european cement research academy

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Preliminary assessment of the state of NO_x emissions and NO_x abatement technologies at the Rørdal Plant of Aalborg Portland / Denmark

Dear Mr. Damtoft,

Please find below our preliminary assessment (step 1) of Aalborg Portland's NO_x emissions and the applied NO_x abatement technologies compared to BAT.

Introduction

The production of cement clinker is an energy-intensive process which requires very high temperatures. This results in the formation of NO_x. As nitrogen oxides are environmentally relevant air pollutants, the clean air policies in Europe and in the member states intend to further reduce NO_x emissions.

In Denmark, an increase of the tax on NO_x emissions is currently being discussed. Through this, the authorities are aiming to promote NO_x reductions. Up to now, exemptions have been granted to industrial sectors with particularly high NO emissions because otherwise the competitiveness of the affected companies would be impaired.

Aalborg Portland is the sole cement producer in Denmark. The Rørdal plant is one of the major stationary NO_x emission sources in Denmark and is thus in the public eye. During the past years, Alborg Portland was able to reduce the NO_x emissions of the plant significantly, but now the potential for further reduction steps seems to be limited.

The European Cement Research Academy (ECRA) was therefore commissioned by Aalborg Portland to assess the current level of NO_x emissions from the Rørdal plant and the applied NO_x reduction technologies. This paper represents a first

and preliminary assessment of the emission situation in the Rørdal plant of Aalborg Cement. The European BAT Reference Document for the cement industry should be used as a standard for the comparison of abatement technologies which are applied at the Rørdal plant. Furthermore, an overall evaluation should be made if the state of NO_x reduction in the cement sector has changed during the last years and if the reasons for reliefs from the Danish NO_x taxes are still valid.

Best Available Techniques for NO_x reduction in the cement sector

According to the European IPPC Directive, the permit of industrial plants shall include conditions and emission limit values based on “best available techniques” (BAT) but taking into account local considerations such as characteristics of the installation and any special needs of the local environment (today, the contents of the IPPC Directive have been incorporated in the new “Industrial Emissions Directive”). The relevant technical information from the different industrial sectors was collected and issued in so-called BAT Reference Documents (BREF Documents) for the respective sectors. The first BREF Document for the cement and lime manufacturing industries was published in 2001 and provided an overview about the current state of cement production and emission abatement technologies for the most important air pollutants. During the past years, the cement BREF Document was revised and the second edition was published in 2010.

The cement BREF Document contains amongst other things a list of measures for NO_x reduction that have been successfully applied in the cement industry. It should be emphasized that the mentioned reduction measures do not have a cumulative effect on the reduction efficiencies. Based on expert judgements, BATs were selected and associated emission levels and/or consumption levels were defined. According to the current version of the cement BREF Document, the following measures or techniques (applied individually or in combination) are considered as BAT for NO_x reduction:

a) primary measures/techniques, such as:
   I.) flame cooling
   II.) low-NO_x burners
   III.) mid-kiln firing
   IV.) addition of mineralisers to improve the burnability of the raw meal
   V.) process optimisation
b) staged combustion, also in combination with a precalciner and the use of optimised fuel mix
c) selective non-catalytic reduction (SNCR)
d) selective catalytic reduction (SCR), subject to appropriate catalyst and process development in the cement industry

The application of the above mentioned abatement technologies is associated with different NO_x emission levels (BAT-AELs) which have been observed by application of those measures in the cement industry.

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

The BAT-AEL is 500 mg/Nm^3 where after the application of primary measures the initial NO_x level is > 1,000 mg/Nm^3. If SNCR is applied as a NO_x reduction measure, the NH_3 slip should be kept as low as possible, but below 30 mg/Nm^3 as a daily average. If a high initial NO_x concentration requires a high NO_x reduction rate, the NH_3 slip may be higher (up to 50 mg/Nm^3). The NH_3 slip may be even higher for Lepol and long rotary cement kilns.

Short description of the kiln lines and the applied NO_x reduction measures

At the Rørdal Plant, seven rotary cement kilns are installed: five for the production of white cement clinker and two for the production of grey cement clinker. The next paragraphs give a short description of the kiln systems and the applied NO_x abatement technologies.

Cement kilns for the production of grey cement

The rotary kilns 85 and 87 are installed for the production of grey cement clinker. Kiln 85 is a long wet kiln with a present clinker production of 1,500 tpd. The following NO_x reduction measures are applied at present:

- flame cooling
- addition of mineralisers
- SNCR (as a test installation)

Kiln 87 is a rotary cement kiln with cyclone preheater and precalciner. The current clinker production is 4,632 tpd. The following NO_x reduction measures are applied:

- low NO_x burner
- addition of mineralisers
- SNCR

Though the kiln line is equipped with a precalciner, the potential of staged combustion technology could not be utilised up to now.

Cement kilns for the production of white cement

There are five long wet kilns for the production of white cement clinker at the Rørdal Plant, namely the kilns 73/79 (clinker capacity: 400 tpd each), the kilns 74/78 (clinker capacity: 520 tpd each) and the kiln 76 (clinker capacity: 670 tpd). The flue gases are emitted into the atmosphere via three stacks. All five white cement kilns are equipped with mixing air devices at the middle of the kiln. The injection of mixing air can reduce the stratification of the kiln gases and can contribute to a more stable kiln operation. Furthermore, the amount of excess air in the kiln flame can be reduced which leads to a lower NO_x formation. A burn-out of CO can also be achieved by the injection of mixing air. All in all, the staged injection of air is a useful primary measure for NO_x reduction at long wet kilns. However, only at kiln 76 was the mixing air installation upgraded. At the moment it is not clear how the experiences from kiln 76 can be transferred to the other white cement kilns. Further NO_x reduction measures were considered but not continued due to the demanding technical requirements from the long wet kilns for white cement production.

NO_x emissions and NO_x reduction potential

Based on NO_x figures provided as long-term average emission concentrations by Aalborg Portland, the NO_x levels of the kilns in the Rørdal Plant can be evaluated with respect to BAT as follows:

Cement kilns for the production of grey cement

According to the BREF Document, the achievable NO_x emission level for kiln 85 (wet kiln) is 400 - 800 mg/Nm^3. The current emission limit values for NO_x and NH_3 are 800 mg/Nm^3 and 50 mg/Nm^3 respectively. By the application of SNCR, NO_x emissions below 800 mg/Nm^3 can be achieved at this kiln line (see **figure 1**). The NH_3 level is far below the emission limit value. The associated emission limit values for NO_x are met.

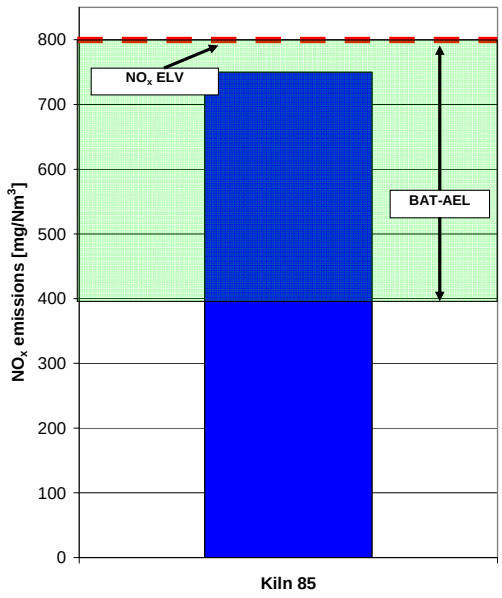

Fig. 1: NO_x emissions from kiln 85

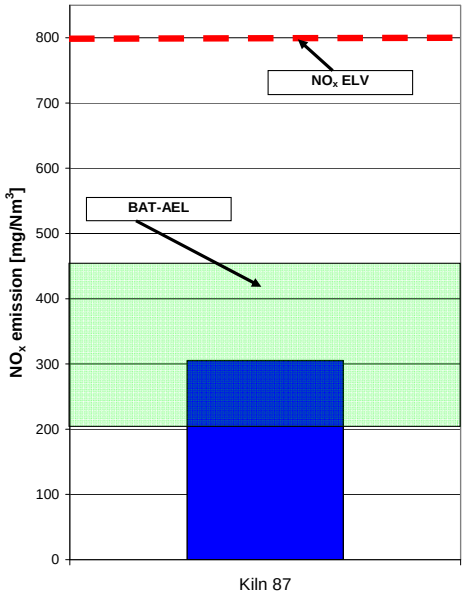

Fig. 2: NO_x emissions from kiln 87

Figure 2 shows the average NO_x emissions from kiln 87. The current emission limit values for NO_x and NH_3 are 800 mg/Nm^3 and 10 mg/Nm^3 respectively. The emission concentration is far below the current NO_x emission limit value and furthermore meets the so-called BAT associated emission level. The very low emission limit value for NH_3 is a limiting factor for the application of the SNCR process because an increased injection of the reducing agent would most likely lead to a higher NH_3 slip.

Cement kilns for the production of white cement

The present operation of the white cement kilns exhibits NO_x emissions which are at the lower end of the BAT-AEL (400 - 800 mg/Nm^3, see **figure 3**). The present emission limit values are met with a sufficient safety margin due to the application of process optimisation measures.

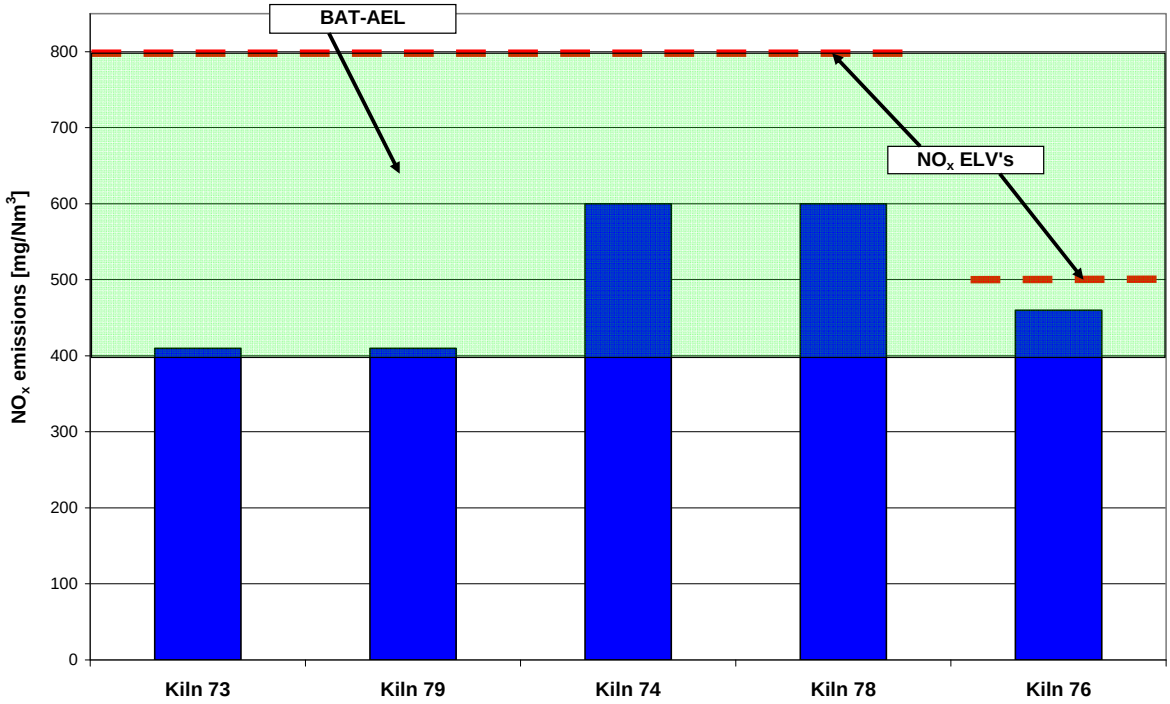

Fig. 3: Present NO_x emissions of the white cement kilns (three stacks), BAT-AEL and NO_x emission limit value

In principle, a mid-kiln firing could be installed at long wet kilns for NO_x reduction. However, as the fuel characteristics are very decisive for a good quality of the white cement clinker, this potential NO_x reduction measure was no longer considered. The application of additional primary measures would allow only slight improvements of the NO_x reduction. The SNCR process is not BAT for long wet kilns because the appropriate temperature window for the reduction reactions is given in the rotary kiln itself so that the injection of the reducing agent would be problematic. The principle of staged combustion can only be applied at precalciner kilns. All in all, there is only a very limited potential for further NO_x reduction steps.

SCR as a potential secondary measure for NO_x reduction

In principal, the SCR technology could be applied at all types of kiln systems. If the gas temperature and the gas composition would not allow the installation of a high-dust plant, at least a tail-end installation could be considered. However, an investment in the SCR technology should only be carried out after completion of the demonstration projects of the European cement industry, meaning not before 2015/2016. The investment costs would be very high, depending on the plant size between 5 and > 10 Mio. € for each flue gas string.

Summary

The preliminary assessment of the NO_x abatement measures of the Rørdal plant is based on information provided by Aalborg Portland which also includes average NO_x emission concentrations for the kilns in question. Although BAT-associated emission levels are based on daily averages, the situation with respect to BAT can be summarized as follows:

- At all kiln lines, BAT measures for NO_x reduction are applied. There are constraints depending on the type of kiln regarding which measure can be applied, especially for the long wet kilns.
- All kilns meet the current NO_x emission limit value.
- The NO_x emissions from all kilns are within the so-called BAT associated emission level (BAT-AEL).
- The state of NO_x abatement in the cement sector is almost the same as two years ago, because the SCR process is not yet developed to a state-of-the-art technology in the cement sector.
- Therefore, the possibilities for a further reduction of the NO_x emissions are very limited and the plant operator hardly has a chance to invest in more effective NO_x reduction measures. As a consequence of this, an increase in the NO_x taxes would only result in an increase of the production costs which would impair the competitiveness of cement production in Denmark.

Yours sincerely,

European Cement Research Academy GmbH

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