# Determination of Some Operational Characteristics of the Flue Gas Desulphurization Installation in TPS "Maritza East 2"

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*Abstract* – **In this paper they are given some experimental results concerning the behaviour of the newly built Flue Gas Desulphurization Installation in TPS "Maritza East 2". Mainly, they are presented and analyzed the results connected with the next characteristics: *$SO_3$* concentrations in the gas, absolute pressure, volume flow of the gas, gas temperature. It is followed the change of the values of this characteristics in the different places (sections) of the installation.**

*Keywords* – **Environment Protection; Flue Gas Desulphurization Installation; Coal Power Station**

## I. INTRUDUCTION

The biggest Bulgarian coal field (with coal-beds about 3,5 billion tons) is called "Maritza East".

The lignite coal in the East Maritza basin are characterized not only with their relatively low heating value but also with high moisture water, high ash content and significant sulphur content. This is evident from Table 1.

Table 1

| Quality characteristic | | | | |
|---|---|---|---|---|
| No | Index | Measure | Symbol | Quantity |
| 1. | Moisture | % | $W^r$ | 51÷62 |
| 2. | Ash | % | $A^d$ | 29÷45 |
| 3. | Sulphur | % | $S^d$ | 3,83÷5,42 |
| 4. | Heating value | kJ/kg | $Qi^r$ | 4856÷7744 |

The exploitation of the power blocks using coals with such characteristics is accompanied with considerable problems. One of the most essential problems is the pollution of the environment with harmful ingredients and on the first place the emission of smoke gases with extremely high $SO_2$ content.

According the legislation in force in Republic of Bulgaria, the rates for permissible emissions (concentrations and flue gases) of harmful substances, emitted in the atmospheric air from stationary sources are given according the thermal power of the combustion installations in MW.

In particular for TPP "Maritza East 2", the thermal power of the power plant blocks 1 to 4 is about 200÷250 MW, which stands for Utmost Permissible Concentration (UPC) of $SO_2$ – 1456 mg/Nm$^3$ and for blocks 5 to 8 the thermal power is over 500 MW – and UPC is 400 mg/Nm$^3$.

According the European standards (which we aim to observe), power plants that burn local fuel with high sulphur content and are not able to keep the UPC for the sulphur dioxide in their emissions, without applying too expensive technology for desulphurization, have the right to exceed the UPC in reasonable rates. These power plants according the regulations, have to achieve a minimum of 90% desulphurization capability.

According the Bulgarian standards, in cases where coals with high sulphur content are burnt and a concentration of 1456 mg/Nm$^3$ could not be assured (for block with thermal power 200÷250 MW), is necessary a desulphurization 45÷53%, and for blocks with thermal power over 500 MW the necessary desulphurization is 90 %.

The necessary ratios for desulphurization ($\mu$, %) are shown on the figure 1:

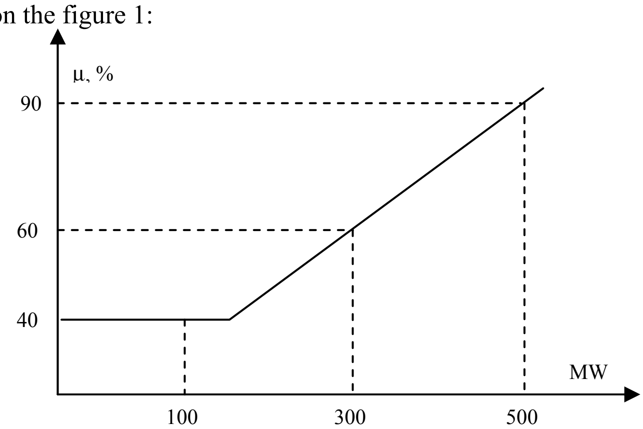


Fig. 1

The wet limestone process is chosen to desulphurize the flue gases emitted in the power blocks that burn low-rank lignite coal for the complex "Maritza East".

In TPS "Maritza East 2" have been already constructing two flue gas desulphurization systems (of block No 7 and No 8) based on this method, whose advantages can be summarized on the following way:

1. The desulphurizing ability of the wet processes reaches up to 98 %. With less financial expenditures they easily ensure the sufficient, according our legislation desulphurizing of 90 %, and there is left a reserve for more stringent requirements.

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2. The large quantity of circulating suspension in the absorber in the wet process allows the installation to deal with the abrupt changes in the $SO_2$ content and the quantity of the smoke gases.
3. During the “washing” of gases in the absorber are caught at least 35 ÷ 45% of the past through the el. filters ash.
4. In the proximity of the TPP there is enough quantity of high-quality limestone, necessary for the wet technologies.
5. The waste product from these technologies can be used further or deferred to cinder.
6. The processes with wet limestone are the most widely-used in the world – over 90 % of the flue gas desulphurization systems operate on the basis of this technology, especially when desulphurize flue gas with high $SO_2$ content. These processes are realized on both small and large blocks – up to 500 MW.

## II. DESCRIPTION OF THE PROCESS IN FLIE GAS DESULPHURIZATION SYSTEM (FGDS)

The process of flue gas desulphurization, applied to TPP “Maritza East 2” in Block 7 and 8 is a wet limestone-gypsum process with accelerated oxidation (Fig. 1). It has the functions mainly for the elimination of sulphur dioxide ($SO_2$), as well as the hydrogen chloride (*HCl*) and the hydrogen fluoride (*HF*) from the flue gas and its transformation into gypsum ($CaSo_4*2H_2O$). The reactions are accomplished within the absorber. The general chemical formulas are:

a. $2SO_2 + O_2 + 2CaCO_3 + 4H_2O \rightarrow 2CaSO_4*2H_2O\uparrow + 2CO_2\downarrow$
b. $2HCl_2 + CaCO_3 \rightarrow CaCl_2 + CO_2\uparrow + H_2O$
c. $HF + CaCO_3 \rightarrow CaF_2 + CO_2\uparrow + H_2O$

The flue gas, coming from the boiler enters the absorber from the side of the liquid level and leaves it from above. The bottom of the absorber is filled with a suspension, composed of a mixture mainly from water and gypsum (the reaction product), as well as limestone ($CaCO_3$).

The suspension is pumped out to the top of the absorber (by means of pumps for suspension circulation) and enters through nozzles into the absorber. The falling splashes from the suspension and the flue gas form an opposite flow, causing their intensive mixing. As a result, the gases such as $SO_2$, *HCl* and *HF* are absorbed by the water and dissolve in it. The fly ash in the raw gas is also absorbed to a certain extent, although it does not take part in the further chemical reactions. At the next step, the limestone and the oxygen react with the dissolved gases, so that to obtain gypsum, calcium chloride and calcium fluoride, respectively. The oxygen is fed directly into the absorber by the oxidized air feeding system. The quantity of the limestone suspension (about 25 weight per cent) is regulated by valves for limestone control. The commanding variable is the quantity of $SO_2$ in the raw gas.

The controlled variable is the value of acidity in the absorber (*pH*). It is recommended that the acidity to be kept within the limits $pH = 4,5 \div 5,5$.

If there is a surplus of limestone, *pH* increases and the reaction leads to the formation of calcium suplhide, instead of calcium sulphate (gypsum). This case is unacceptable, because of the possibility for fast and concentrated scorching of the interior of the tubes and other surfaces of the FGDS. The sedimentary reservoir of the absorber has a volume of approximately 2000 $m^3$ regarding the provision of enough time to suppress the reaction realization. For better mixing in the absorber there are mounted paddles.

The gypsum content in the solid phase is approximately 95 weight per cent. The remaining elements are inert materials from the limestone, fly ash from the waste gases, calcium fluoride, as well as non-reacted surplus of calcium carbonate.

Because of temperature differences of the suspension and the flue gas in the absorber is induced evaporation of a certain quantity of water, which cools the gas down to a saturation temperature of about 64 ÷ 71 $^oC$. Regarding the provision of mass balance, the evaporated water is continuously replaced with fresh industrial water. Before leaving the absorber, the desulphurized flue gas is cleaned up from the suspension drops in a demister (a drop catcher), located in the upper part of absorber.

After the absorber, the gas is warmed up in a gaseous heat-exchanger so that to avoid the critical temperature of condensation of the water vapours in the clean gas and the creation of corrosion conditions. The energy, necessary for heating the process, is obtained from the raw gas with a temperature after the electro-filters of 150 ÷ 180$^oC$. The flow of the smoke gas in the system is ensured by means of a fan, mounted ahead the absorber.

In case of fault in FGDS and at initial kindling of the boiler in Block 7 and 8 with black oil, FGDS is separated from the boiler through opening a bypass valve and closing the valves for the raw gas and the valves for the desulphurized gas.

The scheme of the FGD installation is presented in fig. 2.

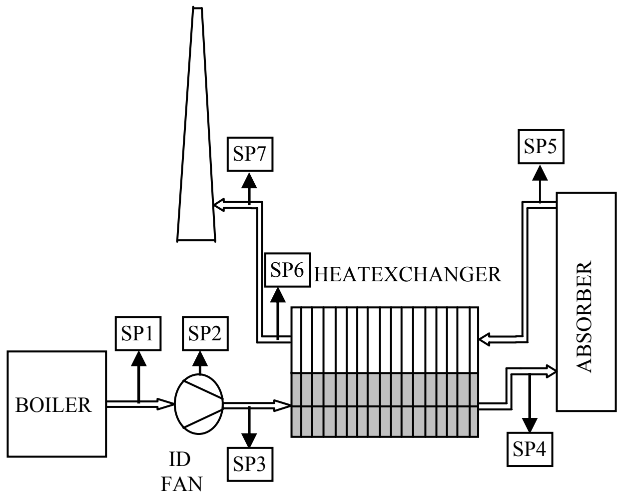



Fig. 2. Scheme of the FGD installation

## III.MEASUREMENTS AND RESULTS

Part of the guarantee and performance measurements of the FGD installation are implemented by group of Department of Thermal and Nuclear Power – Technical University of Sofia. The results for $SO_3$ concentration in the gas, absolute pressure, volume flow of the gas, gas temperature are presented in fig.

3, fig.4 and fig.5.

The sampling points (SP) mentioned in this figures (as well as in fig.2) correspond to the next conditions of the flue gas:

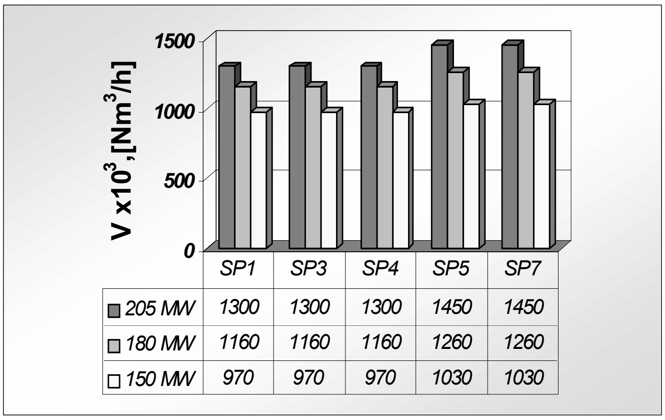
*SP1* – Untreated Flue Gas before ID Fan;

*SP3* – Untreated Flue Gas before Heat Exchanger;

*SP4* – Untreated Flue Gas between Heat Exchanger and Absorber Entrance;

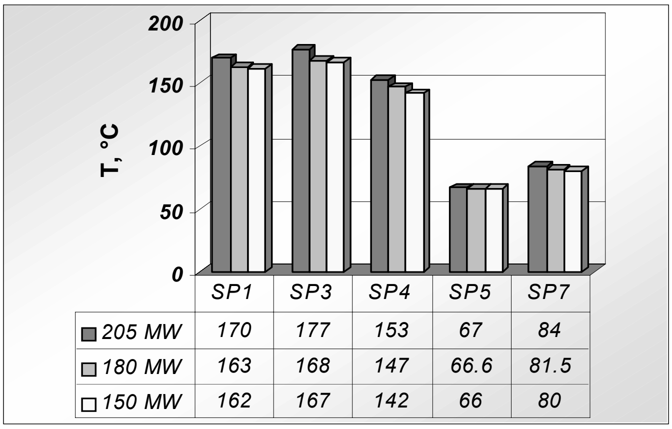
*SP5* – Treated Flue Gas between Absorber Outlet and Heat Exchanger;

*SP7* – Treated Flue Gas at Stack Entrance;



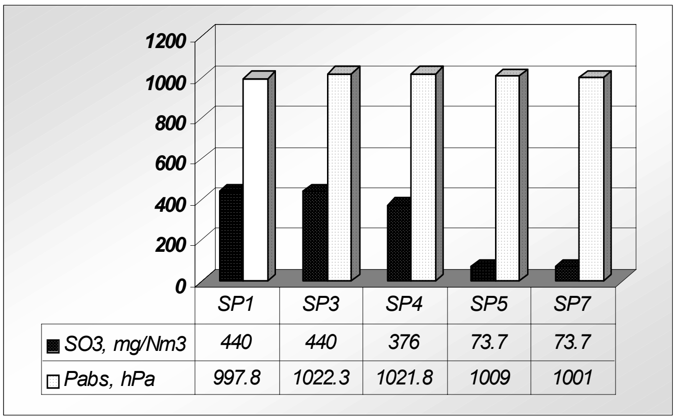

| | SP1 | SP3 | SP4 | SP5 | SP7 |
|---|---|---|---|---|---|
| 205 MW | 1300 | 1300 | 1300 | 1450 | 1450 |
| 180 MW | 1160 | 1160 | 1160 | 1260 | 1260 |
| 150 MW | 970 | 970 | 970 | 1030 | 1030 |

Fig. 3.




| | SP1 | SP3 | SP4 | SP5 | SP7 |
|---|---|---|---|---|---|
| 205 MW | 170 | 177 | 153 | 67 | 84 |
| 180 MW | 163 | 168 | 147 | 66.6 | 81.5 |
| 150 MW | 162 | 167 | 142 | 66 | 80 |

Fig. 4.




| | SP1 | SP3 | SP4 | SP5 | SP7 |
|---|---|---|---|---|---|
| SO3, mg/Nm3 | 440 | 440 | 376 | 73.7 | 73.7 |
| Pabs, hPa | 997.8 | 1022.3 | 1021.8 | 1009 | 1001 |

Fig. 5

## IV. CONCLUSIONS

The results of the experiments show that the behaviour of the FGD installations corresponds to the designed one. More important connections illustrated in the figure are:

- The volume flow of the gas increase after the absorber, as well the increasing stage is higher for higher electrical load – approximately *11,5 %* under 205 MW load; *8,6 %* under 180 MW and *6,2 %* under load of 150 MW;
- In the absorber the gas temperature sharply decrease. The risk of the low temperature sulphur corrosion (in SP7) is higher under the lower electrical load;
- In the absorber also, it is established considerable reduction of $SO_3$ concentration in the flue gas – about 80 %.

## REFERENCES

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