STUDY THE POSSIBILITY OF REDUCING THE AMOUNT OF DUST IN THE CORBU COAL STORAGE USING WETTING PLANTS

SORIN MIHĂILESCU[1], GABRIEL PRAPORGESCU[2]

Abstract: Powders represent one of the main industrial noxae. They become a health risk only when their concentration is high. Thus, in order to reduce the quantity of particulate matter the following are recommended: endowment with mobile sources to splash the access areas and the manoeuvre areas in order to decrease the concentration of dust in the atmosphere; devices to retain powders in the coal discharge areas; periodic splashing and loosening of coal and periodic movement of stocks in the coal storage facilities; dedusting of the installations that produce dust in the coal storage facilities.

This paper shall establish the sizing of the wetting plants in order to diminish the quantity of dust particles resulted in the coal storage facility – Corbu enclosure, so that the environmental regulations in force are observed.

Keywords: environment, mining, dust, water

1. INTRODUCTION

The main issues that affect the environment refer mainly to the soil quality due to mining activities and to the risk of landslide. These phenomena can be found in full in Gorj County.

The powders that pollute the atmosphere in Gorj County differ in nature according to the generating sources, respectively: fossil fuel power plants, cement factories, quarries, slag and ash storing facilities, waste dumps. The emissions of particles were estimated as total powder, recording a slight decrease (22,466 t) in comparison with 2006 (23,387 t). The trend can be explained by the refurbishing – modernisation works of the dedusting installations (electric filters), reducing the operating time of the non-refurbished power units, reducing the activity in the open cast mining, decrease of the cement production, etc. recorded at county level.

[1] *Assoc. Prof. Eng. PhD., University of Petroşani, mihailescus@gmail.com*
[2] *Assoc. Prof. Eng. PhD., University of Petroşani, gpraporgescu@gmail.com*

2. CORBU COAL STORAGE FACILITY

The perimeter of the Ruget quarry (Fig. 1) falls within Gorj County, being located in the area of Ruget, Roşia de Amaradia commune. The surface currently occupied by Ruget quarry is 393.9 ha

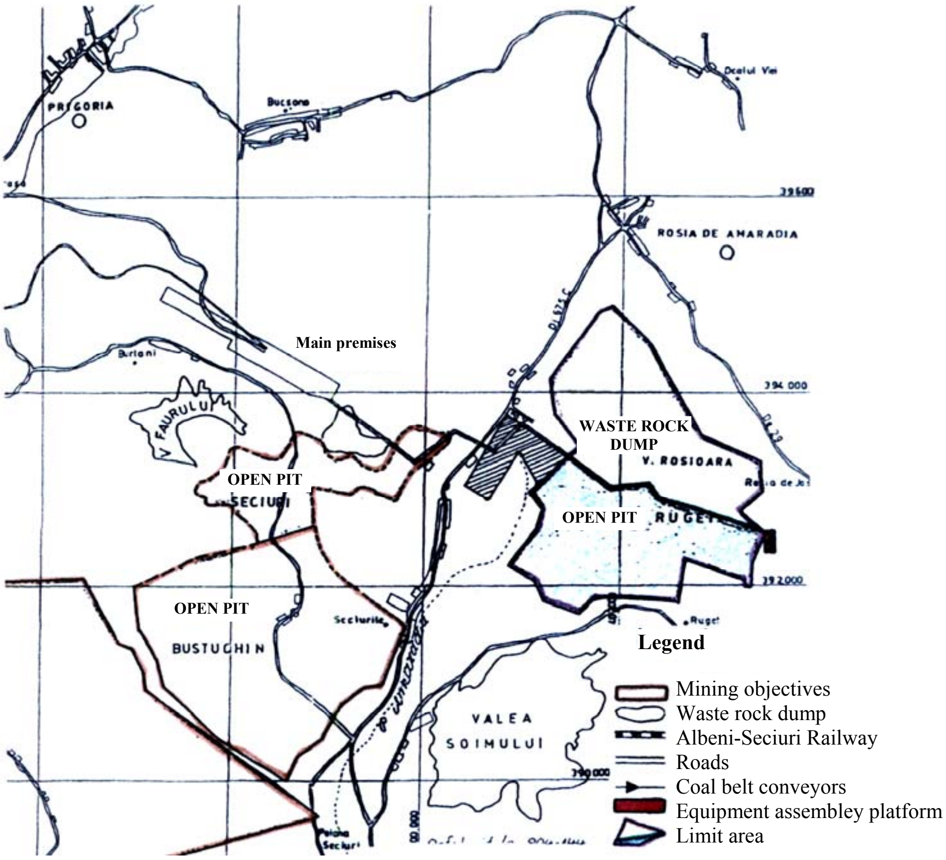

Fig. 1. Gilort-Amaradia Mining Basin Map

In Ruget open pit the continuous flow mining technology, excavation – loading of the mining mass using rotor excavators, transportation of the sterile and coal on conveyor belts, storing of the sterile using dumping installations are used.

The coal storage facility is located in the mining enclosure in the area called Corbu. It is situated at 5 km from Ruget quarry from where it receives the coal on a circuit made of 8 belt conveyors. In the storage facility, the coal is laid in two stacks using two T-2053 and KSS T-3855 type stacking machines. The discharge from the storage facility is done using belt conveyors loaded by a T-2846 type loading machine, to the loading point into carriages that is built in the western part of the storage facility.

The capacity of the coal storage facility is 30,000 tons. Also, in the same enclosure they built a storage facility for lump coal (sort 80...300 mm), which has a capacity of 1,500 tons and a storage facility for small sort coal for the heating plant from the mining site.

The coal storage facility is equipped with the following installations (Fig. 2):

- Installation for sorting lumps;
- Installation for coal supply of the heating plant;
- Installation for loading small sort into carriages;
- Installation for loading lump sort into carriages;
- Installation for pulling carriages for loading;
- Belt conveyors.

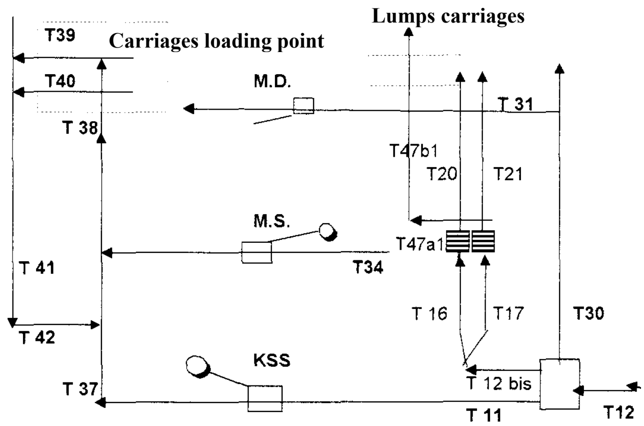

Fig. 2. Diagram of the technological flow at the Corbu coal storage facility

The activity carried out at the Corbu coal storage facility represents a source for atmosphere pollution mainly with suspended particles released by the equipment during the coal transportation process on the belt conveyors and coal storage process, as well as those released by the machines that move on the access roads and the roads for intervention on the equipment. The highest emissions of suspended particles occur during the storage-excavation phases for loading and shipping the coal in carriages. The emissions were evaluated taking into account the maximum capacity on the storage facility of 750,000 t of coal and they are of 2,880 kg/year suspended particles.

Mathematical modelling of dispersion did the evaluation of the impact of the main pollutant – particulate matter – on the air quality in the perimeter of the corridor of main belt conveyors. The results obtained are presented summarised in table 1.

As a result of changing the delivery method from the quarry's storage facility, delivery to the CFR carriages, certain problems occurred related to the increase in the pollution degree in the areas adjacent to the storage facility. Measures for the mitigation of the negative impact generated by the delivery activity from the storage facility on the environment are provided for the areas with high pollution potential represented by the:

- KSS combined machine;

- Stacking machine;
- Conveyor loading discharge hopper into carriages.

Solutions shall be proposed for these objects for the wetting plants. As first measure for the mitigation of the negative impact of the activity in the storage facility, casing systems and local fog system can significantly reduce the pollution phenomenon.

Table 1. **Particulate matter impact evaluation on air quality in the perimeter of the main belt conveyorss corridor**

Sursa	Poluant	$C_{med\ yearly}$, Ng/m^3	CMA_{yearly}, Ng/m^3	$C_{max30\ min}$, Ng/m^3	$CMA_{30\ min}$, Ng/m^3
Storage	particulate matter	54	75	572	500
Belt conveyors	particulate matter	129	75	360	500
Storage coal – coal loading	particulate matter	55	75	254	500
Total storage-expedition activities in Corbu	particulate matter	129	75	744	500

3. ANALYSIS OF THE ENVIRONMENTAL CONDITIONS IN CORBU AREA

The potential environmental impact is maintained for the entire exploitation period of the deposit. It appears as possible area pollution with particulate matter, especially coal dust, in extreme climate conditions such as the droughty and strong windy periods. So, the solid particles can be engaged and transported on relatively large distances from the quarry, waste dump, coal storage facility, open area, which may affect the local communities and may generate discomfort for the population, especially in the area of the locality neighbouring the transportation circuit that connects to the coal storage facility.

The impact produced by the various pollution sources in the Corbu enclosure can be summarised as follows:

- In case of dust emissions, the activity carried out within the coal storage facility represents a pollution source of the atmosphere mainly (and almost exclusively) with suspended particles;
- The highest emissions of suspended particles occurred during the storage, transport and loading of coal into carriages phases;
- The emissions were assessed taking into account the maximum production capacity of 750,000 t. Under these conditions, the emissions of suspended particles presented the following values:
  - Coal loading: 108 t/year;
  - Belt conveyor transport: 1,229 t/year;
  - Coal storing: 108 t/year.
  - Besides these, we could mention the emissions due to the operation of

the own equipment and means of transportation in the storing facility. For the own equipment and means of transportation an annual consumption of fuel (150 t) is estimated.

In this case, the pollutants emissions into the atmosphere by exhaust gas and engagement of particles, especially on dirt roads and particularly during transport of coal by vehicles from the coal storage facility are as follows:

- particulate matter 2,680 kg/year 0.333 g/s;
- SO_2 164 kg/year 0.119 g/s;
- NO_x 29.6 kg/year 0.033 g/s;
- CO 8.2 kg/year 0.008 g/s;
- COV_{nm} 0.70 kg/year 0.0009 g/s.

4. ESTABLISHING THE WETTING SOLUTIONS IN ORDER TO REDUCE DUST EMISSIONS

The technical solutions proposed to be adopted for the reduction of coal dust emissions in the area of Corbu coal storage facility reside in wetting the discharge-excavation areas from the storage facility and of the areas for loading into carriages so that the environmental regulations in force are observed in respect of soil pollution with coal particulate matter.

The construction of the wetting system involves the execution of several targets:

- Execution of the catchments' front with the flows required to make the system. Supply with drinking and industrial water is possible to be done from the existing network, or, otherwise, from new catchments' fronts that would provide the calculated flow;
- The resulted wastewater shall be collected from the platform and from the arranged area of the storage facility and they shall be discharged into the arranged channels and from here into the natural emissary. The resulted technological water together with the other water collected from the platform is considered wastewater, which needs to be treated before being discharged into the natural emissary;
- Execution of the minimum accumulation reserve for settling and filtering the drilling water, in accordance with the adopted system;
- Execution of the pumping stations at the level and flow required by the network;
- Execution of the constructions for the pumping stations;
- Execution of the network and fog installations in the local points;
- Satisfying the requirements for safety in operation of the equipment, as well as the specific environmental conditions.

4.1. Constructive analysis of the water fog plants

The water fog plants (Fig. 3) are efficient and economical in comparison with other installation using water (installations of sprinklers, drenchers, pulverised water). Their use leads to the significant reduction of the water consumption. Using the water fog plants is recommended when the water reserves are limited, when the water supply is done with restrictions, when the required water supplies cannot be ensured, intangible for the entire theoretical normed operating time, as well as in case the use of water as compact jets, dispersed in drops or pulverised, cannot be collected in high quantities at soil level due to the nature of the land and to the length of the water screen.

Fig. 3. As water, spray (fog)

By pulverising water as fog the ratio between the drops' surface and their mass increases significantly and the mass transfer between the pulverised water and the dust particles engaged by the air currents is intensified. Between the hygroscopic dust particles and the water pulverised as fine particles a mass transfer occurs that engages the dust particles thus hampered by the water collected from the water screen to fall by gravity into the channels built in the takeover area.

The efficiency of the water fog depends on several parameters. The grading of the water drops in the pulverised jet is one of the factors that lead to the efficiency of dust and of solid coal suspensions removal from the atmosphere.

Three types of water fog quality can be distinguished, analysing the statistical distribution of the average diameters of the water drops in the pulverised jet (the spectre of the pulverised water jet), graphically represented in the diagram (Fig. 4). In the diagram, on the x-coordinate the average diameter of the drops is shown, *d*, in microns (μm) and on the y-coordinate the percentage fraction of the water volume made of drops of a given diameter, *Dv* (in %) is given, of the total volume of pulverised water:

- class I, where 90 % ($Dv_{0,9}$) of the entire volume of pulverised water is made of average diameter drops, *d*, included in the range 100 μm and 200 μm;
- class II, where 90 % ($Dv_{0,9}$) of the entire volume of pulverised water is

made of average diameter drops, *d*, included in the range 200 μm and 400 μm;
- class III, where 90 % ($Dv_{0,9}$) of the entire volume of pulverised water is made of average diameter drops, *d*, included in the range 400 μm and 1000 μm.

The choice of type shall be done according to the following factors:
- Distances from the inhabited areas;
- Distances from the electric power networks;
- Required flows;
- Purpose of the fog vapour screen.

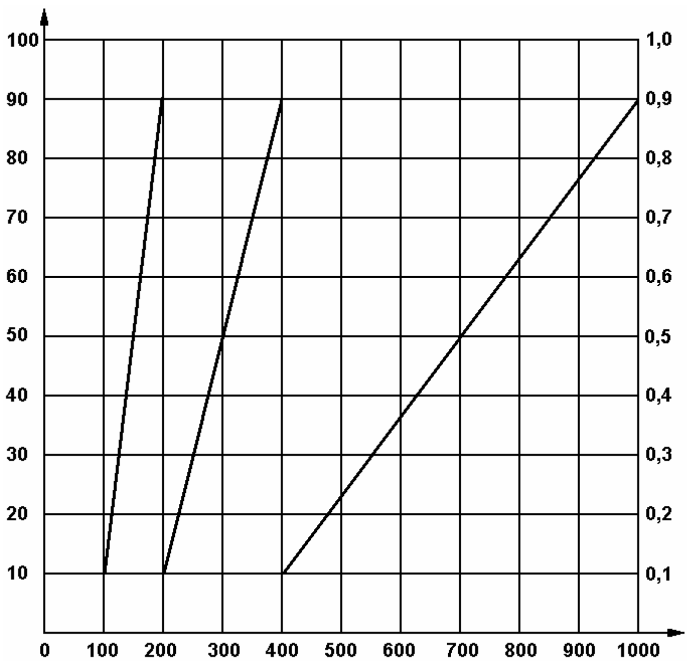

Fig. 4. The statistical distribution of the average diameters of the water drops in the pulverised jet

The pulverisation heads (nozzles) (Fig.5) do not produce particles of the same size, but a spectre of drops of different diameters whose amplitude depends both on the pulveriser's construction, and on the water pressure. That is why their jet is characterised according to the average diameter of the drops, as well as by the maximum diameter in certain cases. Experiments showed that for 50 m H_2O the jet of the neat construction pulverisers includes 90...96 % drops with a diameter of 0.1-1 mm. For high pressures, the average diameter remains constant but large drops are eliminated, which do not have high efficiency, without noticing considerable movements in the range of small and average to fine drops.

For the systems with local action wetting on limited surfaces is provided in the discharge/takeover point from the technological flow of the protected object. This system with local action is activated in case of need by automatic nozzles or by its own detection, signalling and control system. These types of nozzles with local action are necessary to be installed in ASG (in the conveyor's discharge area), on KSS (in the loading or unloading area) as well as in the areas with a high risk of dust generation, respectively the area for loading into carriages.

Fig. 5. Fine water pulverisation nozzles

For the design and execution of the dedusting installation with water, fog measures and technical conditions shall be provided to lead to the observance of the provisions of the „Law regarding the quality in constructions", no. 10/1995 with supplemented, regarding the providing of the following requirements:

- Resistance and stability of the installations;
- Safety during operation of the installations;
- People's safety, environment's protection and restoration.

The requirements regarding the quality and resistance of the wetting plants with water are ensured by the appropriate construction and sizing of their structural strength and their correlation with the constructive system of the Corbu coal storage facility. The component elements of the water supply installations are executed buried, below the freezing temperature limit, and for the areas where the networks are above ground, they shall be protected against freezing.

4.2. Calculation for the requirement of nozzles and water

The wetting plants are proposed in order to execute dedusting in three distinct points in the Corbu storage facility:

- Combined KSS stacking machine - minimum 6 nozzles;
- Stacking machine - minimum 6 nozzles;
- Discharge hopper into carriages - minimum 4 nozzles.

The hydraulic, geometrical and functional characteristics of the pulverisation nozzles for forming water fog, which are to be taken into account for the choice of their types and numbers, are:

- Specific flow, q_h, *l*/s, executed at a certain available water pressure in the section of the discharge orifice of the nozzles, *H*, mH_2O, called pulverisation pressure;

- The diameter of the discharge orifice of the nozzles for water pulverisation, d_i, mm;
- The geometrical shape and structure (spectre) of the pulverised water jet, respectively the quality of water fog;
- Protected area, A_p, m^2, and the area for the simultaneous triggering of the water pulverisation nozzles, A_s, m^2;
- Intensity of water pulverisation, i_i, l/sm^2, and intensity of dedusting, i_s, l/sm^2.

The manufacturer for each nozzle type specifies the hydraulic, geometrical and functional characteristics of the pulverisation nozzles for forming water fog.

The specific flow q_{is}, l/s, of a type i of pulverising nozzle for forming water fog is determined with the following formula:

$$q_{is} = a_i\sqrt{H_i}\,,\ \mathrm{l/s} = 0{,}08\ \mathrm{m}^3/\mathrm{h} \qquad (1)$$

for the type of chosen nozzle, where: a_i is the coefficient characteristic to type i of nozzle, which depends on the u flow coefficient of the discharge orifice of the nozzle and on its diameter, d_i; H_i, mH_2O, is the available water pressure in the section of the discharge orifice of the nozzle.

The quality of the water fog depends on the structure (spectre) of the water jet pulverised through the nozzles. The water pulverising nozzles do not produce particles (drops) of the same size, but a spectre of drops of different diameters whose amplitude depends both on the pulveriser nozzle's construction (nozzle type and diameter), and on the water pressure. As a result, the pulverised water jets are characterised according to the average diameter of the drops (Fig. 4), and in some cases by their maximum diameter. The spectre of the pulverised water jet is determined experimentally, on the nozzle manufacturer's test bench. The statistical distribution of the drops' average diameters is determined for a certain pressure for the pulverisation of water, when 90 % of the total number of drops has average diameters included within certain limits (Fig. 4).

In table 2, the statistical distribution of the average diameters is presented for the drops in the pulverised water jet and the quality of the water fog, in accordance with the pressures for the pulverisation of water through the nozzles.

Table 2. **The statistical distribution of the average diameters of the drops in the pulverised water jet and quality of the water fog, in accordance with the pulverisation pressures of water through the nozzles**

Water pulverisation pressure	Average diameters of the drops in the water jet pulverised through nozzles	Quality of water fog
High, over 34 bar	100...200	I
Averrage, between 12 şi 34 bar	200...400	II
Low, between 6 şi 12 bar	400...1,000	III

The water requirement for the chosen pressure system is 16 bar, 16 splashing points calculated simultaneously, leads to a water requirement of:

$$Q = 16 \times 0{,}16 = 2{,}56 \text{ m}^3/\text{h} = 0{,}711\ l/\text{s}$$

The performance of pulverised water is generally determined by the characteristics of the nozzle and of the applied techniques. In theory, the drops with a smaller diameter are much more efficient than larger drops, as shown in table 3.

Table 3. **Variation of the surface with the diameter of the drop (1l of water)**

Drop size, µm	1000	100	10
Total numbers of drops	$1.91 \cdot 10^6$	$1.91 \cdot 10^9$	$1.91 \cdot 10^{12}$
Total surface, m^2	6	60	600

4.3. Presentation of the technical solution

For the dedusting system with local wetting it was considered that the sizing of storing and of the wetting plants would be done for a flow of Q = 0.75 l/sec, as follows:

- Storing shall be done in a tank (Fig. 7) of 20 m^3;

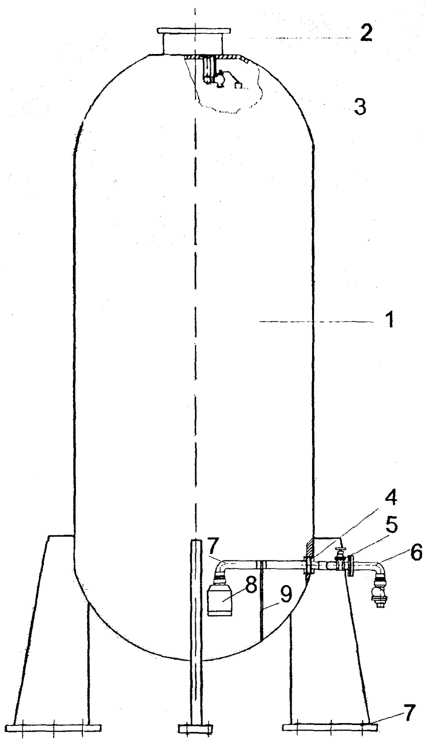

Fig. 7. 20 m^3 tank:

1 – 20 m^3tank; 2 – drain cover; 3 – overflow float valve; 4 – crossing piece; 5 – valve; 6 – Dn 80 main pipe; 7 – support parts; 8 – Dn 80 strainer; 9 - Support

- Pumping shall be done using a double pump with a flow of 10 m^3/h;
- The network shall be of Dn 80 pipes on each branch;
- Buffer tanks shall be mounted on the equipment as follows:
  - For the KS-S combined storing machine buffer tanks shall be mounted on the 2 × 2 m^3 rotation platform;
  - For the stacking machine, water buffer tanks of 2 × 2 m^3 shall be mounted. The mounting shall be done in the rotation axel;
  - The pumps required for the central system and for the local systems that serve the equipment mounted on the machines are made of:
    - 2 pumps (1O + 1S) with Q = 2 m^3/h and p_n = 16 bar for KSS;
    - 2 pumps (1O + 1S) with Q = 2 m^3/h and p_n = 16 bar for the stacking machine;
    - 2 pumps (1O + 1S) for the wetting plant in the loading point.

The distribution network is made of 3 branches of Dn 80 mm pipes with length of 650 m and Dn 20...50 mm pipes on the machines with length of 150 m.

The list of equipment and machines that make up the dedusting installation of the Corbu storage facility is presented in table 4.

Table 4. **Equipment and machines that make up the dedusting installation of the Corbu storage facility**

Nr. Crt.	**Utilajul/Echipamentul**	**Bucăți**
1	Vertical metal tank with “V” series metal support with 20000 *l* capacity	2
2	Horizontal pump flanged on the electric engine’s axel P = 12 kW; p_n = 16 bar, Q = 5 m^3/h	1+1
3	Pulverising nozzles A şi B	16
4	2 m^3 fibre glass tank fully equipped with automation box	4
5	High pressure pumps + driving engine + automation box p_n = 16 bar, q = 0,5...0,8 l/sec	6

5. CONCLUSION

The technical solutions adopted to reduce the coal dust emissions in the area of the Corbu coal storage facility reside in wetting the discharge – excavation points in the storage facility and of the loading points into the carriages so that the environmental regulations in force are observed regarding the pollution of soil with coal particulate matter. The ratio between the surface of the drops and their mass increases significantly, intensifying the mass transfer between the pulverised water and the dust particles engaged by the air currents, by pulverising water as fog. Between the hygroscopic dust particles and the water pulverised as fine particles a mass transfer occurs that engages the dust particles thus hampered with the water collected from the screen to fall by gravity into the channels built in the takeover area.

The efficiency of the water fog depends on several parameters. The grading of the water drops in the pulverised jet is one of the factors that lead to the efficiency of dust and of solid coal suspensions removal from the atmosphere.

The wetting plants are proposed in order to execute dedusting in three distinct points in the Corbu storage facility:

- Combined KSS stacking machine - minimum 6 nozzles;
- Stacking machine - minimum 6 nozzles;
- Discharge hopper into carriages - minimum 4 nozzles.

REFERENCES

[1]. Colda, I., Damian, A., *Dedusting equipment and installations,* Editura Conspress, 2005 (Romanian)

[2]. Diga, S.M., *Electrostatic dedusting installations,* Editura Universitaria, 2001, (Romanian)

[3]. Pavel, D.I., Poenaru, M., *Use of water sprays to limit the effects of fires*, A Patra Conferință a Hidroenergeticienilor din România „Dorin Pavel", 2004 (Romanian)

[4]. Voicu, V., *Control of pollutants in industry*, Editura Tehnică, Bucureşti, 2002 (Romanian)

[5]. *,** *Installations and procedures to catch industrial dust,* I.N.I.D., Bucureşti, 1975 (Romanian)

[6]. *,** *Law for environmental protection no. 137 of 1995* (Romanian)