ACOUSTIC EXHAUST FILTRATION SYSTEM USED IN COMBINED HEAT POWER PLANTS FOR THE SCHEMES OF WET DUST COLLETION

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Abstract **– The wet exhaust gas cleaning is largely used by thermal power plants. In 1994, in order to increase the efficiency, a new, high frequency acoustic system of ash collection was built at number 8 unit of Iujno-Cuzbas thermal power plant. The results were surprisingly good.**
The analysis shows that the proposed components can be installed inside the Vinturi tube, which will contribute to the increase of turbulence and sound generation. It is worth mentioning that in the past these components were not permitted in these loops.

Keywords: *acoustic system, damper, turbulent frequency resonator, tube neck, diffuser.*

1. INTRODUCTION

Climate change is a process that more and more specialists are worried about, as a result of the transformation of different sources of energy. Climate modification and the changes that take place on the Earth are alarming and need direct and indirect intervention from humans. It is well known that the energy produced in any form as we know it and without which it is impossible to imagine the contemporary world. A transformation process at both, extraction and consumption level, always accompanies this. The laws of thermodynamics don't make exceptions even for the contemporary day. The multiple emissions taking place in the energy transformation processes have a major negative impact on the air, water and the land.
The direct intervention of the human could partially change these modifications regarding the destruction of the ozone layer. At this point it is very important that there exists a common effort of the human kind towards the modern technologies and direct intervention to the reduction of the energy consumption without affecting the comfort situation and prevention of the pollution of the environment where the conversion of energy from one type into another takes place.

2. THE ADVERSE IMPACT OF THE ENERGY SECTOR ON THE ENVIRONMENT

The desire to control the atmospheric pollution is an old story, however it increased relatively late. The fears regarding the ozone layer, greenhouse effect and acid rains became a subject of public interest in the last thirty years.
First of all, the source of pollution must be identified. Obviously, the first visit is the industry, with notes for the thermoelectric stations. The concentration of some big capacity conversion elements in relatively small areas contributes to the creation of considerable emissions of pollution agents. The delicate problems appear in the atmospheric insalubrities dispersion process, which means the level of the emissions must be limited to an acceptable volume.
The second major factor is the transport. It is mentioned that in the urban areas the main source of polluting emissions is the transport.
Two strategic primary measures can be mentioned, that can diminish the impact that the industrial pollution has on the atmosphere:
- Increase of the efficiency of conversion installations;
- Utilization of cleaner fuels;

These measures are characterized by legal restrictions of access to conversion technologies, respectively the fuels are of low quality.
As a consequence, a particular attention will be paid to the actions aimed to limit the pollution emissions, special measures for every pollutant.
The measures of dust emission reduction act harshly when it comes to fuel products.
In Table No. 1 there is a short catalogue of these.

Type of installation	Medium efficiency, %	Notes
Mechanical dry gravitational filter (Cyclone)	75-80	Utilized with cauldrons and burning installations of small capacity
Humid mechanical filter	99	Utilized at thermoelectric stations that use high sulfate coal
Electrostatic filter	94-99	- General solutions at thermoelectric stations - Small pressure loses

Table 1: Installations of dust emission reduction.

There are two categories of techniques that aim to reduce the concentration of SO2 in the basket.
- Techniques of treating the fuel. They are used for all categories of fuels: gaseous, liquid or solid. The efficiency of desulphurization can reach up to 99% for gaseous fuels. For liquid fuels, a chemical treatment is carried out during the refinement process that leads, however, to an increase in price of about 30%.
- Techniques of operating combustion process (see Table 2).

Mode of sulfur retention	Technique	Type of realization	Efficiency %
Desulphurization in furnace, during the combustion	Used in ordinary furnaces with liquid hydrocarbons	Additives dissolved in the liquid fuel	60-70
	Used in ordinary furnaces with coal	Additives in the loose condition inserted with the coal dust	60-70
	Used in furnaces with fluidized bed combustion	Additives in the milled state inserted in coal	70-80
Desulphurization of burning gases after the exit from the oven	Wet	Ca(OH)2 pulverization in the burning gases with the generation of wet gypsum	90
	Semidry	CaO pulverization together with a little water with the generation of dried gypsum retained later in the electrical filter	85
	Dry	CaO or HgO pulverization	80-85
	Catalytically dry	Reversible reactions where a catalyst is used	80-90

Table 2: Techniques for reducing SO2 emissions at combined heat power plants.

The processes of gas treatment with liquid substances are the bases of a lot of technological processes, particularly in the chemical, petrochemical, metallurgy, food industry, and other branches of the national economy.
A large part of such processes can or do take place in the wet-type apparatuses intensifiers, with a foam layer generation on the liquid-gas contact level.

3. ACOUSTIC EXHAUST FILTRATION SYSTEM USED IN COMBINED HEAT POWER PLANTS FOR THE SCHEMES OF WET DUST COLLECTION

The environmentally friendly technologies allow avoiding the pollution that may by cause by various technological process of energy generation. Such technologies are in permanent evolution and are aligned with high control and regulation technologies.
Wet filtration schemes make the basis of the exhaust filtration at solid-fuel power stations allowing collecting ash fractions at the rate of 99%. Such schemes are modified each year, becoming more advanced and easier in operation.
The scheme described below is a modification of some elements from the main body of the filter with the inclusion of an acoustic system in its convergent tube.
The operation of such a system includes mounting of a special device at intersection of fluxes of noxious gases and water, of a turbulent pulsation damper. Strings of the damper are the damping source, with the self-contained power supply from the gas exhauster or other exhausters of the aggregate (see Fig. 1).
Specific air consumption, that depends on the filtration device components, amounts to 2-5% of the treated gas volume.
Such technology allows to reduce the atmospheric emission with 1,5%, in comparison with the classic schemes, and removes the drawbacks of the inertial ash-collecting schemes, and finally to reach the profitability reduction for small loads of the energy aggregate.
After the acoustic filtration system is mounted, a slow decrease in gas temperature is observed on the filter's output, while in the noxious gas filtration a considerable increase at the rate of up to 99,7% takes place.
In order to avoid the additional water consumption during the ash collection and to reach the optimal parameters of the injector diffusion specter operation, an additional autonomous Venturi tube moistening block-system is provided.
In some cases, in order to maintain the filtered gas temperature at the proper level, for gases with temperatures reaching up to the dew point, their additional heating after the filtration is provided, thereby creating a plant thermal protection system. This solution provides a stable anticorrosive protection that appears as a result of steam condensation.
Such systems are not enough studied and show a higher level of filtration; however, essential noises of the damper mounted in the convergent tube of the wet filter are observed.

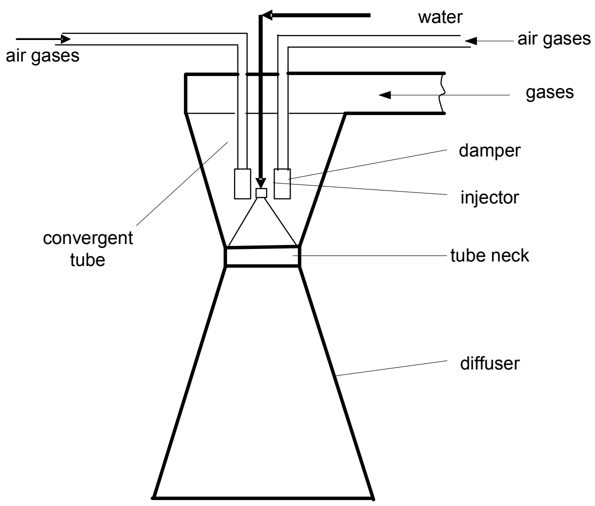

Figure 1: Venturi tube with an acoustic filtration system.

Without the operation of the aeroacustic system during geterogeneous fluxes processes in the Venturi-type ash collectors, the latter can be divided into:
- Accelerating and braking particles in the acoustic field and accelerating and braking liquid particles during the injection;
- Temperature and mass change of liquid particles with exhaust;
- Coagulation and segmentation of liquid particles; and
- Coagulation of ash particles with drops of liquid.

4. MASS AND HEAT CHANGE PROCESSES IN PULSATING FIELDS

In the Venturi tube the following forces will act on the ash particles:
- Force of the acoustic field;
- Force of the special structure of turbulent fields.

On the basis of the above-mentioned, the computing of the schemes shall only take into consideration the "particle-environment" system, and the action ensuing from pulsations of the homogeneously structured environment, which is created by the passage of air through the gas flux bunch resonators.
In the particle mechanics, the parameter τ is widely used.
This process was called the "rest period" and it characterizes the speed of the "particle-environment" system balance recovery.

$$\tau = \frac{2}{9}\frac{\rho_2}{\eta} r^2 \tag{1}$$

If the rest period is not too big in comparison with the speed of the environmental change where these particles are situated.

The particles are moving with the speed, which is almost equal to the speed of the environmental change.
Considering that the condition types of the ash particles can be written as follows:

$$\begin{aligned} m_2 \frac{du_2}{dt} &= 6\pi\eta r(u_g - u_p) \\ u_a &= V_a \sin(\omega t) \end{aligned} \tag{2}$$

where η is dynamic viscosity of gases,
Ug and Up are speeds of gases and particles, and taking into account (1), we get the formula of the environmental condition:

$$\tau \frac{du_a}{dt} + u_a = V_a \sin(\omega t) \tag{3}$$

According to the Elementary Laws of Acoustics in the resonance channels, on the appearance of the resonance field, the distortions appear.
This is due to the field in homogeneity:

$$f_0 > 1.84 \frac{C_2}{\pi D} \tag{4}$$

where f_0 is the oscillation (vibration) frequency,
C_2 is the speed of sound in gases;
D is the channel diameter.
Taking into account the artificial turbulent characteristics, we will introduce into the formulas the inertial coefficients for computing these types that describe the retention of ash particles with water particles.
The corresponding technology is based on the concept of the turbulent and acoustic field acting in the inertial ash coagulation processes in the catcher of the Venturi tube.
The principle of using this technology is the interaction between resonance field and field of gas and air flux intersection.
It is known that the resonance takes place in the resonance bunches situated in staggered rows (Fig. 2).
Its operating frequency is determined from the formula:

$$f = St \cdot U / D \tag{5}$$

where U is the speed of fluxes in the resonators;
D is the speed of the resonance tube;
St is the Sruheli number.
The air consumption in the resonator tubes is determined from the formula:

$$Qb = n \cdot S \cdot U \cdot 3600 \tag{6}$$

where n is the number of resonators;
S is the section of the resonator tube.

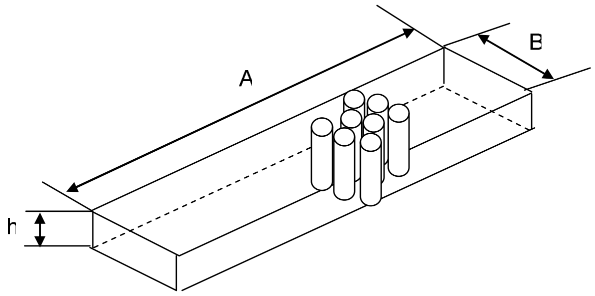

Figure 2: Turbulent Frequency Resonator.

The temperature of the gases on the output of the Venturi tube, after the activation of the resonance system, is somewhat smaller than that without the acoustic system, the former being characterized by a better intensification of mass and temperature change in the acoustic field. The main problem is a high level of noise in such resonators, up to 140 Db, and the insignificant rise in the aerodynamic resistance in the filtration apparatus, up to 127 mmHg.

5. CONCLUSIONS

This work analyses two types of such a scheme: with different freqency of sound and different air mass flow consumption by the acoustic system. By applying the proposed scheme, the Iujno-Cuzbas power plant, in our opinion, has reached the potential limit of the ash coagulation processes in the gas cleaning system.

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