U. P. B. Sci. Bull., Series C, Vol. 69, No.4, 2007 ISSN 1454-234x

EXPERIMENTAL RESULTS CONCERNING FLUE GAS CLEANING TECHNOLOGIES APPLYING SNCR AND COMBINED METHODS

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The research presented in this paper focuses on a facility, the experimental results and interpretation concerning the flue gas cleaning using SNCR processes in a fluidized bed combustion pilot rig. Mainly pit coal from Valea Jiului basin was used as principal fuel in fluidized bed combustion system, in order to demonstrate the efficiency of the for secondary NOx reduction.

Keywords: SNCR process, pit-coal, fluidized bed.

1. Introduction

Literature is indicating details concerning the SNCR processes, during which a reagent is injected into the flue gas, within an appropriate temperature window (the maximum efficiency is achieved for 940-970 °C). The NO_x and reagent (ammonia or urea) react forming nitrogen and water and thus the maximum admitted values according to environmental protection lows for the NO_x in exhaust are reached. The novelty of this paper consists of the fact that it is based on experiments achieved in flue gases from the combustion of different fuels, of fossil or renewable origin, and that the technology was successfully proved for several selective additives. Simultaneous the process has been proved to be active also for other pollutants, according to the injected additive.

2. Experimental setup

The test facility comprises several main parts for the combustion, heat transfer, flue gases de-dusting and flue gases cleaning processes, including the SNCR system. It consists of reagent storage, reagent-injection system and control

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instrumentation. The facility is adaptable to different type of fuels, by only taking sure that first a drying process and a grinding suitable for fluidized bed combustion are accomplished.

Pit coal from the Valea Jiului basin (LCV= 15894 kJ/kg in reference to the humid probe) was used as principal fuel in fluidized bed combustion system, in order to demonstrate the efficiency of the for secondary NO_x reduction. The coal was dried in open air for 24h because of the high humidity content in order to avoid problems occurring in the milling equipment or in the feeding system.

Next table (table 1) gives the elementary analysis and information for pit coal.

Table 1

Elementary analysis for pit coal - Sample 1

Characteristics in reference to humid probe	**Symbol**	**IS unit**	**Value**
Carbon	C^i	%	37.20
Hydrogen	H^i	%	2.43
Sulfur	S^i	%	1.10
Oxygen	O^i	%	9.00
Nitrogen	N^i	%	1.00
Ash	A^i	%	**basin.** 40.30
Humidity	W^i	%	8.97
Inferior heating value	H_i^i	kJ/kg	15.894

The co-combustion system contains the following parts (figure 1):

The main burning subassembly / system components are:

- furnace, parallelepipedic shape with truncated pyramid base
- air distributor, air nozzles for injection of fluidization/main burning air
- air feeding system – air blower, adapting pieces
- fuel bunkers, starting/post combustion burner working with natural gas
- furnace connection – heat transfer system (convective case)
- measuring equipment (temperatures, pressures) and observation holes

The heat transfer subassembly / system components are:

- convective case, parallelepipedic-shaped
- convective case connection with furnace and dust collecting system
- heat transfer – serpentine cooler and water pump
- measuring equipment

The flue gases dedusting subassembly / system components are:

- cyclone dust separator, cylindrical body in vertical position
- convective case connection, tangential upside encased cyclone
- powder measuring socket, thermocouple and siphon gauge-cyclone inlet
- socket/appliance for flue gas analysis and powder/dust sampling, thermocouple/ thermometer, manometer – cyclone outlet

The flue gases cleaning subassembly / system components are:

- scrubbing tower with Raschig rings, cylindrical body in vertical position with a cone-shaped base
- neutralization reactor with Raschig rings, cylindrical body in vertical position with a cone-shaped base
- demister, parallelepipedic-shaped with division wall, in vertical position
- reagents circulation pumps

The main characteristics of the functional facility are:

- Thermal energy:	0.21- 0.42 MJ
- Electrical power consumption:	2 - 4 kWh
- Flow of the water system:	2 - 4 m^3/h
- Flow of combustion/fluidization air:	200-300 m^3/h
- Flow of compressed air for flue gases cleaning pumps:	0.5 - 1 m^3N/h
- Flow of natural gas for the start:	2 - 5 m^3st/h
- Mass flow of coal:	25 - 50 kg/h
- Mass flow of biomass:	15 - 30 kg/h
- Flow of the washing liquid (p = 2 bar):	0.2 - 0.6 m^3/h

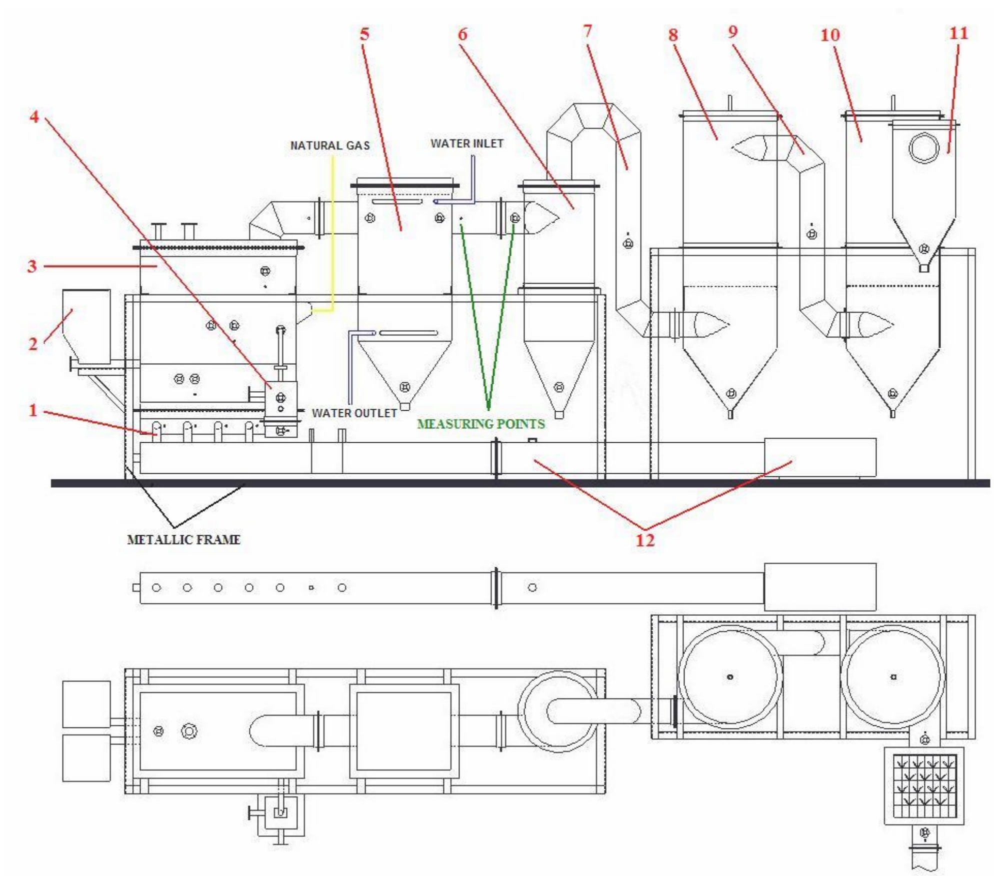

Fig. 1. Design of the co-combustion facility in fluidized bed
1.Air distributor 2.Fuel feeding system 3.Furnace 4.Ash cooler 5.Convective case 6.Cyclone dust separator 7.Cyclone-scrubber connection piping 8.Scrubbing tower 9.Scrubber-reactor connection piping 10.Neutralization reactor 11.Demister 12.Air feeding system.

3. Results & Conclusions

The temperatures and pressure losses have been recorded during tests with the help of a data acquisition system, on line, in several important points. The values of pollutants concentration is measured with dedicated gas analyzers, placed before and after the flue gas cleaning system.

The values of pollutants concentration were measured with two simultaneous working gas analyzers, placed before and after the flue gas cleaning system. Main results representing average values obtained during operation in a stabilized regime are given in the next figures (Fig 2, 3, 4, 5).

Temperature profiles demonstrate that the process is stable and achieves the presumed characteristics. Main results representing average values obtained during operation in a stabilized regime are given in the next figures (Fig. 2, 3, 4, 5).

The research activities were performed in two stages:

• first, ammonia was used for both NO_x and SO_2 concentration control (PT1);

• second, ammonia was used to lower SO_2 concentration and urea to lower NO_x concentration (PT2).

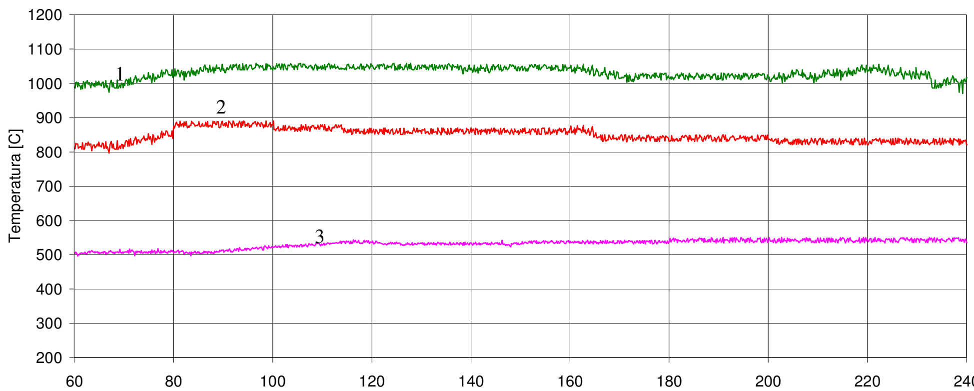

Fig. 2. Temperatures variation in furnace and convective case for approx. 3 hours of running with pit coal
1-furnace (middle), 2-convective case inlet, 3-convective case outlet

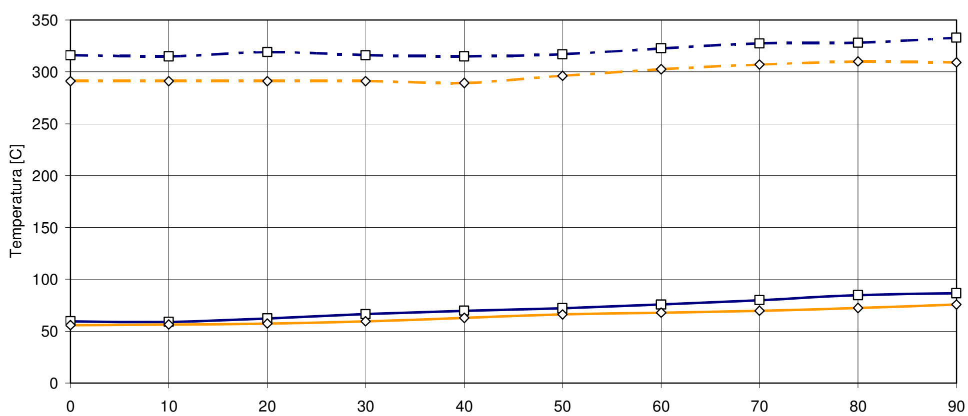

Fig. 3. Temperatures variation before and after the flue gas cleaning system (FGCS) for pit coal (PT1, PT2)
□ PT1, ◊ PT2, - - - - - before FGCS, ——— after FGCS

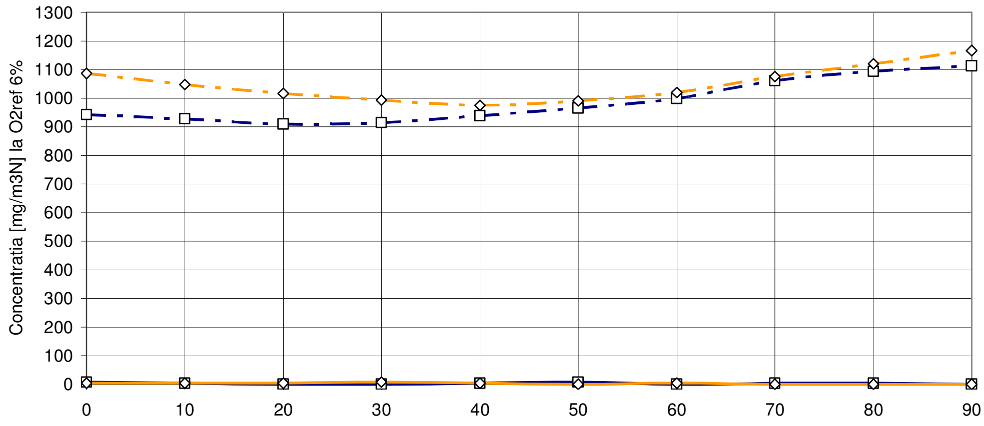

Fig. 4. SO_2 concentration for pit coal (PT1, PT2) by O_{2ref}
□ PT1, ◊ PT2, - - - - - before FGCS, ——— after FGCS

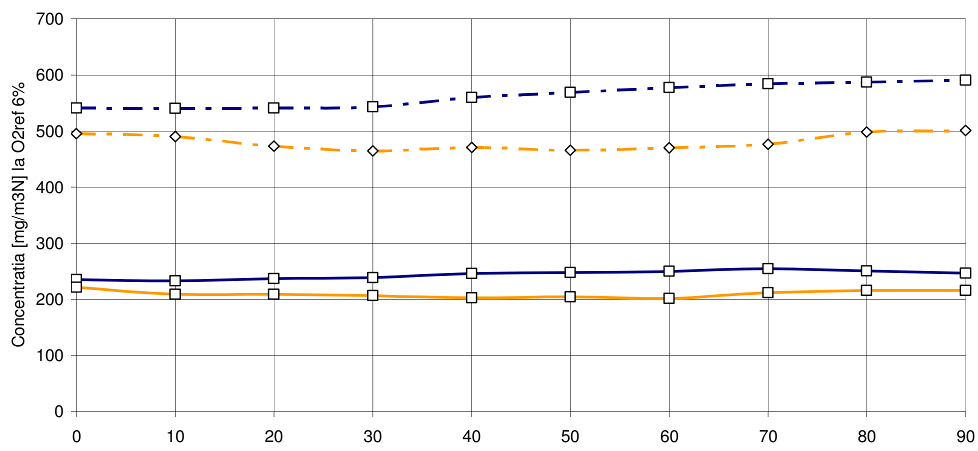

Fig. 5. NO_x concentration for pit coal (PT1, PT2) by O_{2ref}
□ PT1, ◊ PT2, - - - - - before FGCS, ——— after FGCS

In order to reduce the pollutant concentrations in the flue gases, especially NO_x and SO_2, in correspondence, different reagent proportioning were tested. Best results were obtained by using NH_3: ammonia water with 16 % NH_3, in amount of 1 l/h ~representing 1.6 g NH_3/ m^3N gas.

Also using urea one achieved good results. Urea particles were mixed with the used fuel and fed directly in the combustion chamber, in amounts such as 150g urea for 10 kg pit coal representing 1.5 %.

In all cases, one used the benefit of the lower temperature profile of the combustion in fluidized bed. Globally the achieved denitrification efficiency is over 55 % (see figure 6).

Simultaneously one proved also the desulphurization efficiency of over 99 % and the particle removal efficiency of approx. 99.7 %.

All final values (concentrations achieved) are satisfactory for respecting the restrictive environmental laws.

One proved that combined methods for nitrous oxides control from flue gases using combined procedures with SNCR techniques are effective and the authors expresses their opinion that these technologies have the best implementing chances in the Romanian industrial boilers, both as retrofit procedure or as new equipments design conception.

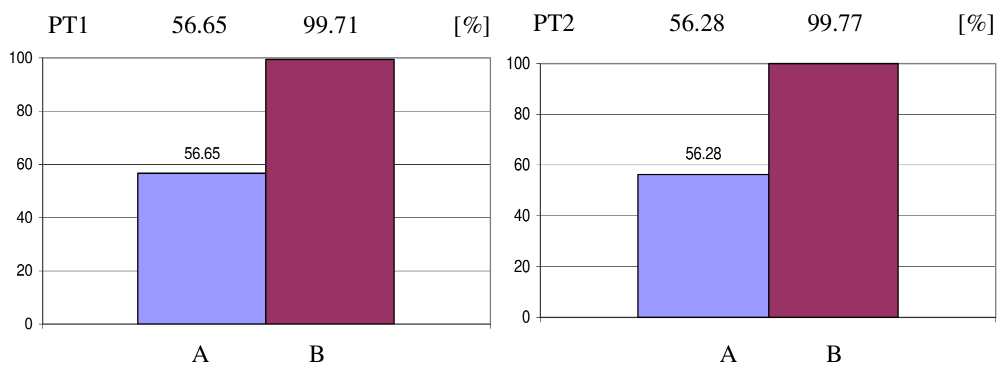

Fig. 6. NO_x and SO_2 retention factor for pit coal (PT1, PT2)
A – NO_x, B – SO_2

Acknowledgement

This work has been carried out with foundings awarded by the Romanian Government in the frame of excellency research projects (TECEBAC, OVAPED).

Also founding through the CORINT research support has been granted. FP6 research project GREENERNGY founding was also support of the research.

For the general co-ordination and scientific advice the coordinator and partners of all mentioned projects are warmly acknowledged.

The anonymous referrers of the paper and the conference organizers are warmly acknowledged.

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