Document on reduction techniques for cement plants

TFTEI technical secretariat
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LRTAP

T F T E I

Agenda

- Objectives
- Limit values of the Gothenburg Protocol
- Reduction techniques and the costs
- Next steps

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Objectives of the work

- ✓ Update an existing document from 2005 and information developed for the revision of the Gothenburg Protocol

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Agenda

- ❑ Objectives
- ❑ Limit values of the Gothenburg Protocol and BAT AELs
- ❑ Reduction techniques and the costs
- ❑ Next steps

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Limit values in the Gothenburg protocol

Limit values for NO_x emissions released from cement clinker production[a]

Plant type	*ELV for NO_x (mg/m³)*
General (existing and new installations)	500
Existing lepol and long rotary kilns in which no waste is co-incinerated	800

[a] Installations for the production of cement clinker in rotary kilns with a capacity >500 Mg/day or in other furnaces with a capacity >50 Mg/day. The O_2 reference content is 10%.

Limit values for dust emissions released from cement production[a]

	ELV for dust (mg/m³)
Cement installations, kilns, mills and clinker coolers	20

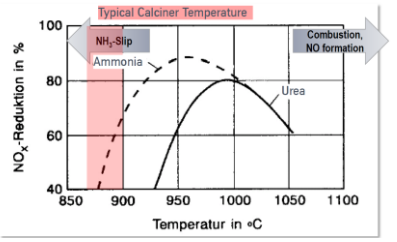
[a] Installations for the production of cement clinker in rotary kilns with a capacity >500 Mg/day or in other furnaces with a capacity >50 Mg/day. The reference oxygen content is 10%.

Reduction techniques for NOx

- ✓ Primary measures:
  - Flame cooling
  - Low NOx burners
  - Staged combustion
  - Mild kiln firing
  - …
- ✓ SNCR (Selective non catalytic reduction)
- ✓ SCR (Selective catalytic reduction)

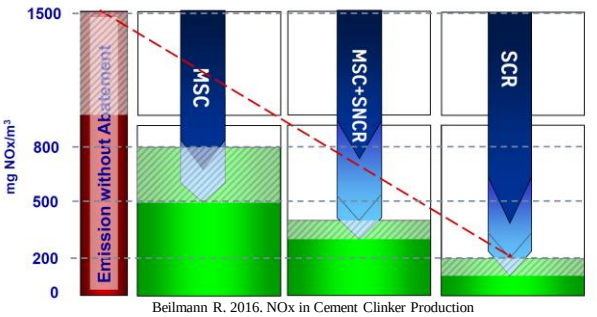
Reduction techniques for NOx

- ✓ Primary measures:
  - 500 mg/Nm^3 at 10%O_2 daily average
  - Optimum condition frequently in conflict with the best setting for the kiln operation
- ✓ SNCR
  - Injection of an urea solution or an ammonia solution in the kiln calciner at around 900°C
  - An efficiency of 30 to 50% achieved with stoichiometry of 0.5 to 0.9 %
  - 60 to 80% achieved with stoichiometry (NH3/NOx) of 1.2 to 1.8 %
  - Able to reach 500 mg/Nm^3, possible 200 mg/Nm^3 in some specific cases
  - Ammonia split if optimal conditions not obtained



Reduction techniques for NOx

- ✓ SCR
  - 200 mg/Nm^3 at 10% O_2 daily average, can be obtained
  - 8 plants equipped in Europe in 2016



Beilmann R. 2016. NOx in Cement Clinker Production

BAT AELS for NOx and NH_3

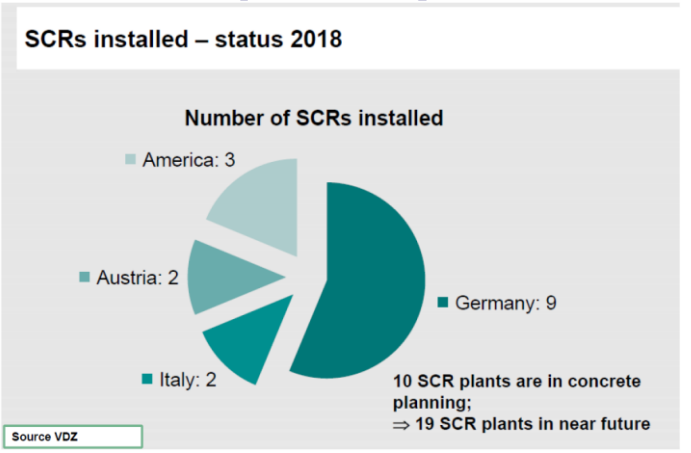
Kiln type	Unit	BAT-AEL (daily average value)
Preheater kilns	mg/Nm^3	< 200 – 450 (1) (2)
Lepol and long rotary kilns	mg/Nm^3	400 – 800 (3)

(1) The upper level of the BAT-AEL range is 500 mg/Nm^3, if the initial NO_x level after primary techniques is > 1 000 mg/Nm^3.
(2) Existing kiln system design, fuel mix properties including waste and raw material burnability (e.g. special cement or white cement clinker) can influence the ability to be within the range. Levels below 350 mg/Nm^3 are achieved at kilns with favourable conditions when using SNCR. In 2008, the lower value of 200 mg/Nm^3 has been reported as a monthly average for three plants (easy burning mix used) using SNCR.
(3) Depending on initial levels and NH_3 slip.

Parameter	Unit	BAT-AEL (daily average value)
NH_3 slip	mg/Nm^3	< 30 – 50 (1)

(1) The ammonia slip depends on the initial NO_x level and on the NO_x abatement efficiency. For Lepol and long rotary kilns, the level may be even higher.

Equipment in NOx emission reduction techniques in Europe



Source: Cinti J. Experience on NOx emission reduction- TFTEI berlin workshop 2019

Costs of SNCR for cement plants

SNCR		Updated cost data
Average daily NOx concentrations to be abated	mg/Nm3 at 10%O2	1200
Outlet daily NOx concentrations reached	mg/Nm3 at 10%O2	800-400
Investments (Capex)	kEuros	1600 - 2000
Operational cost (Opex)	Euro per t clinker	0.3-1.0
Electricity consumption	kWh per t clinker	0.1-1.0

For a plant of 3000 t clinker per day :

- Emissions are reduced from 2650 t/year to 1770 or 880 t according to limit applied

Considering a lifetime of 20 y and 4% interest rate, the annual costs range between:

- 406 k€/y to 1110 €/year
- 0.42 to 1.15 €/t clinker
- 460 to 1250 €/t NOx abated

Costs of SCR for cement plants

SCR		Updated cost data
Average daily NOx concentrations to be abated	mg/Nm3 at 10%O2	1200
Outlet daily NOx concentrations reached	mg/Nm3 at 10%O2	200
Investments (Capex)	kEuros	5000-15000
Operational cost (Opex)	Euro per t clinker	0.3-1.1
Electricity consumption	kWh per t clinker	3-7

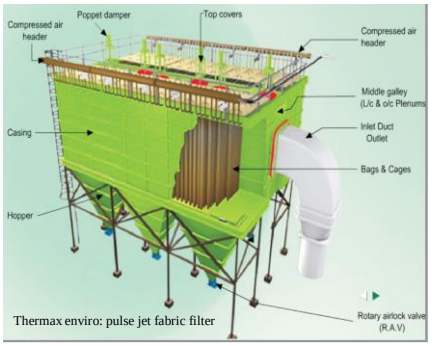
For a plant of 3000 t clinker per day :

- Emissions are reduced from 2650 t/year to 440 t

Considering a lifetime of 20 y and 4% interest rate, the annual costs range between:

- 655 k€/y to 2160 k€/year
- 0.70 to 2.15 €/t clinker
- 300 to 980 €/t NOx abated

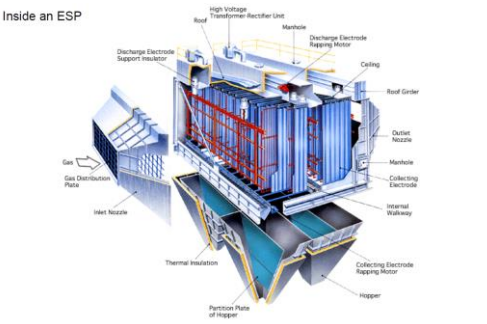
Reduction techniques for dust emissions



Thermax enviro: pulse jet fabric filter

For diffuse emissions from dusty operations, reduction can be encapsulation of some operations, covering conveyors…

For the kiln firing processes and cooling and milling processes, BAT associated emission levels range from <10 – 20 mg/Nm3 , as the daily average value. ESP and fabric filters are used



(https://www.indiamart.com/proddetail/retrofiring-of-electrostatic-precipitator-esp-6650529130.html)

Costs of a fabric filter for cement plants

Fabric filter		Updated cost data
Average daily PM concentrations to be abated	mg/Nm3 at 10%O2	56
Outlet daily PM concentrations reached	mg/Nm3 at 10%O2	5
Investments (Capex)	kEuros	4000 - 10.000
Operational cost (Opex)	Euro per t clinker	0,3
Electricity consumption	kWh per t clinker	4,0

For a plant of 3000 t clinker per day :

- Emissions are reduced from 124 t/year to 11 t/year

Considering a lifetime of 20 y and 4% interest rate, the annual costs range between:

- 580 k€/y to 1020 k€/year
- 0.60 to 1.10 €/t clinker
- 5170 to 9100 €/t dust abated

Reduction techniques for SO_2

SO2 emissions from cement plants depend on the total input of sulphur compounds and the type of process used and are primarily determined by the content of the volatile sulphur in the raw materials and possibly by the fuels.

- ✓ Primary measures:
  - optimisation techniques, such as optimising the clinker burning process including the smoothing of kiln operation,
  - uniform distribution of the hot meal in the kiln riser
  - prevention of reducing conditions in the burning process
  - choice of raw materials and fuels

- ✓ Secondary measures when SO_2 emission are high
  - Addition of absorbent such as slaked lime, quick lime…to the raw material
  - Dry adsorption in a dry scrubber
  - Wet scrubber

The BAT AEL in daily average value ranges from < 50 to 400 mg/Nm3

BAT AELs for SO_2

Parameter	Unit	BAT-AEL (1) (2) (daily average value)
SO_x expressed as SO_2	mg/Nm^3	< 50 – 400

(1) The range takes into account the sulphur content in the raw materials.
(2) For white cement and special cement clinker production, the ability of clinker to retain fuel sulphur might be significantly lower leading to higher SO_x emissions.

Costs of adsorbent injection for cement plants

Adsorbent injection		Updated cost data
Average dailySO2 concentrations to be abated	mg/Nm3 at 10%O2	600-1000
Outlet daily SO2 concentrations reached	mg/Nm3 at 10%O2	400
Investments (Capex)	kEuros	200-750
Operational cost (Opex)	Euro per t clinker	0.3 - 0.7
Electricity consumption	kWh per t clinker	0.1 - 0.3

For a plant of 3000 t clinker per day :

- Emissions are reduced by 440 to 1320 t /y

Considering a lifetime of 20 y and 4% interest rate, the annual costs range between:

- 300 k€/y to 730 k€/year
- 0.30 to 0.80 €/t clinker
- 700 to 1650 €/t SO_2 abated

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Costs of wet FGD for cement plants

Adsorbent injection		Updated cost data
Average dailySO2 concentrations to be abated	mg/Nm3 at 10%O2	700 - 1300
Outlet daily SO2 concentrations reached	mg/Nm3 at 10%O2	50 - 400
Investments (Capex)	kEuros	10.000-26.000
Operational cost (Opex)	Euro per t clinker	0.4-1.4
Electricity consumption	kWh per t clinker	8-10

For a plant of 3000 t clinker per day :

- Emissions are reduced by 660 to 2760 t /y

Considering a lifetime of 20 y and 4% interest rate, the annual costs range between:

- 1120 k€/y to 3260 k€/year
- 1.20 to 3.40 €/t clinker
- 1700 to 4900 €/t SO_2 abated

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Next steps

- Finalization of the second draft of document
- To be circulated in a small working group
- Finalization of the document by end of 2019

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Thank you very much for your attention! Questions?

TFTEI Technical Secretariat