Determination of Water Content in the Clean Gas after the Absorber in FGD Installation in TPS "Maritza East 2"

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Abstract – **In this paper it is presented a method for determination of the water droplet contained in the gas setting in motion. They were made measurements (on the base of this method) connected with the Flue Gas Desulphurization (FGD) in TPS "Maritza East 2". Some of the obtained results for the water droplet contained in the clean gas after the absorber in this installation are presented and analyzed**

Keywords – **Flue Gas Desulphurization Installation; Measurements; Water Droplet Contained in the Gas.**

I. INTRUDUCTION

The described below method and facilities for determination of droplet content in flue gases answer the following requirements:

- detect the presence of droplet phase either in saturated as well as in unsaturated gas flows;
- give information about the quantity of the droplets in a unit of volume of the gaseous phase;
- detect the droplet spectrum in the measured quantity for dimension of the droplets 10 ... 100 μm and higher;
- operate at gaseous flow rate of 10 … 20 m/s;
- the measurements could be carried out in different checkpoints of the flue stack, maximum distance for sampling is 4 m from the inspection hole (manhole);
- the measurement facility is transferable.

II. MEASUREMENT FACILITY (PROBE)

The probe consists of two tubes of aluminium alloy, concentric situated one in another. The outer tube is referred as protective, and the inner one - supporting. At the operating end of the supporting tube is situated the support of the droplet printout glass. This glass is 3 mm thick and the dimensions are 10 x 30 mm. A thin layer of soft metal oxide is applied at one side of the glass. The droplets freely hit the metal oxide layer and therefore a permanent trace is formed.
The steady positioning of the glass is ensured by pressure facility. When there is an axial shifting of the protective tube referred to supporting tube, the measurement glass uncovers and is under attack by the droplet phase. The axial shifting is carried out by means of a handle.

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The probe is protracted through connecting with the appropriate fittings the supporting and the protective tubes.

The measurement droplet printout glasses are removed from the probe after every measurement and should be gathered in a file for further storage and consequent observation.

The precise operation of the facility for measurement and processing of the results requires the following equipment:

muffle furnace with temperature controller, needed for heating of the measuring end of the probe; chronometer; digital thermometer; tube of Pito-Prandtl; measurement microscope with accuracy of 1μm; photo camera; computer and software for processing of the droplet flow data.

III. NATURE OF THE METHOD

The measurement droplet printout glass is situated in the supporting tube and after that it is closed by the protective one. The operating end is imported in the muffle furnace and heated to temperature 5°C higher of that of the gas flow. After that the probe is swiftly moved to the checkpoint. The handle is turned for a certain period of time (5 … 30 s) and the sampling takes place.
After that the probe is exported and the measurement glass is labeled carefully and stored in the file.
When the droplet hits the layer, they leave a printout. The printout is bigger then the dimensions of the droplet, which caused it. For small droplets and gas flow rate of <20 m/s a calibrating (reference) graph is plotted, giving the relation between the diameter of the droplet and the dimension of the printout. The low of preserving the volume of the droplet before and after the impact on the soft layer of metal oxide.
The measurement of the printouts is carried out in a fixed zone of the measurement glass, where the gas flow is homogeneous. The results received are processed in order to receive quantitative assessments and distribution of the droplets in a unit of volume.

In the checkpoints the rate of the gaseous flow is measured hence the volume of the passed through the probe flue gas.
The method allows determining of the solid particles – sulfates, carbonates, etc., carried by the gaseous flow. Those particles implant in the oxide layer and sharply shape a boundary surface, while the droplets form surface of morphological crater type.

IV. MEASUREMENT AND CALCULATIONS

On the base of the presented method it was implemented a measurement program for determining the operating features of the droplet phase in the treated flue gas, between the absorber outlet and the heat exchanger.

General conditions on carrying out the test:

Output of the power unit (average) – 205 MW.

Mean flow rate of the flue gas was $\varpi \approx 14$ m/s. The temperature of the flue gas $t_g \approx 67°C$, ambient temperature of the air approximately 3°C. (For each of the checkpoints were carried out exact measurements of ϖ and t_g).

The repetition of the tests was triple. The droplet printout glass and the probe were heated before the test to the temperature of 70 - 80°C.

Morphological shape of the droplets' printouts was examined with the help of a measurement microscope with accuracy of 1μm.

The measurements are the type "grid measurements".

The calculations were made in the next succession:

1. Determining the number and the dimensions of the droplet printouts on a unit of sensitive area (0,1 mm^2) and classifying the results in tables;
2. Determining the dimensions of the droplets, corresponding to the registered printouts, as well as the frequency of their appearance;
3. Plotting the graph correlation, illustrating the probable distribution of the droplets (carried by the gas flow) in accordance to their dimensions;
4. Determining the total volume of the droplet phase "registered" during the test, according to the following dependence:

$$\overline{V_d^t} = \sum \bar{v} * \overline{V_d}, \quad \mu m^3$$

Where :

$\bar{v}$, *number – the numbers of "appearance" of droplets of equal dimension;*

$\overline{V_d}, \mu m^3$ *– the volume of the droplets of a certain defined dimension*

5. Determining the overall weigh of the droplet phase:

$$G_d^t = \overline{V_d^t} * \rho, mg$$

Where :

$\rho, {kg}/{m^3}$ *– the density of the droplets*

6. Determining the volume of the flue gas at the checkpoint:

$$V_g = w_g * t_e * S, mm^3$$

Where :

$w_g, {m}/{s}$ *– mean velocity of the gas;*

t_e, s *– time of measurement;*

S, mm^2 *– the area of observation on the layer;*

7. Calculation of the concentration of the droplets in a unit of volume of gas:

$$g_d = {G_d^t}/{V_g^{ref}} \; {mg}/{Nm^3}$$

Where :

$$V_g^{ref} = V_g * \frac{273}{(273 + t_g)} * \frac{P_{stat}}{1013} * \frac{(100 - H_2O)}{100} * \frac{(21 - O_2)}{(21 - 6)}, Nm^3$$

The distribution of the droplet content in the clean gas at demister outlet is shown in fig.1.

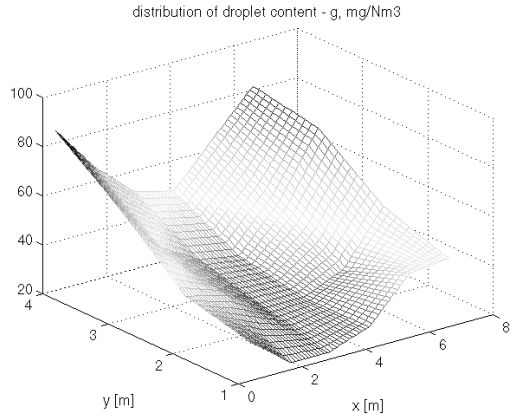

Fig. 1

V. CONCLUSIONS

The following general relations were determined in the morphological pattern:

- For the chosen times of exposition was not detected overlaying of the printouts;
- There is uneven distribution of the printouts on the surface of the measurement body hence the distribution of the droplets in the flue gas is uneven;
- It can be stated for sure that printouts with dimensions over 30 μm are absent. This dimension of the printout corresponds to max. dimension of the droplet of 25 μm;
- Printouts of droplets under 10μm are difficult for readout. The validity of the method used is for droplet sizes over 8μm.

As a result of the measurements, calculations and analysis (according to the method described) was established that the mean concentration of droplets with dimensions over 10μm for cross – section SP5 (situated between the absorber outlet and the heat exchanger) is 48,43 mg/Nm^3 which means that is lower than the required limit of max. 50 mg/Nm^3.

REFERENCES

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