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INFLUENCE OF FUEL CHARACTERISTICS ON ATMOSPHERE POLLUTION AT ROVINARI POWER PLANT

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Abstract: The combustion of Rovinari lignite generates large amounts of pollutants, such as ash, carbon dioxide, sulfur dioxide and nitrogen oxides. The emission of pollutants in the atmosphere depends on the composition of fuel, installation of fuel preparation, combustion installation, effectiveness of ash retaining system and effectiveness of burning system. The paper analyses how each of the above factors contribute to the atmosphere pollution.

1. Introduction.

Rovinari coal fired power plant uses as fuel lignite from Rovinari open pit and for stabilization of combustion natural gas is used.

The lignite from Oltenia open pit, being a low quality coal, produces a large amount of ash. Approximately 1% is carried by the flue gas stream and discharged on the chimney stack. Flue gas contains CO_2, SO_2, NO_x and ash particulate.

These emissions are responsible for environment pollution by mean of the following actions:

- impact on climate by greenhouse effect of CO_2;
- increase of soil acidity by generation of H_2SO_4 resulting from SO_2 and H_2O combination;
- generation of nitrogen acid from NO_x and water which influences the soil through acid rains;

- chemical pollution of water generated by leakage of chemical compounds in the surface water;
- local attenuation of solar irradiation generated by smoke and water vapor from cooling towers.

The scale of the pollution depends on the coal used, on combustion technology and on performance of cleaning technology. A stochastic factor is the operation personal which can influence by its actions the level of pollution.

Dust contributes to increasing of water opacity; by mean of rainfall the pollutants go into the water and change the pH, the conductivity and enriching it in sulfates, nitrates, chlorines and metals.

The composition of fuel plays an important role in atmosphere pollution. Not only sulfur contributes to the pollution but also other compounds generated during the combustion process.

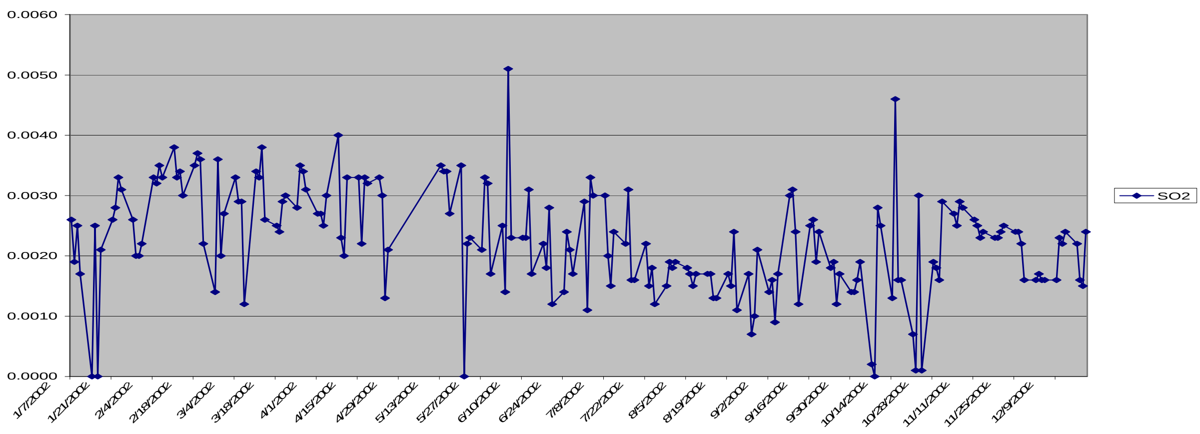
The level of pollution depends on the coal dust preparation utility, on the efficiency of ash retaining system and also on the efficiency of burning installation.

The present paper analyses how fuel influences the pollution of atmosphere.

2. The actual situation of pollution generated by Rovinari power plant

The 330 MW power units use approximately 350 tons of coal per hour. Lignite from Oltenia coal pit has a large amount of ash (40-50%). Most of the ash is collected in the furnace or in electrostatic precipitators which operate at an efficiency of 98-99%. Nevertheless, a large quota of ash generated during combustion is evacuated in the atmosphere. The sulfur content of the coal is less than 1% and it is to be reduced.

Figure 1 presents variation of SO_2 production in the period 2002-2003



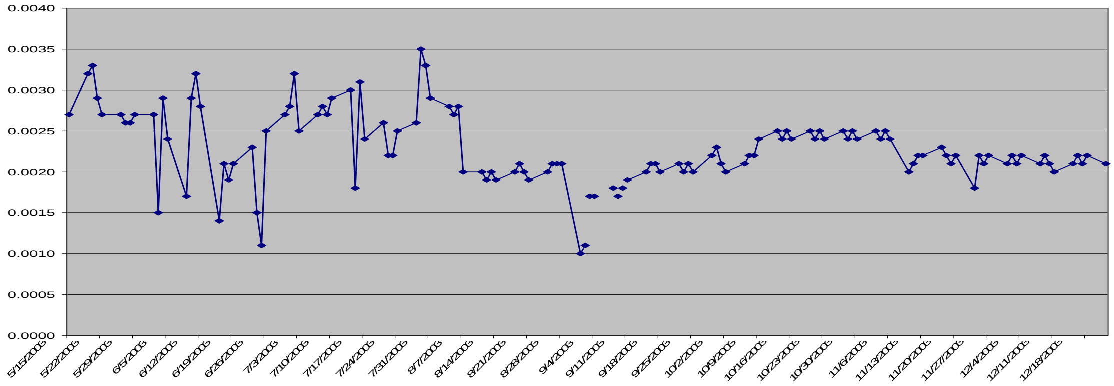


Fig. 1. Variation of SO_2 production over the period 2002-2003

It can be ascertained that in 2003 SO_2 production is smaller than in 2002 as a result of some cutting down measures. Nitrogen oxides emission doesn't differ in 2002 in comparison with 2001 due to the fact that no measures for cutting down have been taken.

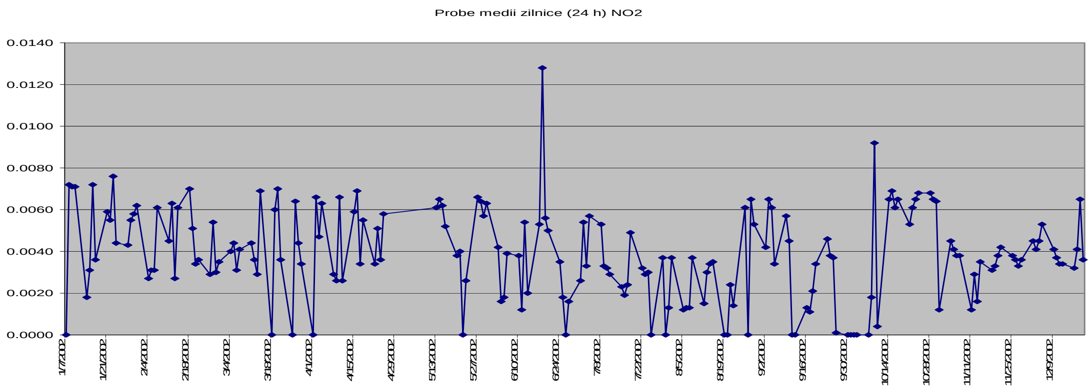


Fig. 2. NO_x emission over the period 2002

As the above graphs reveal, the daily variations are very large, although the same type of fuel was used. The large variation can be explained through defective operating of combustion installations or incorrect control of combustion process. At Rovinari power plant all emission values exceeded the maximum values; as a result, taking of emergency cutting down measures is compulsory.

3. Influence of fuel quality on pollution

Lignite used in the boilers from Rovinari power plant has the following characteristics:

- calorific value 1400-1800 kcal/kg

- carbon content 18,3-21,9%
- hydrogen content 1,7-2,0%
- combustible sulfur content 0,7-0,8%
- N_2+O_2 content 8,8-10,3%
- Volatile matter 18,6-21,4%
- Ash 24-25,5%
- Water 41-45%

Rovinari lignite has a rather high combustible sulfur content 0,7-0,8%. It contributes to the generation of sulfur compounds which remain in the furnace (calcium, magnesium and sodium sulfates) and the rest is carried by flue gas in the form of SO_2. A fraction of SO_2 turns into SO_3 given the appropriate temperature and oxygen concentration.

The combustible fraction of Rovinari lignite is in the range 48,1-56,4%. Out of this amount sulfur represents 1,4%.

The calorific value of solid fuel is given by the relation:

$$Q_i = 339C + 1030H + 109(S_c - O) - 25W_t \quad [kJ/kg]$$

One kilogram of sulfur generates through combustion an amount of heat of 103000 kJ (2600 kcal).

Elimination of sulfur from fuel leads to mitigation of heat amount given out of combustion. The result is a lower theoretical temperature in furnace. The theoretical temperature in furnace is given by the following relation:

$$Q_i + \left(1 - \frac{q_m}{100}\right) V_{a\,um}^{0} c_p^{um} \left(t_{p2} - t_0\right) = \left(1 - \frac{q_m}{100}\right)\left[I_g(t_t, t_f) - I_g(t_0, t_f)\right] +$$
$$+ \left(Q_m + Q_{ch} + Q_{rf} + a_f Q_{ex}\right)$$

in which the following symbols were used: q_m percent loss by unburned coal; $V_{a\,um}^{0}$ theoretical volume of humid air; c_p^{um} specific heat of humid air; t_{p2} air temperature at the air preheater outlet; t_0 reference temperature; $I_g\left(t_t, t_f\right)$ flue gas enthalpy at the furnace air excess and temperature; $I_g\left(t_0, t_f\right)$ flue gas enthalpy at the furnace air excess and reference temperature; Q_m mechanical loss; Q_{ch} chemical loss; Q_{rf} heat loss through solid waste evacuated form the furnace; Q_{ex} heat loss through the walls of the furnace; a_f fraction of the heat lost through the walls of the furnace.

The extraction of sulfur from fuel decreases the calorific value with 1-2%. The amount of heat given out in the furnace will decrease, resulting in a lower temperature in furnace. A lower temperature in furnace means a poorer burning and heat exchange processes.

From the perspective of combustion, the elimination of sulfur from coal is a loss but from the pollution perspective it is a gain.

The mitigation of pollution is much too important to give it up in favor of furnace temperature increase.

The carbon content in fuel represents an important component for increasing of calorific value since it has a high calorific value. By burning of carbon CO_2 is generated. The high content of CO_2 increases the radiative heat transfer due to tri-atomic gases, which results in smaller heat transfer surfaces.

4. The increase of power unit efficiency as a method of pollution mitigation

The amount of substances given off through the chimney stack is proportional with the amount of fuel burned in the furnace. The amount of fuel burned itself depends on the efficiency of boiler as the following relation states:

$$B = \frac{Q_u}{\eta Q_i}$$

with Q_u the amount of heat transferred to water and steam.

The decrease of fuel consumption is the most cost-effective method for mitigation of pollution. By reducing of fuel consumption the SO_2, CO_2, NO_x and dust emissions reported to the same amount of generated power decrease accordingly.

Taking into account that investment in cleaning technology is large, presently, the only way to reduce pollution is increasing the power generation efficiency.

In order to increase the boiler efficiency the following methods can be employed:

- decrease of flue gas temperature
- decrease of heat loss of the boiler
- increase of feed water temperature
- decrease of condensing pressure

The decrease of flue gas temperature is possible only by decrease of fuel sulfur content. Otherwise, the decrease of flue gas temperature leads to reaching the dew point temperature and which makes possible generation of sulfuric acid.

The decrease of heat loss of the boiler can be achieved by improving the combustion, by improving the insulation of the boiler and by minimizing the air excess to the required value.

The decrease of condensing pressure is the cheapest and the fastest method for increasing the efficiency. By increasing the boiler efficiency, the cause is dealt with and by cleaning utilities the effect is dealt with. In order to reduce the condensing pressure (advanced vacuum) the following methods can be employed:

- airtight condenser
- increase of vacuum pumps efficiency

Such methods were implemented at CET Craiova [1] where by decreasing of condensing temperature with 20 ^{0}C a decrease of fuel consumption of 20 grams of conventional fuel per kWh was achieved.

5. Conclusions

The 1035 t/h boilers from Rovinari power plant generate large amounts of pollutants. The decrease of sulfur content in fuel or its complete elimination has not been possible so far due to the high costs implied. The only way to decrease the pollutants is the increase of power unit efficiency. By increasing the efficiency of the power unit the cause of pollution is dealt with and by cleaning measures the effect is dealt with.

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