Monitoring the Particulate Matter (PM10) Emissions from Bacau City Thermo-Energetic Industry

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Air pollution is one of the major environmental problems with short, medium and long-term effects. Substances emitted into the atmosphere (CO2, SO2, NOx, PM10) contribute to the amplification of the effects of climate change, acidification, air quality deterioration. The most important sources of PM10 emissions come from commercial, institutional and household sectors, industrial processes, road transport and agriculture. In order to protect the atmosphere and improve air quality, are needed measures of control at pollutant emissions. Early pollution reduction actions have led to a significant decrease of PM10 emissions especially from the production and distribution of energy, combustion processes and road transport has significantly diminished. Improving air quality requires continuous monitoring of emissions and, in particular emissions of particulate matter/ PM10. The paper presents the results of the monitoring activity of particulate matter/ PM10 from the thermo-energetic industry. The results of the monitoring include the particulate matter/ PM10 values in the range (68.083 mg/Nm3 - 93.166 mg/Nm3), values that do not exceed the emission limit values.

Keywords: emissions, particulate matter/PM10, fuel, monitoring, emission limit value

Air pollution leads to a series of consequences on environment (such as the greenhouse effect, acid rain or changing the ozone layer, odors, reduced visibility and/or product quality decrease) and health (pulmonary diseases, asthma and breathing problems) [1-7]. Industry has been frequently blamed given the origin of the particulate matter PM10 and along with it, transportation, incineration processes and combustion processes [8-9]. The particulate matter PM10 is reckoned by some organizations as being the primary pollutant source, having a high potential of risk on human health. Industrial evolution along with rapid economy has led to the rise of energy consumption and the quantity of air pollutant emissions which affect the air quality in large cities, as in the case of developing countries [10-17].

In a study viewing the emissions of particulate matter (PM10) done by the European Agency of Environment in 2014, it was emphasised that, between 1990 and 2011, the emissions of PM10 have reduced with 24 %. The most significant decrease has been registered in Cyprus (61%), Slovakia (59%) and Great Britain (59%). In contrast, the emissions of PM10 have been rising in 8 countries since 1990; the most spectacular increase being registered in the following countries: Finland (154%), Island (107%) and Latvia (63%). Similarly, the increase of emissions in Romania is due mainly to the emissions recorded from residential combustion sources which have increased by 15% on average since 1990, so that the emissions reported for the year 2011 were 18 times higher than for the year 1990. According to the study, the most important sources of PM10 emissions in 2011 have been registered in the commercial, institutional and household sectors (35%), industrial processes (29%), road transport (11%) and agriculture (8%). Between 1990 and 2011, the PM10 emissions have decreased with 6% and respectively 1.9% [15-17].

In the European Union, the air quality is regulated by the 2008/50/CE Directive viewing the air quality which employs the member states to monitor and report emissions of pollutants [11]. Moreover, the Directive also covers the limit emission concentration for the main pollutants in the atmosphere: SO2, NO2, NOx, PM10, PM2.5, Pb, C6H6, CO and O3. The world production of electricity is dominated by the use of coal (41.5%) and forecasts indicate that this share will not change mainly as a consequence of the increase of population and economy in developing countries like China and India. The use of this technology is connected with the natural resources depletion, global environment impact and local pollution, with implications on human health and ecosystems. Compared to other electricity producing systems, the technology that bases on the use of coal has a weaker performance and it is associated with significant emissions of O2, SO2, NOX and particulate matter PM10. Given these conditions, the question of developing special equipment to improve its operation and become competitive on the energy market [13, 17,18].

This paper presents the results of the particulate matter PM10 emissions monitoring from the Bacau Electro-thermal plant.

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REV.CHIM.(Bucharest) • 70 • No. 8 • 2019 http://www.revistadechimie.ro 2869
Experimental part

The central heating and power plant of type 1 has the mission of providing public service with heating supply for the inhabitants in Bacau according to the required quality parameters, with a nominal horse power/rated output of 419 MWt, with two large combustion plants, including auxiliary installations [12, 19, 20]:

- IMA 1 with a thermal power/heat output of 343 MW, formed of the thermal energy reservoir/boiler of type CRG 1870 that produces steam output of 420 t/h. The steam produced by the reservoir is used to produce cogeneration of electricity and heat by the expansion of its DSL turbine 50. The main fuel used is lignite with natural gas or black oil added. The energy application to the thermal duty of the reservoir given by natural gas or black oil may vary between 10% (the minimum required to ensure the stability of the combustion process in the furnace) and 100% depending on the availability of the solid fuel supply system.

- IMA 2 with a thermal power of 76.5 MW, is formed of the industrial steam boiler (ISB) of BABCOCK type that can produce a steam output of 100 t/h. The boiler uses natural gas or black oil as fuel. The steam produced is supplied to industrial heat-consumers or used to heat the water circulated through district heating networks. The industrial steam boiler of 100 t/h capacity constitutes a backup for the safety of thermal energy supply in Bacau and is used only in the following situations: during the cold season when the boiler of 420 t/h is unavailable; during the summer when the hot water boiler (HWB) of 100 Gcal/h is unavailable.

The waste gases from the two combustion plants (which operate alternately) are discharged through the chimney of 220 meters height. The chimney has the role to ensure the dispersion of the gas into the atmosphere and is sized so as not to achieve the admissible concentration limit values for the pollutants emitted into the atmosphere. The gases that result from the combustion processes of coal (lignite) in the thermal energy reservoir of 420 t/h contain a large amount of ash (70g/Nm³), for which, the electric plant has been designed with a retaining system of solid powders in suspension within the fume discharged through the creel/chimney [12, 19]. Bacau Electro-thermal plant has a compliance period as stipulated by the GD 440/2010 concerning the emission limit allowed for dust (Table 1) as required by the Council Directive no. 2001/80/CE on the limitation of certain pollutants emission into the air from large combustion plants, as in the Commitment resulted from the negotiation process in Chaprer 22 - Environment (MA, 2006) [12, 19]. Until compliance, the combustion plant is allowed to function provided the annual limit emissions negotiated are respected (MA, 2006).

The monitoring of the particulate matter emissions for both types of combustion plants is made 3 times a week. The values resulting from the measurements are compared with the emission limit values imposed by the environmental authorization, respectively with the standards imposed by the GD 440/2010. The present paper analyses the measurements carried out during November 2010 and March 2011, a period in which the boiler had a normal functioning. The main scope of the measurements has been to determine the dust emissions values [12, 19].

The eudiometer DELTA 2000CD IV has been used as a measuring machine. Figures 1 and 2 emphasize the way the measurement points were located in order to determine the dust emission values for the CRG 1870 type of boiler [12, 19].

According to the requirements imposed by the environmental authorization GD 440/2010, the large combustion plants from Bacau Electro-thermal plant have to respect the following emission limit values for different types of fuel (Table 2) [14].

### Table 1

| The name of the large combustion plant | The name of the boiler | Thermal power, MWt | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 |
|--------------------------------------|-----------------------|-------------------|------|------|------|------|------|------|------|
| Bacau Electro-thermal plant no 1 (IMA 1) | Thermal energy reservoir type CRG 1870 (of 420 t/h) | 342 | 262 | 262 | 156 | 156 | 156 | 156 |
| Bacau Electro-thermal plant no 2 (IMA 2) | BabcockSteam boiler of 100 t/h | 76.5 | 1 | 1 | 1 | 1 | 1 | 1 | - |

Fig. 1. The scheme emphasizing the location of the measurement points to determine the dust emission values emitted by CRG 1870 boiler [19]
As IMA 1 functions with mixed fuel, the emission limit values will be calculated taking into consideration the following relation [19]:

\[ V_{LE} = \frac{\sum Q_i \cdot P_{cii}}{\sum Q_i \cdot P_{cii}} \]  

where: \( V_{LE} \) represents the emission limit value for a certain pollutant in the case of mixed furnaces/fire-boxes; \( V_{LEi} \) - emission limit value for a certain pollutant in case of using the fuel \( i \); \( Q_i \) - fuel discharge for \( i \); \( P_{cii} \) - net heating power of the \( i \) fuel.

**Results and discussions**

As one can see in the curve represented in figure 3, the measured values for particulate matters PM10 vary between 68.083 mg/Nm\(^3\) and 77.104 mg/Nm\(^3\), the maximum of the value being registered on the November 30, 2011. The measured values situate within the emission limit values stipulated by the GD 440/2010 which varies between 79 mg/Nm\(^3\) and 89 mg/Nm\(^3\), these values are in accordance with the amount of fuel used.

Particulate matter emissions varied between 70.88 mg/Nm\(^3\) ÷ 75.81 mg/Nm\(^3\) in December 2010, the maximum value recorded on the 10th of December 2010. These emissions are corroborated with a large amount of coal having a net heating power value. The emission limit values situate within the emission limit values calculated in accordance with the GD 440/2010, which varies between 74 mg/Nm\(^3\) ÷ 86 mg/Nm\(^3\) (fig. 4).

The measurements made in January 2011 highlight the fact that the measured values for the emissions of particulate matter varies within the range (71mg/Nm\(^3\) ÷ 93.166 mg/Nm\(^3\)). The maximum of the value recorded on the 28th of January 2011, (93.166 mg/Nm\(^3\)), exceeds the maximum value calculated for the emissions of particulate matter PM10, according to GD 440 /2010, respectively 85 ÷ 93 mg/Nm\(^3\). The level of the emissions is influenced by the net heating value of the large amount of coal used (fig. 5).

**Table 2**

| Pollutant | Emission limit values (mg/Nm\(^3\)) – GD 440/2010 |
|-----------|-----------------------------------------------|
|           | Fire box supplied with solid fuel (6% O\(_2\)) | Fire box supplied with liquid fuel* (3% O\(_2\)) | Fire box supplied with fuel gas (3% O\(_2\)) |
| **IMA 1 - 243 MW** |                                           |                                            |                                            |
| Dust      | 100                                         | 50 (100*)                                 | 5                                           |
| **IMA 2 – 76.5 MW** |                                           |                                            |                                            |
| Dust      | -                                           | 50 (100*)                                 | 5                                           |

* - the limit value of 100 mg/Nm\(^3\) is applied when the black oil has a content of ash higher than 0.05%.

Note: Examining the agreement, the formula used for the operation with the fire-box burning point will be formula (1).
Some measurements taken/done in February 2011, show an exceeded emission limit value for PM10 (76.4 Nm3 ÷ 89.58 mg/Nm3), especially on the 1st of February 2011 (87.49 mg/Nm3) and on the 18th of February 2011 (84.79 mg/Nm3) due to the use of a fuel of net heating power value (fig. 6). In March 2011 (Fig. 7), the values of the particulate matter emissions PM10 (71.63 mg/Nm3 ÷ 84.48 mg/Nm3), recorded an excess of the emission limit values calculated in accordance with the GD 440 (2010), (68 mg/Nm3 ÷ 79 mg/Nm3), the maximum value recorded on the 1st of March 2011 (84.48 mg/Nm3).

For the monitoring of the period between January 2011 and March 2011 the PM10 emissions record within the limit values imposed by the Romanian regulations, except for the values that recorded on the 28th of January 2011, (93.166 mg/Nm3), 1st February 2011 (87.49 mg/Nm3), 18th February 2011 (84.79 mg/Nm3) and 1st March 2011 (84.48 mg/Nm3) as a result of the use of lower calorific coal (figs. 5, 6 and 7).

Conclusions

The measurements of the particulate matter PM10 emissions discharged by Bacau electrothermal plant, from IMA1 highlight an excess of the maximum emission value calculated in accordance with GD 440/2010.

The data obtained points out that:
- The measured PM10 emission values were found within the limit values stipulated by the Romanian regulations (figures 3 and 4), for the entire period of monitoring (November 2010 - December 2010); - Bacau electrothermal plant received a transition period for compliance with the environmental requirements with reference to PM10 emissions, its functioning is allowed provided the plant respects the annually negotiated emission limits. Complying with the emission limit values and with the applicable regulatory requirements means taking actions that register within the category of the best available techniques (BAT):
  - The continuous monitoring of the particulate matter and applying the necessary measures to reduce particulate matter emission;
  - dust removal by using electrostatic filters or textile filters, in combination with the desulphurisation equipment depending on the thermal power of the combustion plants;
  - The setting of the gas turbine of 13.9 MWt.

Acknowledgements. The work has been funded by the contract research no. 6/2010 "Research on monitoring the exhaust emissions (CO, CO2, NO, SO2, PM10) from thee combustion plants on the platform of Bacau electrothermal plant, using the measuring device DELTA 2000 with the purpose of acquiring data on continuous flow from IMA I.

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Manuscript received: 19.12.2018