TR

Optimizing the Clinker Cooler

Technical Reference
Corporate Cement Industrial Performance
Version 2.0 August 8th, 2016

LafargeHolcim

Abstract

This document describes synthetically the main considerations to be taken in account when optimizing a Grate Cooler. It aims to give a general conceptual background that can be useful when planning changes in the operational set points of a clinker cooler, it is a good aid to analyze the results out of the '*Recommended Tool – Clinker Grate Cooler Air Distribution'*.

Content

1. Health and Safety

All of our activities must be aligned with the Group's H&S Policy, remember that until further notice rules from your legacy company apply. For the latest versions of the policy, the FPEs and HSSTs please visit https://sites.google.com/a/lafargeholcimgroup.com/health-safety/.

2. Introduction and Objectives

A clinker cooler has 2 major functions:

- Heat recovery toward the kiln, precalciner, coal mill, raw mill and cogeneration.
- Cooling of clinker

To calculate the cooler efficiency in a proper way, a complete heat and mass balance of the kiln system has to be carried out. Check the official LH Heat and Mass balance tool.

It is extremely important to master clinker cooler control as it represents an integral part of the clinker-burning process. Cooler conditions have an impact on the burning process in the kiln and consequently, on the quality of clinker, the stability of the kiln and the lifetime of the cooler itself.

Each cooler is unique therefore observation through cooler inspection windows is indispensable for evaluation of operation. Apply a step-by-step approach, measure, evaluate and record each step. Carry out the "walk-by" inspection regularly to get familiarized with your own cooler.

Some coolers have design shortcomings (e.g. undersized fans). In these cases, the cooler can be optimized but compromise on objectives may be needed.

3. Scope and Applicability

This document applies to all generation of grate clinker coolers. This is a recommended Technical Reference and not of mandatory application.

4. Overall description

The scope of this technical reference is to describe how to interpret the results of a cooler balance and how to optimize its performance, including the efficiency indicators and how to derive actions for cooler performance improvements.

Reminder: poor cooler performance can also be caused by other factors not directly linked to the cooler operation, e.g. clinker nodulization in the kiln.

5. Tools

Fill in the Clinker Grate Cooler Air Distribution tool to help you in your analysis.

6. General Concepts

6.1 Preparation phase

To get maximum benefit from optimization, the cooler and its auxiliaries should always be in the best possible mechanical shape (no broken plates, no leakage between compartments etc.);

Gather basic data for the cooler including operating data sheets, fan curves, including a grate map showing dead grates, dams and different grate types;

Perform a cooler audit – including cooling fans calibration, observation of cooler operation through inspection windows (take a look at the latest walk-by inspections and do one yourself);

Define objectives based on the cooler audit results – try to reach best proven performance, benchmarking similar coolers in the Group.

6.2 Initial estimation the specific grate aeration

Calculate real specific grate aeration for each cooler compartment (Nm3/m2/s) using the effective area (area covered by clinker) and total air load (Nm3/kg ck) based on your site measurements.

Suggest a specific grate aeration for the compartment #1 – it should be in range from 1,3 to 1.8 Nm3/m2/s taking into account 30% fan pressure reserve in case of a kiln push (variation in clinker bed depth).

- Remark: for old generation cooler without any static inlet blowing density can reach up to 2.5 to 3 on some occasions where chamber 1 section is very small. Objective there is to fluidize clinker to ensure a good distribution.

Use the clinker cooler air distribution tool for initial estimation of specific aeration for each compartment (cross-check with supplier and LH recommendations).

- The strategy is to put as much air as possible in recuperation zone and gradually reduce it towards the end of the cooler.
- Remember that fans should run at ~70% of full capacity under normal operating conditions.

6.3 Optimization

The target is:

- To have high recuperation, i.e. high cooling efficiency;
- To achieve the desired clinker exit temperature;
- To avoid damaging the cooler components.
- All these with a minimum of total air load.

Apply initial estimation of blowing specific grate aeration for each compartment (keep some fan reserve for fluctuations in load coming from the kiln).

Maximize air load in the recuperation zone (keep total air load the same), start from the first compartment (step about 0,1 Nm3/m2/s) – limited by bed stability (popcorn, red rivers) and dust formation. In some cases with a fixed inlet, secondary air can become very hot, limit to 1200°C. Be careful about temperature measurement of the secondary air.

Minimize total cooling air to reduce power consumption, start from the last compartment (step about 0,1 Nm3/m2.s) – limited by exit clinker temperature and plate temperature (thermocouple on plates are a must).

It may be necessary to change clinker exit temperature by decreasing/increasing air load:

- Lower temperature can be desirable to avoid high temperatures in the cement mill impacting on cement quality (false setting due to gypsum dehydration).
- Higher clinker exit temperature can be desirable when milling cement using wet additives or in wintertime – In that case, take into consideration the heat resistance of the handling and storage facilities. It also reduces the cooler STEC, but be aware that hot clinker can damage the plates and the transport and dosing equipment.

7. Action Steps

7.1 Define an objective by benchmarking

In principle, try to achieve a cooler operating mode, where

- The grate speed is low
- The fans running close to their maximum capacity.

For good operation, in general clinker must be well granulated (or nodules). Mix targets must be well controlled and in some cases mix targets must be changed to avoid fine dusty clinkers. This is especially true for fixed inlets (critical).

The Guidelines and hints section in the *'Recommended Tool – Clinker Grate Cooler Air Dirtribution'* provide general operation figures for different types of coolers. Compare actual cooler data and historical audit results to these guidelines.

Once the potentials for optimizations are identified, go step by step:

- Modify only one parameter
- Observe
- Take notes
- Evaluate results
- Decide on further actions

Optimization objectives could be one or many of the following:

- Increase heat recovery
- Decrease clinker temperature
- Improve kiln stability
- Reduce power consumption
- Reduce vent flow
- Improve equipment reliability

7.2 Maximize bed depth to a stable level

Reasons:

- To increase the heat exchange between air and clinker and consequently improve the clinker cooler efficiency.
- To slow down the grates and reduce wear.

Track the bed depth by visually inspecting it (see video on cooler inspection):

- Old 10 degree sloped Fuller coolers can only achieve 175-200 mm of practical bed depths
- Newer conventional coolers can maintain 500-700 mm
- Coolers with fixed inlets could maintain 700-1200 mm

Depending on design, consider installing dead grates, high nose grates or cooler dams (instead of alternating moving and fixed rows – make 3 consecutive fixed rows near end of grate section) – to not only help control red rivers but also encourage a deeper bed for the same grate speed.

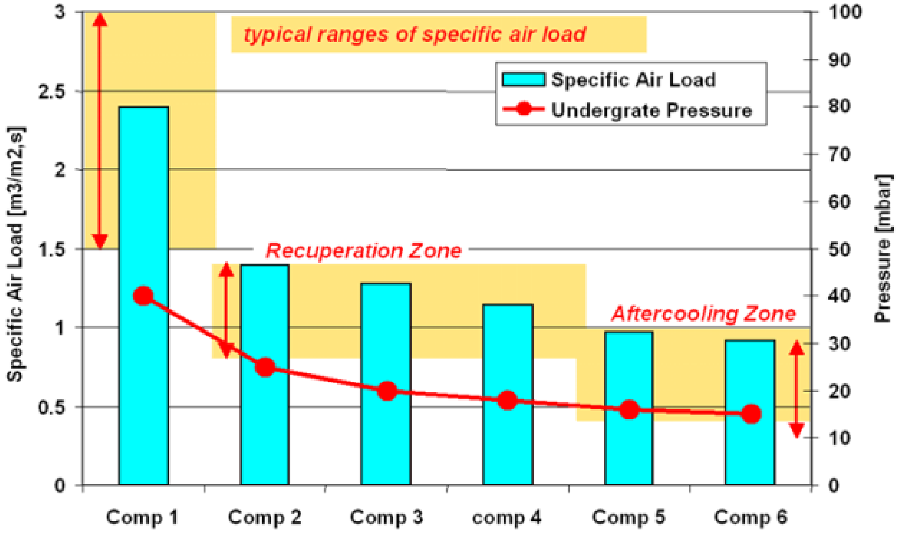
For fixed inlet coolers, horse shoe design, refractory curb and air blaster distribution are important

There is a point at which the increase in cooler efficiency through a higher bed depth is no longer worth the price of the extra power cost for the cooling fans. Therefore keep monitoring the cooler's power consumption and evaluate the costs and benefits.

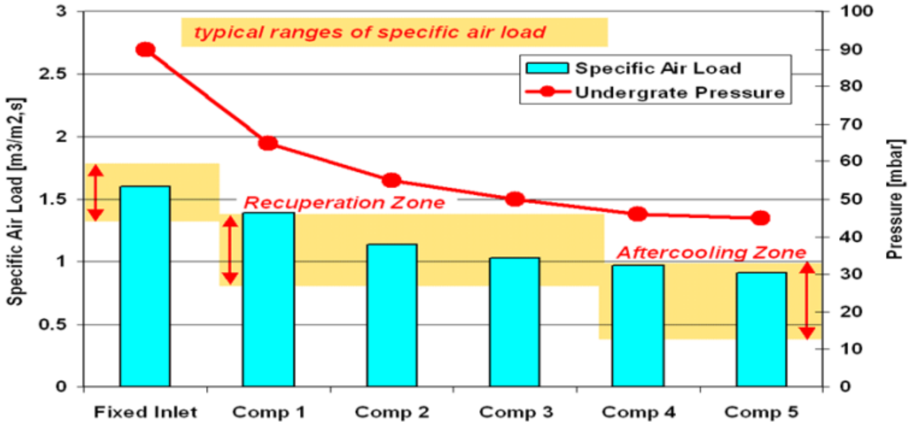
7.3 Maximizing air in the recuperation zone

Compare the specific compartment aeration of your cooler calculated in the LafargeHolcim cooler audit spreadsheet with the typical ranges of specific air load provided in the same tool:

- Grate cooler without fixed inlet:



- Grate cooler with fixed inlet:



- Always visually observe changes on the air distribution;
- Check for fans operation point at or close to maximum capacity;
- Ensure that no pop corning or volcanoes are created due to excessive air blowing density or excessive bed depth. This is more common on older Fuller designs. This effect is made worse with fine clinkers. This is less of a problem with modern coolers (air beam or reduced fall through (RFT) type plates).

7.4 Minimize total cooling air

Decide on the target clinker temperature (no need to go far below the max. temperature)

Minimize cooling fans in the cooling zone (not recuperation zone)

7.5 Optimize grate speed control loop to achieve an uniform bed depth

Set up a PID control loop for the cooler grate speed;

Select the most upstream stable pressure as a process variable. Generally:

- For first generation cooler, under-grate pressure for compartment 2 or 1;
- For 2nd generation cooler, air beam pressure in compartment 2;

Use the speed of the first grate as controller output.

Couple the speed of grate 2 (if applicable) with grate 1.

Visually observe the impact of different set points for under-grate pressure on the cooler bed depth.

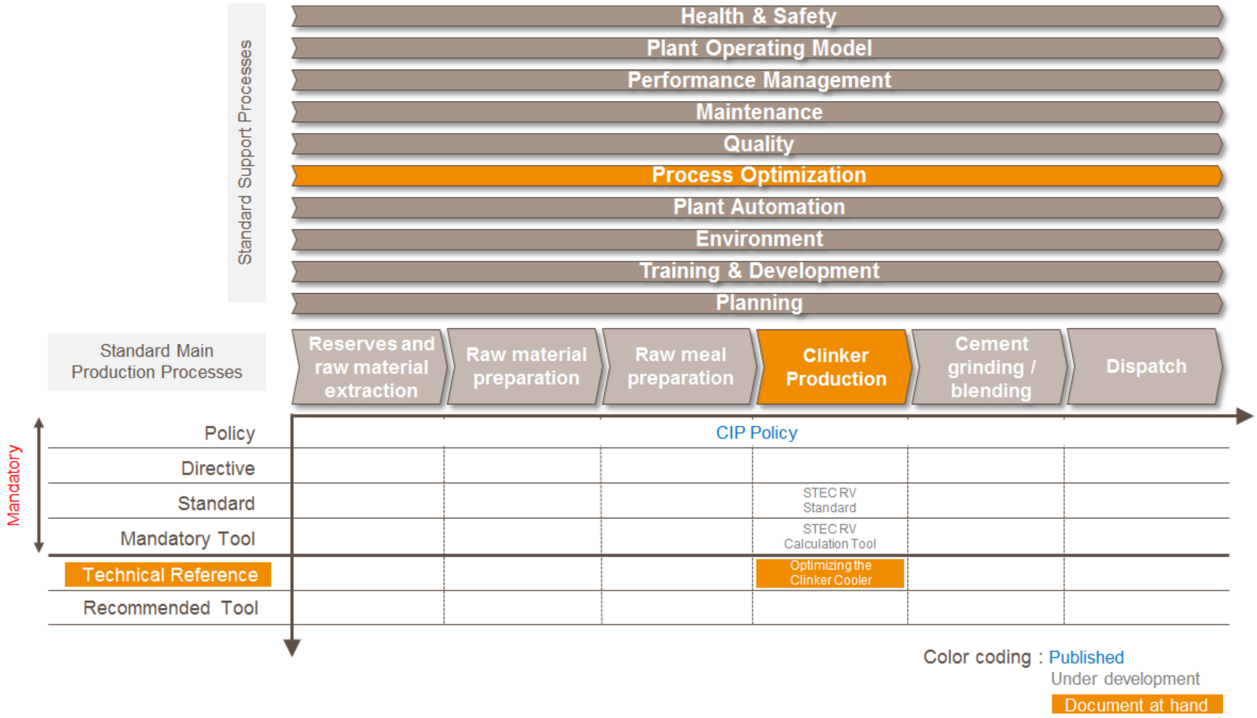
7.6 Ensure a constant air/clinker ratio

- Operate cooling fans in automatic mode by a PID control loop;
- Set point: air flow rate;
- Controller output: fan speed or damper position;
- Install automated cascade set points with kiln throughput.

8. Document management

8.1 Cement Industrial Framework

The Cement Industrial Framework shows the Standard Production and Support Processes in cement manufacturing. The Framework indicates (in orange) the related processes and the type of the document at hand and displays its leading documents.



8.2 Document information & revisions

Content owner	Head of Thermal Technology		
Author(s)	Sergio García		
Reviewed by	Giancarlo Della Vedova		
Validated by	CIP Standards and Tools		
Revisions	**Version**	**Date**	**Main changes**
	1.0		First version
	2.0	08.08.2016	Harmonization after merger. New template, adaptation to new corporate language, harmonized guidelines.

8.3 Related Documents

	Type	Name
I	Policy	CIP Policy
II	Directive	
III	Standard	STEC Reference Values
IV	Mandatory Tool	STEC Reference Values
V	Technical Reference	Clinker Temperature Measurement Snow Man, Red River and Geyser Control
V	Recommended Tool	Anemometer and Prandtl Tube Measurements Clinker Grate Cooler Air Distribution