Performance in NOx Emission Reduction with Lignite Staged Combustion Technology

L. Mihăescu, G.Negreanu, I. Pîşă, A. Adam, C. Mândrean, E. Pop, V. Berbece

Performance in NOx Emission Reduction with Lignite Staged Combustion Technology: *The paper presents a synthesis of experimental test results on reducing NOx emission from pulverized lignite staged combustion. The final goal of the research is to achieve information for combustion technology transfer to a 525 t/h boiler from the Isalnita CHP Plant. The experiments were conducted on a 2 MW pilot boiler equipped with a slots burner designed according to the principles previously tested by numerical modelling and in a wind tunnel. The experiments showed a significant decrease of NOx emission in staged combustion of pulverized lignite, that confirm the possibility of refurbishing the 525 t/h burner boiler from Isalnita CHP Plant.*

Key words: *Combustion, NOx emissions.*

INTRODUCTION

The experimental research concerning the combustion technology of pulverized lignite from Oltenia coal field, by staged combustion technology in order to reduce the emission of NOx, is a fundamental task before implementing the technology to the industrial boiler of 525 t/h of Işalniţa CHP Plant.

By observing the similarities in thermo-gas-dynamic between the combustion processes for the two power plants, the measured values indicated a high degree of generalization. The design solution for the burner was previously analysed by numerical modelling and gas dynamics tested on a wind tunnel. Lignite from Oltenia coal field, which is used frequently in the power plant, was used for experiments.

Experimental research has been conducted in order to achieve the following:

- determining the lower limit of operation with thermal support fuel (natural gas);
- determining the flame stability;
- thermodynamic regime for furnace;
- pollutant emissions;
- monitoring the reduction of NOx emission by using staged combustion technology comparing with classic combustion with slots burners.

The technical analysis has been determined by ICEMENERG SA laboratory, RENAR accredited laboratory:

W^i_t = 41.29 % - moisture content;

A^i = 23.94 % - ash content;

V^i = 34-36 % - volatile matter content;

Calorific value - 7298,3 kJ/kg.

A low calorific value has been noticed, due to the very high moisture content. Moisture and ash content being quite high, the fuel was classified as an inferior coal.

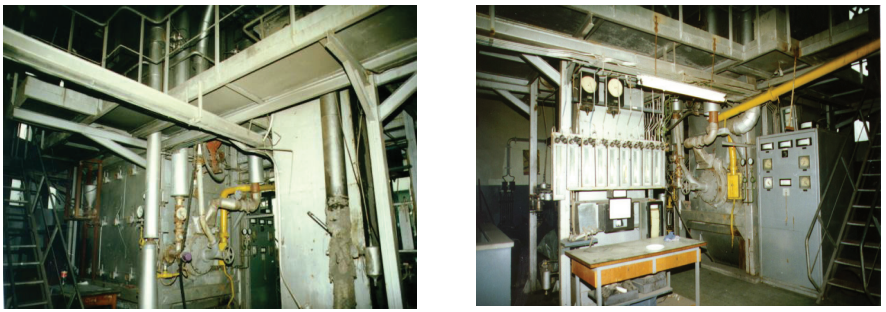
Figure 1 presents the 2 MW pilot boiler, where the experimental program has been conducted and figure 2 presents the burner for lignite staged combustion.

As a result, it has been imposed a fineness of grinding performance similar to the industrial lignite ($R_{0,09}$ < 75%), in order to control the ignition and combustion stability.

The relatively high sulphur content (S^i_c=1.05%), conducted to increased emissions of sulphur dioxide.

It has been noticed a sensible influence for the final value of the nitrogen oxides emission (NOx), due to the relatively low percentage of nitrogen.

During the experiments, the thermal load produced by the mill at a maximum flow rate of 0.14 t/h has been adopted. The gas flow rate used as thermal support had a maximum value of 36 m^3_N/h. Three coal flow rates of 0.1 t/h, 0.11 t/h and 0.14 t / h have been used.



a. b.

Fig.1. 2 MW pilot boiler construction
a. Boiler longitudinal view; b. Boiler front view

Figure 3 presents the flue gas fan and ash remover system comprising three cyclones.

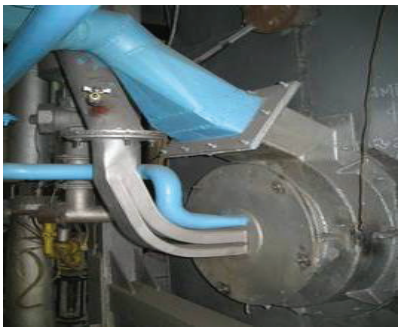


Fig.2. Staged combustion burner, functional model used in experiments

Fig.3. Final part of the boiler with flue gas fan an ash remover cyclones

As a result of the lignite low quality, the thermal load of furnace volume varied between 58.5 kW/m^3 and 70 kW/m^3, a value accepted as the absolute lower limit for a boiler furnace with pulverized lignite combustion.

The similarities between the experiments and the real processes from an industrial boiler for pulverized lignite combustion include the following criteria:

- the thermal volume load of the furnace, kW/m^3;
- the temperature at the end of the furnace;
- the excess air at the end of the furnace;
- the fineness of grinding of the pulverized coal;
- the pressure at the end of the furnace.

For a maximal appreciation of the experimental and the real (industrial) results, the values of these criteria (the values used in operation) must be as close as possible.

The pilot boiler efficiency is not a criterion of similarity to the real installation due to the fact that the pilot boiler cold air injection for thermal protection from the flue gases area situated between the air preheater and the flue gas fan, has its efficiency affected (although the efficiency was situated between 73% and 82.1%).

Figure 4 shows the variation of the moisture content of the pulverized coal at the mill exit, depending on the mill flow rate. Due to the very high moisture content of the raw coal

over the mill load of 100 kg/h, the drying process has been insufficient.

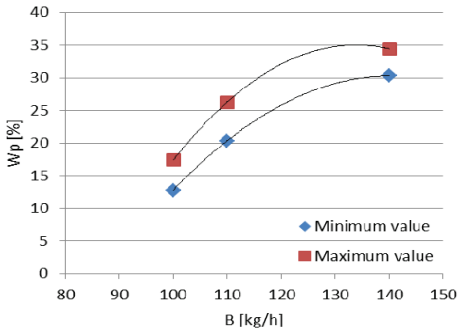


Fig.4. The variation of the particles moisture content at the mill outlet according to the mill flowrate

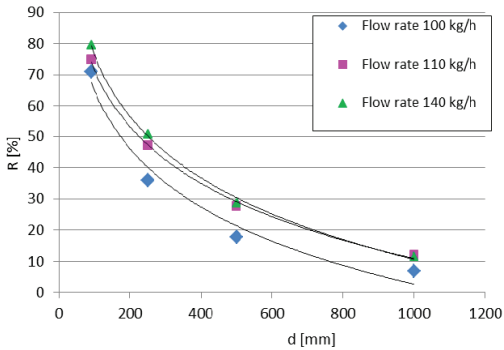


Fig.5. Fineness of the grinding for different mill loads

The fineness of the grinding for the various mill loads is shown in figure 5. It is noted the fineness of grinding is within the industrial normal limits ($R_{0,009}$ = 71.02 to 79.39%) for all the experiments. The achieved fineness of the grinding comply with the requirement of similarity with the industrial values, four cases in five complying to the condition of R0,09 <75%.

The depression at the end of the furnace was within -1.24 % to -3.2 %, similar with industrial boilers exploitation.

The air excess at the end of the furnace, an important indicator for the combustion performance had values in the range from 1.27 to 1.3, normal values considering the low quality lignite experienced.

Fig.6. The system for coal dust capture located on the burner supply line

Fig.7. Measurement of electrical parameters of coal mill

For the grinding system, on the pulverized coal path from the outlet of the mill separator, a system for pressure and temperature measurement has been installed, in order to characterize the thermo-gas-dynamics parameters of the primary agent, On the same route, a pulverized cyclone type coal capture system, was also installed, in order to determine the fineness of grinding –figure 6.

Electricity consumption of the mill is achieved by measuring the intensity and the

required DC voltage - Figure.7.

The thermo-gas-dynamics parameters of the flame at the nucleus level and respectively, at the end of the furnace, expressed through the flue gas composition and temperature, have been monitored by means of two gas analysers - figure.8 and 9.

Fig.8. Horiba gas analyser location for NOx data acquisition from the end of the flame

Fig.9. The location of the NOx measurement point at the end of the system (after the flue gas fan)

The values for the NOx emissions, using staged combustion burner, expressed by measurement at the end of the boiler are shown in Figure 10 respectively 11. The values bellow 250 mg/m^3_N for an excess air expressed by the oxygen concentration of 6%, has been noted. Using a burner without staged combustion, NOx emissions raised to values of 350 mg/m^3_N.

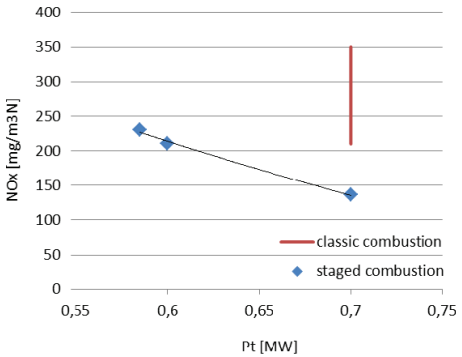


Fig.10. NOx emissions according to the thermal load of the boiler for classic and staged combustion

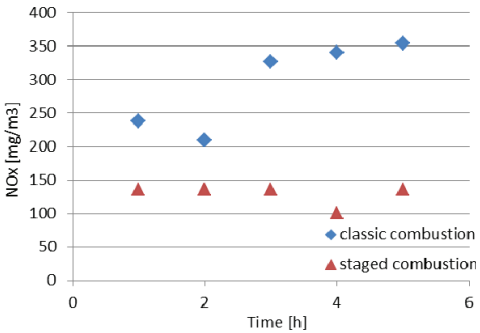


Fig.11. NOx emissions in time for classic and staged combustion

CONCLUSIONS AND FUTURE WORK

The experiments have shown that lignite combustion from the Oltenia coal field, took place in good conditions using a slots burner pilot with staged combustion. The staged combustion is performed by directing jets with differential penetration of the pulverized coal, the secondary and the tertiary air. There were no problems with ignition and flame stability, although the humidity was high and the calorific value, very low. The NOx emission level was within the expected limits, confirming the possibility of the implementation of the tested technology to the new burner combustion for the 525 t/h

boiler of Işalniţa CHP Plant. During the experiments, there have not been noticed slagging tendencies, but the number of hours of experimentation was reduced to finally have such a conclusion.

Following this set of experiments, the NOx emission level obtained create the premises for a possible integration of such a burner within the maximum limits of 200 $mg/m^3_{N,}$ objective that must be reached soon in power production in Romania.

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