be achieved with stable conditions of the kiln.
- OPTIBAT® optimizes fuel mix (coal and six AF) base on process conditions, emissions, quality and price, in order to reduce specific energy cost.

Assets

1. KILN ✔

Project Constrains

- Open loop ✔
- Quality maintained ✔
- Alternative fuel use increased ✔

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THANK YOU!

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