GAS EMISSION FROM THERMAL POWER PLANTS IN MACEDONA

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Abstract: *Operation of coal thermal power plants (TPP) has the most destructive influence for environment mainly from GHG emission and other pollution for water and soil. Coal combustion is the process which influence with emission of carbon monoxide (CO), carbon dioxide (CO_2), nitrogen oxides (NO_x), sulphur dioxide (SO_2), as well as PM and ash. The dominant power plant in Macedonia is lignite fired TPP Bitola with 3 units, each of 225MW installed power, or total 675 MW, and TPP Oslomej with one unit of 120 MW. The lignite consumption in Bitola is 300 t/h for one unit and 200 t/h for the unit in Oslomej. The other TPP is Negotino which is oil fired with installed power of 210 MW. Also the new gas power plants start to operate this year. The total production from thermal power units in Macedonia is near 5000 GWh in a year which covers almost 70% of the electricity demand in Macedonia. The paper presents the emission of the gases through chimney from TPPs in Macedonia mainly the concentration near the plants. The measured values will be comparing with the theoretical calculations made based on chemical content of the fuel as well based on technology for electricity production.*

Keywords: FOSSIL FUEL, THERMAL POWER PLANTS, TPP, OPERATION, COMBUSTION, GAS EMISSION, ECOLOGY, ENVIRONMENT

1. Introduction

The fossil fuels, which basic constituents are carbon and hydrogen, with oxidization release heat. Despite basic elements the fossil fuels consisted of others burning components like sulphur, moisture and unburned components (ash). In the process of fossil fuels combustion, that takes place in the steam boilers or furnaces of gas power plants, gases are being released between which the most dominants are CO_2 and H_2O, and then deepening on content of sulphur in the fuel and the combustion temperature, SO_2 and nitrogen oxides (NO_x).

Solid fossil fuels are mainly consisted of carbon and mixture of sulphur, moisture and mineral ingredients. While the liquid and gaseous fuels are mixture of hydrocarbons. Among gaseous fuels the most important is natural gas that mainly consists of over 90% (vol) methane, about 7%(vol) ethane, and the residue is propane and butane. The hydrocarbons usually are noted as C_mH_n where *m* stands for the number of carbon atoms and $n = 2m + 2$ is the number of hydrogen atoms in the molecules.

The products of fossil fuels combustion, after partly filtering, are emitted into the atmosphere. The analysis's objective of environmental impacts of Thermal Power Plants operation is to determine the amount and type of combustion emitted products into the atmosphere, because it is a base for further ecological studies and conclusions. As a consequence of growing environmental concern, the impact of conventional power plants on the environment is being considered and efforts are being made to limit this impact.

The pollutant emissions mainly depend on combustion and few categories as the following ones:

- Chemical fuel content and other parameters for its quality
- Boiler design
- Technology for fuel combustion
- Efficiency of the ecological systems for clean energy

As the fuel combustion process in the boiler, the base flue gasses pollutants which come out of chimney are: sulphured oxides, nitrogen oxides, carbon monoxide and carbon dioxide. The solid particles are the ash and the dust or PM. The quantities depend on content of each element in the coal. From the total quantities of sulphur oxides about 98% are emitted as SO_2, and the rest part of 0,5 - 2% is SO_3. The nitrogen oxides are comes mainly from the exceeded air in the boiler and around 90 – 95% is emitted as NO and the rest as NO_2. Carbon monoxide comes as the result of incompletely coal combustion which depends on:

- Short time of the coal in boiler
- Insufficient mixed of coal and air
- Not adequate relation of coal and air
- Low heat temperature

The ash and PM products are also the results of incompletely coal combustion, and the quantities depend on coal quality and the efficiency of the filter.

The pollutants which come out from TPP Bitola and TPP Oslomej are controlled in continuation measurements of SO_2, NO_2 and PM. Observation of emissions in the atmosphere are made in order to have the record from thermal power plants and to calibrate of the instruments for following the emissions.

The paper presents the results from investigations according emission records from three years period (2005/2008), with main goal of estimation the environmental impact from thermal power plant operation. The analyses of the emission from thermal power plants are done according the methodology from the regulation and standard VDI 2066 from the Ministry of environment in Germany.

Following the pollutant emission in the atmosphere is complex process and the methodological procedure is in few steps:

- Testing
- Laboratory investigation
- Interpretation of the results and analyses

In order to have the good record for concentration of solid meters and flue gasses as the results of technological process in electricity generation from thermal power plants, some measurements should be done in the exit canals of the ash filters. The measurements are for following parameters:

- Dynamical (P_{din}) and static pressure (P_{st})
- Volume flow of the gasses (Q_{sr}) [m^3_n/h]
- Average speed of the gasses (v_{sr}) [m/s]
- PM concentration [mg/m^3_n]
- Concentration of pollutant gasses [mg/m^3_n]

The speed of the flue gases in the exit canal can be expressed as:

$$v_{sr} = \frac{1}{n}\sqrt{\frac{2}{\gamma_g}} \cdot \sum_{n=1}^{n} P_{din}[m/s]$$

$$\gamma_g = \gamma_0 \cdot x \cdot \frac{T_0}{P_0} \cdot x \cdot \frac{(P_{atm} \pm P_{st})}{(T_0 \pm t)}[kg/m^3]$$

where:

n - Number of the measurement spots

$T_0 = 273,15$ [K] - Absolute temperature in normal condition

$P_0 = 101,325$ [kPa] - Absolute pressure in normal condition

$\gamma_0 = 1,2829$ [kg/m^3] - Gas density in normal condition

T [^{0}C] - Gas temperature in the canal

P_{at} [Pa] - Atmospheric pressure for measurements

P_{st}[Pa] - Static pressure for the gas in the canal

P_{din} - Dynamic pressure for the gas in the canal

γ_t [kg/m^3] - Gas density in the canal

According the database for the speed, the average volume flow of the gas in the canal is:

$$Q = 3600 \cdot A \cdot v_{sr}$$

where: A [m^2] – is the area of the canal

The speed is measured on the some canals and spots on the area and the calculations are made taking into account the dimensions of the canal.

Measurements of the emission of the dust are taken with the gravity measurement instrument GRAVIMAT SICK – SHC, and for concentration of SO_2 and NO_x is used the instrument TESTO 33.

2.Results and comments

The results from the observation of the pollutants emission in the atmosphere from TPP Bitola are presented on Table 1, and the same results from TPP Oslomej are presented on Table 2.

The total pollutants emission in the atmosphere from lignite fired TPP Bitola and TPP Oslomej are given on Fig.1 and Fig.2. The basic data for TPP Bitola are the following:

- Power of the unit 225 [MW]
- Fuel consumption 300 [t/h]
- Chemical content of the fuel:
  - Unit I: Ash (A) 13,38%
    Moisture (W) 49,75%
    Sulphur (S_{sog}) 0,51%
    Caloric value 7,729 [kJ/kg]
  - Unit II Ash (A) 16,27%
    Moisture(W) 48,00%
    Sulphur (S_{sog}) 0,56%
    Caloric value 7,491 [kJ/kg]
  - Unit III Ash (A) 17,55%
    Moisture (W) 48,78%
    Sulphur (S_{sog}) 0,44%
    Caloric value 7,039 [kJ/kg]
- Basic analysis (average)

C – 24,17% S – 0,52%

H – 2,36% N + O – 12,17%

Table 1. *Pollutant emission in the atmosphere from TPP Bitola*

Measurement spot	Volume flow of the gas [m^3_n/h]	PM Particular meter		SO_2		NO_x		CO	
		mg/m^3_n	kg/h	mg/m^3_n	kg/h	mg/m^3_n	kg/h	mg/m^3_n	kg/h
Unit I	1.435.58	72,3	103,7	1.7	2.52	168	241	34,4	49,48
Unit II	1.374.40	66,9	91,9	1.6	2.212	151	207	47,4	65,20
UnitIII	1.091.00	39,4	42,9	2.3	2.52	261	284	29,2	31,89
Total	3.900.98	61,2	238,7	1.8	7.26	188	732	37,5	146,5

The basic data for TPP Oslomej for calculation of the pollutant emission are the following:

- I Technical analysis
  - Fuel consumption 200 [t/h]
  - Moisture 50 – 55 %
  - Ash 10 – 20 %
  - Volatile 19 – 26 %
  - Combustible 20 – 40 %

- Cocks 17 – 19 %
- C – fix 14 – 17 %
- S total 0,55 – 0,70 %
- S in elements 0,12 – 0,20 %
- S combustible 0,43 – 0,50 %

- II Basic Analysis
  - C 19,6 – 23,8 %
  - H_2 1,7 – 2,0 %
  - S_{com} 0,43 – 0,50 %
  - $O_2 + N_2$ 8,0 – 10,0 %

- III Caloric Value
  - Q_{gorna} 7,500 – 9,200 kJ/kg
  - Q_{dolna} 5,800 – 7,600 kJ/kg

Table 2. *Pollutant emission in the atmosphere from TPP Oslomej*

Measurement spot	Volume flow of the gas [m^3_n/h]	PM Particular meter		SO_2		NO_x		CO	
		mg/m^3_n	kg/h	mg/m^3_n	kg/h	mg/m^3_n	kg/h	mg/m^3_n	kg/h
Canal2	167.453	74,28	12,44	1.670	279,65	388	64,97	81	13,56
Canal3	145.222	73,96	10,74	1.620	235,26	381	55,33	51	7,41
Total	312.675	74,13	23,18	1,645	257,45	384	60,15	66	10,48

The results from Table 1 and Table2, as well as from Fig.1. and Fig.2, shows that the significant quantities of pollutants come from TPP Bitola, because the higher installed power capacity and lignite combustion. In the base, the pollutants emission depend on the technologies for coal combustion , clean technologies for reduction of emissions, quality of the coal, the coal consumption intensity and other factors.

Figure 1. *Graphical interpretation of total pollutant emission from TPP Bitola and TPP Oslomej in [mg/m_n]*

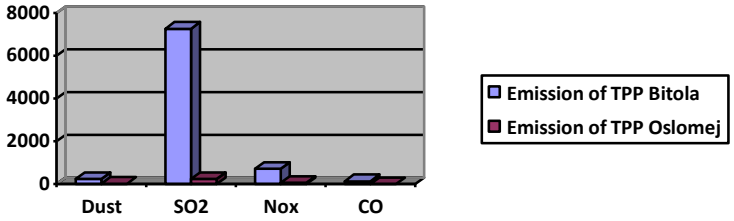
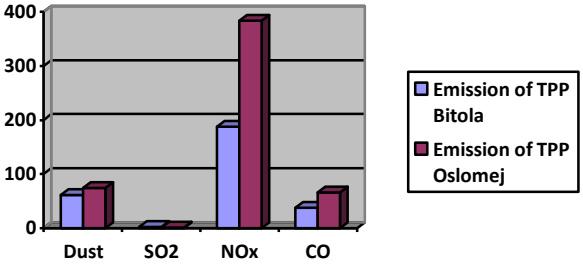


Figure 2. *Graphical interpretation of total pollutant emission from TPP Bitola and TPP Oslomej in [kg/h]*



Based on the measurements results of the pollutant emission in the atmosphere, some estimation and conclusion of the environmental impact of the thermal power plant capacities can be given.

3.Conclusion

Before identifying the priority field where actions are needed, very important thing is making evaluations of the current situation. The main conclusions from the measurements and analyses:

1. The measurements and analyses show that the lignite thermal power plants in Macedonia (TPP Bitola and TPP Oslomej) have emission of 4.213.662 [m^3_n/h] gases, 261,89 [kg/h] of PM, 7,517,45 [kg/h], and 792,15[kg/h] nitrogen oxides.

2. According the regulations for maximum concentration and quantities of pollutants emission in the atmosphere can be concluded that:

   - Emission of nitrogen oxides is in allowed quantity.
   - Sulphur emission is above the maximum limitation and depends on coal quality
   - PM emission is in the design values for filter and the concentration is 50 mg/m^3.
   - In order to reduce the pollutants emission in the atmosphere, the additional investments for clean technologies should be done in the TPP Bitola and TPP Oslomej.
   - Macedonia as the member candidate for EU should respect the regulations and declarations, as well as conventions in the field of environmental protection from thermal power plants, and the obligation will start after 2015.

Lately, as a result of the human activity, such as: industrialization, burning fossil fuels, enhancement of methane emissions etc, and greenhouse effect is becoming serious threat. As risks from global climate changes are more and more obvious, there is a need of taking actions for reducing greenhouse gas emission and minimizing climate changes bad influence.

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