

Reducing NOx emissions thanks to revamping

Discussion with **Frédéric Bury**, of **PILLARD (EGCI)**

Complying existing boilers to the decree taken on July 30th, 2003 (European Directive 2001/80/CE) often implies removing and replacing their oil or dual-fuel burners by new higher performance models. In many cases, nitrogen oxide emissions can be reduced by over half, without a loss in efficiency.



► View of the BRAILA Thermal Power Station (south-east of Romania).

In 1999, “Conel” - who have since become “Termoelectrica”⁽¹⁾ - obtained the necessary financial help from the EC to revamp⁽²⁾ the two boilers of Braila Thermal Power Station (south-east Romania). The main target was to make them comply with the requirements of European Directive 2001/80/CE. The first step was taken by the decree of June 20th, 2002 (which transposes the Directive according to the French legislation) imposing that new boilers of over 20 MW meet emissions limits⁽³⁾. The last step has been made by the decree of July 30th, 2003 which extends the application to existing boilers. The limit date for compliance is set at 1st January 2008.

The two boilers at Braila Power Station were re-started in June 2003. The official measurement campaigns which followed show that their NOx and dust emissions levels are now

much lower than the EC standards (in spite of the use of hot combustion air at 240°C).

► EIGHT 36 MW BURNERS PER BOILER

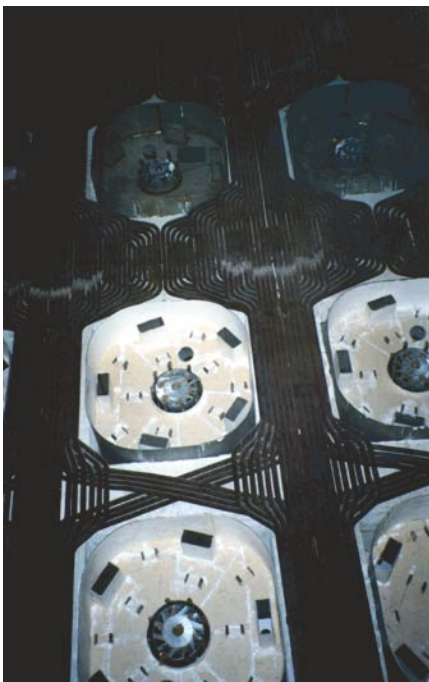
The “turn-key” revamping contract was awarded to Alstom Power France, who sub-contracted burner replacement to Pillard*. Each of the two existing boilers was fitted with eight 36 MW burners located in opposed front firing positions (four per side, on two levels). The old burners were opposed but aligned along the same axis, which caused interpenetration of the opposed flames, and therefore temperature peaks generating a high level of NOx emission. This is why the axis of the new burners was separated by a sufficient distance. Moreover, each (new) burner flame is split into five elementary and independent flames allowing to further reduce the peak flame



► View of the Bucharest-South Thermal Power Station.

temperature, and to increase the internal flue gas recirculation into each elementary flame segment, thus reducing the local O_2 content.

The burners are equipped with combustion air staging which allows to reduce the available O_2 concentration at the root of each flame, which not only has a good effect on NOx emission but at the same time allows to master the external envelope diameter of each



► Partial view of the burners from inside the furnace Bucharest-South Thermal Power Station.

burner flame. Finally, the lower level burners are adjusted to stoichiometric condition⁽⁴⁾ the excess air being added thanks to the upper level (creating a reburning⁽⁵⁾ effect). Aiming in priority to reduce NOx emissions when firing heavy-oil, the use of the air staging technique allows also to reduce NOx emissions when firing gas alone or in dual-fuel mode (gas + heavy oil together). It's to be noticed that the reburning effect is reserved for the most difficult situations (for example high combustion air temperature) and is to be considered only as a complement to the Pillard low-NOx burner technology.

Since the quality of heavy-oil available in Romania varies, the guaranteed emissions (see table 1) have been given for a maximum nitrogen content in the oil equal to 0.4 %. Such a limit does not exist for gas since the only nitrogen transformed into NOx is that of combustion air, and the essential factor of influence is flame temperature. The gas burner has been designed to operate at a very low pressure of 240 mbar. The specified turn-down ratio of 1 to 10 obliged the use of a double gas injection system, one close to the burner axis for firing at low firing loads, the other external for high loads.

When considering the importance of the project, such a revamping cannot be subject to mistakes. This is why design calculations and sizing were verified in true scale at the Pillard Research Center in Marseille (F) on a 36 MW pre-series burner (diameter = 3 meters,

weight = 3 tons). Several tests at partial load (15 MW) were carried out in order to be sure of burner operational reliability. Alstom Power (France) co-operated to validate the results. Then the manufacture of the 15 other burners was completed. The sitework to fit each boiler with the new burners was carried out by Alstom. Pillard engineers assisted Alstom for the commissioning of the revamped boilers.

► A THERMAL POWER STATION IN BUCHAREST (SOUTH)

For the Braila revamping, Pillard based their design upon the expertise acquired on similar previous boiler revampings, particularly the one of Bucharest (Ro), and also on the Dalkia/SETE boiler revamping of Strasbourg (F), and the Cogema boiler revamping in La Hague (F). As a matter of fact, in 1998, Renel (Ro) had signed with the BEI (European Investment Bank) an agreement for the revamping of two boilers in the Bucharest-South Thermal Power Station. Such financing help had been awarded under the condition that the EC Directive concerning NOx emissions was to be strictly respected.

Such a project was, here again, awarded to Alstom Power (F) who subcontracted burner replacement to Pillard. Each of the two existing boilers was fitted with 18 burners of 16 MW each, front firing comprising three levels of 6 burners. The sitework included : modification of the boiler front tubes, of the combustion air distribution and of all the heavy-oil preparation system, supply of a new digital control system. Such works were completed in November 2000. Boiler n°3 was re-started, commissioned and fully operational in May 2001, and n°4 at end 2002. The new burners were immediately operational.

The official measurement campaign for emission control was carried out in April and May 2003 (see Table 2). The NOx



► View of a flame. One of the boilers of the Braila Thermal Power Station.



► Split flames principle (Pillard patent)

emissions varied from 355 to 402 mg/Nm³ at 3 % O₂ when firing heavy-oil, from 189 to 244 mg/Nm³ at 3 % O₂ when firing natural gas, and from 196 to 379 mg/Nm³ when firing in dual fuel mode, heavy-oil and gas together. Such values are much lower than the limits required by the new EC standards in spite of the use of very hot combustion air at 280°C.

► 60 % NOX REDUCTION AT STRASBOURG (F)

Before revamping by PILLARD, boiler n°4 of the "Esplanade heating plant" run by Dalkia/SETE in Strasbourg (F) had excessive emissions levels : when firing heavy-oil, they reached 1060 mg/Nm³ of NOx, 50 mg/Nm³ of CO, less than 100 mg/Nm³ dust.

Such a boiler produces 45 MW of superheated water and is dual fuel fired (heavy-oil/natural gas). The particular difficulty came from the existence of an internal refractory lining producing a flame temperature increase in the furnace, and also the reduced volume of the furnace which led to a high thermal load (in kW/m³) which did not allow an increase in flame length or diameter.

The technical target was to reduce NOx emissions by 60 % when firing heavy-oil, thus maintaining emission values below 450 mg/Nm³ at any load without increasing dust emission (< 100 mg/Nm³) and without reducing boiler efficiency (about 90 % before revamping).

Further to revamping, NOx emissions were reduced to 419 mg/Nm³ when firing heavy-oil. When firing natural gas, the measured NOx emission (< 100 mg/Nm³ at 100 % load) was lower than current emission limits as well as future ones. To date, the revamped



BOILER 1A, BRAILA THERMAL POWER STATION EMISSIONS MEASUREMENT

% load	50 %	70 %	100 %
Heavy-oil firing			
NOx maximum (mg/Nm ³)	388 (480)	409 (480)	383 (400)
CO maximum (mg/Nm ³)	0 (170)	0 (170)	0 (170)
Natural gas firing			
NOx maximum (mg/Nm ³)	160 (320)	168 (320)	232 (320)
CO maximum (mg/Nm ³)	0 (100)	0 (100)	0 (100)
Dual fuel firing			
NOx : 30 % gas + 70 % heavy-oil	371 (480)		338 (480)
NOx : 50 % gas + 50 % heavy-oil			
NOx : 70 % gas + 30 % heavy-oil	291 (375)		148 (375)
CO maximum (mg/Nm ³) (For any mixing gas + heavy-oil)	0 (170)		0 (170)

In each column, the (value) corresponds to the guaranteed one. All emission values are at 3 % O₂ dry basis.

boiler has been operating continuously in self-checking mode (without human presence) for three years, without any problem.

► THE PARIS AREA

Based on the same burner technology, two new, dual fuel type burners (natural gas/heavy oil), 13 MW each, will fit one of the boilers for the Aventis Pharma heating plant in Romainville (F). The boiler is run by Elyo France.

► EASTWARDS

Pillard also completed the revamping for Dalkia / Tallina Küte (Estonia) of a 120 MW boiler (type KVGGM), natural gas fired, in the Central Heating Plant of Kadaka in Tallin (Estonia). Further to the success of this revamping (NOx was reduced to less than 80 mg/Nm³), Pillard was awarded the order concerning the second boiler. Several revamping projects exist in former Eastern

Europe countries, notably in the Steel Industry or in Thermal Power Stations. Pillard Germany (subsidiary of Pillard France, Taunusstein (G)), was awarded the revamping of several boilers for the EMA Power Company (Hungary). Each boiler is fitted with 8 low NOx burners. It has to be pointed out that their integration into the EC gives boiler users only 4 years to make their heating plants comply with the new EC regulations concerning emissions. ◀

Interview made by Franck Gauthier

* www.pillard.com

⁽¹⁾ Termoelectrica is the equivalent of EDF in France

⁽²⁾ Revamping : complete renovation

⁽³⁾ NOx < 450 mg/Nm³ for heavy oil, NOx < 120 for natural gas, CO < 100 mg/Nm³, dust < 50 mg/Nm³ all values at 3 % O₂ dry basis.

⁽⁴⁾ Stoichiometric combustion corresponds to a perfectly homogeneous mix between fuel and combustive, leading to a complete oxidation of carbon and hydrogen and the use of all the oxygen available in the combustion air. In such a case, the volume of the flue gas is minimum.

⁽⁵⁾ Reburning : "Recombustion" : a lack of oxygen due to sub-stoichiometric conditions may lead to a reduction of the NOx already formed, the lack of combustive being compensated for at a second stage, thus explaining the word.



BOILERS OF THE BUCHAREST-SOUTH THERMAL POWER STATION EMISSIONS MEASUREMENT

% load	50 %	70 %	100 %
Combustion fioul			
NOx maximum (mg/Nm ³)	391/355 (450)	412/397 (450)	400/402 (410)
Natural gas firing			
NOx maximum (mg/Nm ³)	189/200 (320)	184/240 (320)	244/204 (320)
Dual fuel firing			
NOx : 30 % gas + 70 % heavy-oil	314/375 (450)	220/379 (450)	339/355 (450)
NOx : 50 % gas + 50 % heavy-oil	336/307 (450)	376/350 (450)	331/310 (450)
NOx : 70 % gas + 30 % heavy-oil	325/198 (350)	196/267 (350)	279/312 (350)

In each column, the first value corresponds to the measurement on the boiler n°3, the second to the boiler n°4. The (value) corresponds to the guaranteed one.