SNCR Retrofit of a Lignite Power Plant to Meet the new EC NOx-Limit of 200 mg/Nm3

Dipl.-Ing. Zoltan Teuber, Dr.-Ing. Wolfgang Schüttenhelm, Karlheinz Huber

ERC Technik GmbH
Bäckerstr. 13
D-21244 Buchholz i. d. Nordheide
Germany

NO_x emissions could be lowered very effectively and cost-efficiently by the application of modern SNCR-technology. Therefore, the SNCR-technology already entered into the field of large-scale power plants over the last years [1, 2, 3]. Especially in case of older boiler plants, with a limited term, this technology is preferred [4]. Major investments in alternative technologies do not turn out to be economical any longer due to their limited remaining operational time.

A large number of coal power plants which are still not complying with the new EU NO_x-regulation exist in many EU countries. Here, the SNCR technology in conjunction with primary measures is the right choice for solving the problem of NO_x. In the following this paper will present a new SNCR reference of the ERC Technik GmbH for large power plants. It is Mátrai Erömü in Visonta, Hungary's largest thermal power plant being fueled by lignite.

Fig. 1: Mátrai Power Plant

1. Introduction

The Mátrai Erömü lignite coal power plant (fig. 1) is located near Visonta, a town at the foothills of the Mátra Mountains and next to the largest Hungarian lignite basin. Since 1992 it has been majority-owned by RWE, i. e. 50.9 %, whereas EnBW holds 21.7 %. Its total capacity of 910 MW_{el} is generated by two units (No. 1 and 2) of 100 MW_{el} each, three units (No. 3, 4, and 5) of 220 MW_{el} each as well as two gas turbo generator groups of 30 MW_{el} each.

Just as in case of all European coal power plants it is to ensure compliance with the new mandatory European limit value for NOx emissions of 200 mg/Nm³ till 2016.

At present up to 10 % of biomass is added to the main fuel lignite at the Mátrai Erömü power plant. The tendency is rising as the amount of biomass will be gradually increased up to 15 %. This restricts the selection of secondary methods for flue gas denitrification as application of SCR technology. In case of critical fuels such as lignite and biomass the catalyst lifetime is shortened due to the risk of erosion and poisoning.

In addition and due to the constantly growing share of renewable energy sources in the total energy mix (in Hungary above all wind and sun) the demands on the power station boilers regarding flexibility and adaptability to the guidelines of the regional load distributor increase, too. This in turn generates similar demands on the downstream flue gas cleaning measures which need to be flexible to the same extent. In this respect, too, the SNCR-technology offers significant advantages compared to competing procedures.

2. Project schedule

For these reasons the power station Mátrai Erömü decided, in order to solve the NOx problem, to check ERC's proposal presented by means of the application of the SNCR technology. In 2011, Mátrai Erömü asked ERC to demonstrate the effectiveness of this method in a large-scale field test.

The test was carried out at unit no.3 in November 2011. Following the instructions of the ERC GmbH the customer constructed the injection positions for the lances, i. e. offset tubes were made in the membrane walls of the combustion chamber as well as nozzle sets for the introduction of the dosing lances (fig. 2). Injection positions were determined according to customer specific information of a CFD simulation. In addition, ERC GmbH carried out temperature measurements by means of a thermocouple.

Fig. 2: Nozzle sets for the dosing lances

The main parameters of unit No. 3 (fig. 4) read as follows:

max. electrical power:	220 MW_{el}
max. steam output:	670 t/h
control range:	50 - 100 %
max. flue gas quantity:	1.300.000 Nm³, at 6 % O_2, dry

ERC Technik GmbH, Bäckerstraße 13, D-21244 Buchholz

The test was carried out successfully with a manually operated test facility (fig. 3). It was proven that due to the SCNR technology the NOx limit value of 200mg/Nm³ was kept between 50 and 100 % in all load steps along the unit's control range. Even the NH3 slip in the fuel gas did not exceed 5 mg/Nm3.

Fig. 3: SNCR test facility

Moreover, it could be demonstrated that during this time the NH3 content in the ash did not exceed the required value of 100 mg/kg and the NH3 content in gypsum downstream of the FGD plant did not exceed 10 mg/kg. A fortified urea solution with the commercial name carbamin 5722 was used as a NOx reducing agent.

Based on this successful test the power plant Màtrai Erömü later decided to finally implement the SNCR technology into the units Nos. 3, 4 and 5.

In May 2013 the ERC GmbH received the contract for the equipment of those units. According to the time schedule the installation of unit No. 3 was completed by the end of 2013. Commissioning of the units 4 and 5 took place end of August 2014.

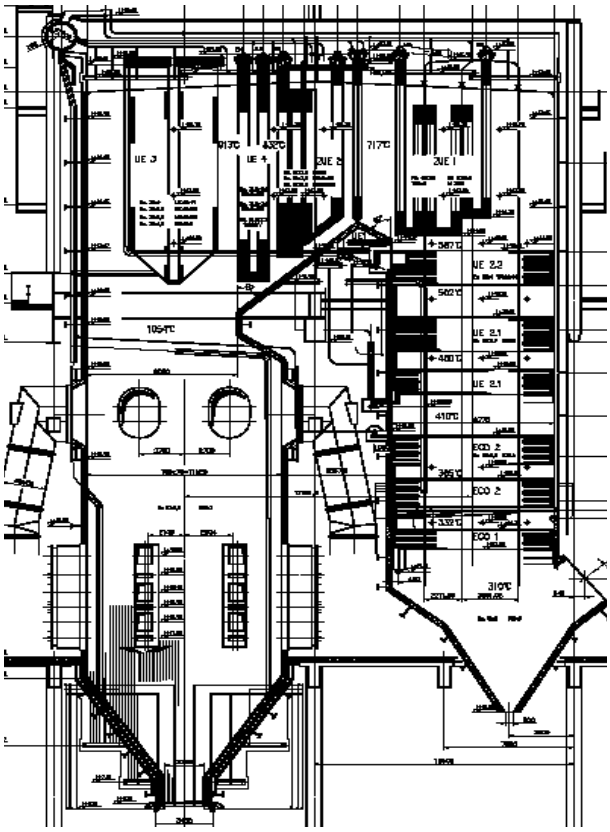


Fig. 4: Mátrai Erömü, unit No. 3

ERC Technik GmbH, Bäckerstraße 13, D-21244 Buchholz

3. Construction of the permanently installed SNCR facility

As lignite is a low-grade fuel, the combustion chamber temperatures in the lignite-fired boilers are relatively low compared to those in coal boilers. On the other hand, high quantities of flue gas resulting from the use of lignite require large combustion chambers for the boilers. Thus, heat loads in the combustion chambers are lower and temperatures between both control range limits of those boilers (mainly 50 – 100 %) vary significantly within the individual areas of the combustion chambers.

Consequently, the requirements of a SNCR facility with respect to flexibility in adapting to the operation conditions of the boiler are very high and, therefore, need to be considered carefully.

Since all three units are next to each other the overall plant consists of a part being common to all three units as well as of unit-specific parts. The storage facility for the NOx reducing agent is the common part (fig. 5).

Fig. 5: Storage facility for the NOx reducing agent

The storage facility consists of two tanks, 100 m³ each, providing all three units with the NOx reducing agent. A process additive similar to the one used during the test will be used as reducing agent. However, this time the reducing agent is produced locally, i. e. an additive called carbamin 5100 is added to a commercial-grade 40 % urea solution while the tank is filled.

The appropriate dosage is adjusted by means of a metering system (fig. 6). Thanks to the additive the reducing agent can be diluted with filtered hard water without any hardness precipitations. Moreover, it increases the responsiveness of the injected reducing agent into the reaction chamber.

The diluted reducing agent is produced in the mixing and measuring modules (fig. 7). These are unit-specific and are placed near the boiler in order to avoid long pipeline routes. Three mixing and measuring modules are provided per unit. Each of them are connected to lances in the front wall as well as in the side walls of the boilers.

Fig. 6: Metering system for carbamin 5100

The diluted reducing agent is also led to the unit-specific injection systems. Those injection systems consist of pneumatic lances being arranged on two levels at each unit. Within each level the lances are arranged into injection groups.

Fig. 7: Mixing and measuring module for the treatment of the NOx reducing agent

The individual lance groups are activated by means of pneumatic valves which release the diluted NOx reducing agent as well as the atomized air for specific groups (fig. 8). Thus, the diluted reducing agent can only flow to those lances that are to be active at a certain point of time. This is determined by a unit-specific control unit of the system. The active lance groups are controlled due to the temperature distribution in the combustion chamber.

Fig. 8: Distribution Modules for lance control

A temperature measuring system continuously measures the temperature distribution over a particular cross-section of the combustion chamber. It consists of eight pyrometers which are distributed over the combustion chamber's circumference. A special software creates maps according to the measured values of the pyrometer. These maps provide information on the temperature distribution as well as on the combustion quality of the cross-section (fig. 9). Furthermore, the operator also uses this information to optimize the combustion.

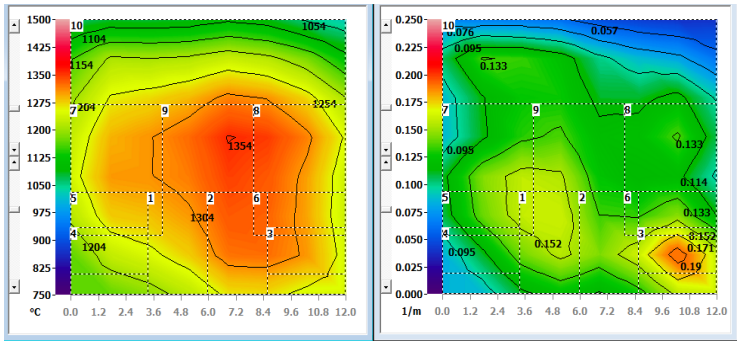


Fig.9: Temperature distribution and combustion quality in the cross-section

The pneumatic lances (fig. 10) required for the injection of the diluted reducing agent are installed into the front wall and into both side walls. They are equipped with nozzles which have a high throw distance. As a result the reducing agent can be injected into the appropriate zone specified by the control unit. The groups of lances are arranged on two levels. Sometimes the lance groups of both level are activated at the same time depend on the combustion chamber conditions.

Control and temperature measuring systems are unit-specific, too. The control cabinet of the SNCR facility is placed into an air-conditioned room next to the control room. Control parameters can be easily set by means of an operator panel (fig. 11) which is included in the door of the control cabinet. A second identical operator panel is included in the door of the mixing and measuring module which prepares the diluted reducing agent for the lances at the boiler's front wall. Thus, settings can be made locally at the boiler.

Fig. 10: Injection lance

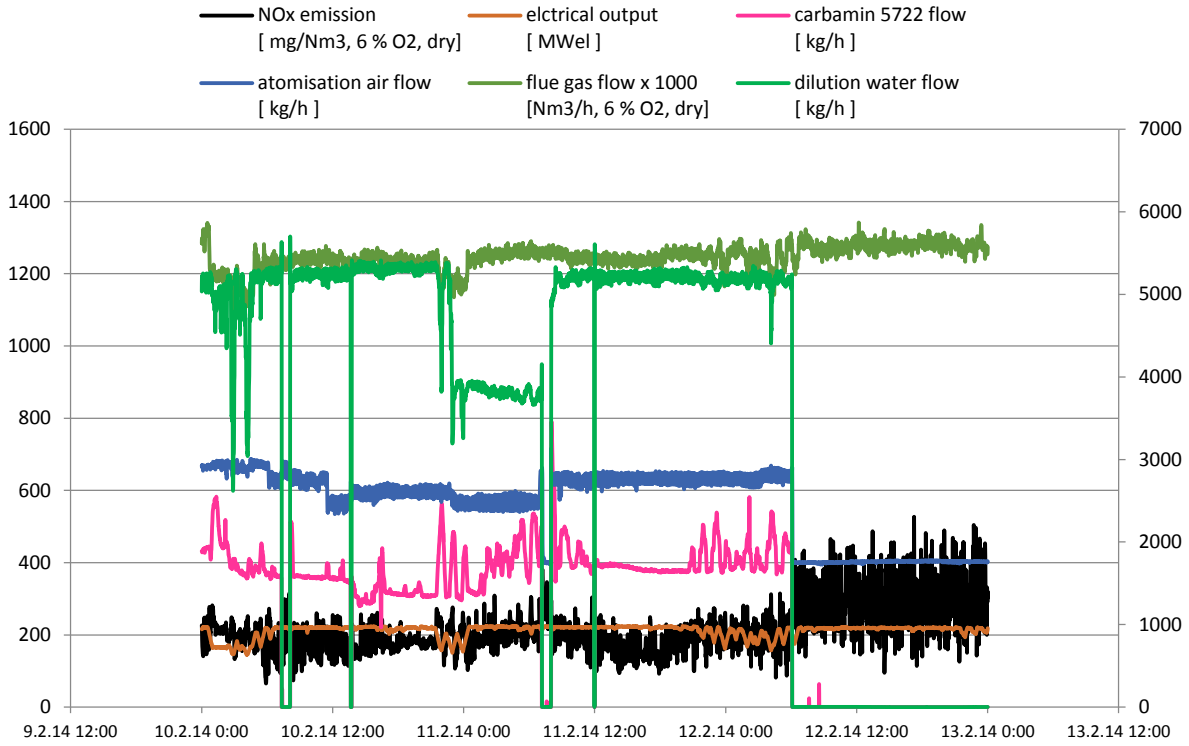
The control cabinet of the temperature measurement system in also placed in the same room as the control cabinet of the SNCR facility. Both controls are connected to one another. The main operating parameters of the SNCR facility as well as the tomographic maps which are provided by the temperature measurement system and which show the temperature distribution and the combustion quality of the combustion chamber cross-section are also presented on a screen in the control room.

Fig. 11: Operator panel for parameterization

4. Operating results

The SNCR system that was designed according to the design parameters as mentioned in chapter 2 operates fully automatically. A unit-specific emission measurement system continuously informs the SNCR system about the current NOx emission signal. In order to define the injected quantity of the diluted reducing agent the control unit also receives some operating parameters of the boiler such as volumetric flue gas flow, load etc. The SNCR system is designed in such a way that NOx emissions of less than 200 mg/Nm³ are maintained in the dry flue gas at 6% O2 in the daily average.

As an example Fig. 12 shows the operating results at unit No. 3 over a period of three days.



The achieved results fully meet the expectations: the NOx emission of 200 mg/Nm³ in the daily average is not exceeded at any time. Furthermore, an independent measuring institute confirmed warranty measurements in offline mode that even the amount of NH_3 slip in the flue gas is less than 2 mg/Nm³.

The period shown in the above graph represents the end of an operating time, just before a planned shutdown. It was intentionally chosen to show the NOx output value. It is clearly seen that after shutdown of the SNCR system, the output values reached 400 mg/Nm³ sometimes or even exceeded 400 mg/Nm³.

5. Conclusion and outlook

The successful application at unit No. 3 demonstrates that the SNCR process for the reduction of NOx offers a technically safe and cost-efficient solution to comply with the NO_x emission requirements, even in case of lignite boilers.

After the successful installation of SNCR of the units Nos. 3 – 5 ERC was recently awarded SNCR retrofit of the 100 MW_{el} unit No. 2. Several other SNCR retrofits for lignite and bituminous coal applications are under planning or installation.

Literature

[1] Schüttenhelm, Wolfgang; Huber, Karlheinz; Teuber, Zoltan: SNCR Technology for Large Combustion Plants – Operational Experiences with a Commercial Installation in a 225 MWel Coal fired Boiler, VGB Workshop Flue Gas Cleaning, Rotterdam, May 15-16, 2013

[2] Schüttenhelm, Wolfgang; Huber, Karlheinz; Teuber, Zoltan: SNCR Technology for Large Combustion Plants – Operational Experiences with a Commercial Installation in a 225 MWel Coal fired Boiler, VGB Power Tech 12, 2013, pp. 71 - 75, Rotterdam, May 15-16, 2013

[3] Teuber, Zoltan; Schüttenhelm, Wolfgang: DeNOx-Technologie für große Verbrennungsanlagen – jüngste Entwicklungen und Betriebserfahrungen an kohlegefeuerten Anlagen mit SNCR und SCR, 45. Kraftwerkstechnisches Kolloquium 2013, Dresden, Okt. 15 – 16, 2013

[4] Schüttenhelm, Wolfgang; Teuber, Zoltan: Most Recent Operational Experiences with SNCR Applications for Coal-Fired Boilers, PowerGen Europe 2014, Cologne, June 3, 2014