SOLUTIONS TO REDUCE THE ENVIRONMENTAL POLLUTION BY THE PRODUCERS OF REFRACTORIES

Radu BUZDUGA[1], Nicolae CONSTANTIN[2], Adrian IOANA[3]

The refractory industry, alongside other industries such as: building materials, metallurgical industry, are polluting and highly energy consuming. The main environmental factor affected is the air and the main pollutant is the dust. Regardless of the physico-chemical characteristics of each type of powder in particular, their presence beyond the limits imposed by legislation constitutes an important warning signal to those responsible for both production processes concerned, and the whole population. In this paper we present pollution sources and proposals to limit pollutants issued by a producer of refractory and building material and construction, namely SC Helios SA Astileu, Romania.

Keywords: pollutants, atmosphere, refractory materials

1. Introduction

The manufacturer of refractory's industry is cited as a polluting industry. The agents most important encountered in this area are dust, gases, waste resulting from the processes. [1]

Refractory industry differs significantly from other sectors of the ceramic industry.

The densities and distributions of airborne fungal spores known to cause respiratory tract disorders were monitored in three educational buildings located in different boroughs in Iaşi.

Field of silica-alumina refractory are somewhat akin to that of the building bricks for the flow of mixture-compression, combustion, as well as the production of cement, in particular in the preparation of silicon-alumina refractory.[2]

The most important component of pollution in this area is the separation and retains dust.

[1] Faculty of Materials Science Engneering, PhD student, University POLITEHNICA of Bucharest, Romania, e-mail: radu_buzduga@yahoo.com

[2] PhD, Faculty of Materials Science Engneering, University POLITEHNICA of Bucharest, Romania, e-mail: nctin2014@yahoo.com

[3] PhD, Faculty of Materials Science Engneering, University POLITEHNICA of Bucharest, Romania, e-mail: adyioana@gmail.com

[4] PhD, Faculty of Materials Science Engneering, University POLITEHNICA of Bucharest, Romania, e-mail: cristiandobrescu@yahoo.com

Particulate emissions from technological processes for manufacturing refractory products into form very important because they contain free crystalline silica and heavy metals. [3]

Silicon-alumina refractory obtaining involve the use of raw materials containing high silica free, extremely harmful to human health. [4]

The lack of suitable frameworks in general population represents an issue for the assessment of health/economic impact of Se deficiency. Further researches are needed in: agriculture, economics and health in order to determine the costs/benefits relationship and monitor the health outcomes of Se supplementation.[5]

Overall separation and retain dust problem is presented as a necessity, firstly in terms of social harmfulness of dust emission, but also as a measure of economic growth in order to recover materials and technological operations efficiency.

Nationally and internationally, separation and retain dust problem is approached from the point of view of legal norms and from the practical standpoint. Separation and retain dust problem is addressed since the design flow. The practice is mandatory fitting of machinery, generator particulate filter installations.

A broad classification of types of separation methods used both nationally and internationally as follows:

• methods and apparatus for separating dust by filtering surfaces;
• processes and apparatus for separating dust by means of electric filters;
• sonic processes;
• wet dust separation processes.

a) Methods and apparatus for separation of dust through filter surfaces

The principle underlying these methods is that the gas passes in which the solid slurry through a filter surface. The nature of the filtering surface characterized by a large number of pores is varied. Depending on conditions, you can use the following:

- Vitro ceramic materials (porcelain, glass synthesized POROLIT);
- Fibrous layer trapped between two metal grids (glass wool, asbestos, etc.);
- Granular materials spills or fillers;
- Textiles in the form of bags.

The technological process of treatment gas through the filter is characterized by several production parameters, namely:

- Filtration rate, represented by the flow of gas passing through the filter unit area per unit time:

- Filtering capacity, expressed as the amount of gas passed through the filter unit area between two cleansings of the filter;
- Pressure loss when passing gas.

The refractory industry, the most commonly used are fabric filters, normally baghouse (sleeve) with the following operating mode : dust-laden gas is forced to pass through a fabric and deposited on its surface and in space of the thread of the dust (> 99 %) contained therein in suspension. The degree of dust collection increases as the fineness of the fabric and yarns roughness. As depositing dust on the filter surface and increases its degree of restraint, but also the hydraulic resistance to the passage of gas. Because of the increase in hydraulic resistance , easy to follow using a manometer, filter fabric is required to be periodically shaken off the dust . Fabric filter effectiveness is influenced by the physical state of gas , degree of humidity and temperature theirs that have a filter .

Gas moisture combined with any filter cooling them in space, thanks to the introduction of cold wash cloth or leaks can lead to clogging of the filter. To prevent this, sometimes it is electrically heated through the air washer.

The way the cloth (wire thickness, twisting), the thickness of the fabric, yarns nature, filter cloths etc give a great variety in their adaptation to the conditions of filtration.

Bag filters most commonly used in refractory industry shows the following technical data:

- 190 ... 220 mm diameter bags;
- Sacks length 2 ... 3.5 m;
- Filter surface of a filter 20..800 sqm;
- Filter pressure drop 0.6 ... 8 kN / m;

Filter material characteristics are very important for improving the efficiency filtration. There are times when synthetic materials high technical performance (number of pores, very good behavior in a wide range of temperatures, good efficiency for particles of very small diameter) resulted in excellent filtration efficiency.

Particularly important is how shaker bags. From this point of view the situation in the world has evolved a lot. Since conventional mechanical shaker systems, it has come to the use of pneumatic systems is shaking. In this case both the method itself and used air parameters were studied according to the specific conditions of each filter reaching high-performing systems whose retention efficiency is 99.5% and very good equipment reliability. Such a plant will be described below.

Another solution commonly used to improve filtration efficiency is filtering those of the sea surface. It basically involves the use of two bags disposed on the same device support (one being a kind of pocket of the other).

b) Methods and apparatus for separating dust by means of electric filters

This method removes dust collection filter bags disadvantage on high pressure loss in the system.

Electric filters are devices that allow separation of fine dust (particle diameter less than 1 micron) at high temperature (approximately 570 K), and with a separation efficiency of more than 99%, a pressure loss of less than 3 kN / m.

Separation and retain dust flue gas or air loaded with dust filters , electric , is a process that is based on the phenomenon that the solid particles in suspension in a gas (air) can be electrically charged and separated from the gas during the crude gas passes through the filter. Filter consists of electrode systems with different polarity at a time. One of these electrodes is grounded, and the other is connected to a source of high voltage DC, so between the electrodes produce an electric field strong. The electrodes are called ground the electrode deposition or precipitation as they are deposited on particles that are separate from the suspension. They are located between the electrodes connected to the source of DC high voltage electrodes called scintillation or ionization, because they emit electrons through the electrical load which is performed and separation of dust particles in suspension.

Under the influence of the electric field, the gas is ionized and the ions carry electric charges; in case of simultaneous formation of a large number of ions in the electric field between the electrodes, the current intensity increases considerably and unloading occurs by sparks, called corona.

A sensitive influence over efficiency electric filter has conductivity value electrical material in suspension of gas and particle concentration in suspension of gas. Electrical conductivity dust particles can be increased by moistening with water crude gas.

Electric vibrating filters can be: tubular electric filters or electrostatic precipitators plate.

c) Sonic treatment processes

Work procedure when using gas scrubbing action of sound waves is as follows: under the action of a specific frequency sound waves can produce small particle agglomeration which then settle more readily under gravity.

Along with the frequency of sound waves, intensity and duration of their actuators have a decisive role on the effectiveness of cleansing. The working frequency is generally between 1 and 100 kHz.

Separation of solids is achieved in a very short time, from seconds and intensities of sound waves ranging between 0.1 and 1 W / cm^2. Limit the particle size of the material can still be separated is less than 10 micrometers and the degree of purification achieved go up to 0.1 g / cm^2.

The generator can be built in several variants; a plant often used is that of the generator jet. The generator is composed of a nozzle and a resonator in an air jet which strikes the product nozzle. The power of the generator may be in the range 70-130 W at a frequency of from 6 to 6.5 kHz, intake air overpressure nozzle is 90 kg / m², and the flow rate of gas that can be treated is from 10 to 20 m³ / h.

In conclusion we can say that this type of treatment is used for low flow gas scrubbing efficiency is very good, and construction of the facility is simple and does not have very high costs. For high power industrial applications, are built generating modified as generator siren. It is driven by a turbine. It has a rotor provided with holes corresponding to openings of a stator and the like. Sound waves are generated at periodic air out through the openings of the stator and rotor. The power of this generator can go up to 10 kW, with intensities of waves of 10 W / cm² at frequencies between 1-200 kHz.

In these cases, the flow of gas that can be treated can reach up 40000mc / h. The gas to be cleaned while undergoing sound field, crossing tower agglomeration after falling into a cyclone where congestion occurs deposition of particles. This type of filter is relatively little used in the refractory industry.

2. Experimental work

Technological processes occurring in the manufacture of refractory and construction materials produced by SC Helios SA Astileu, Romania, accompanied by significant dust release, leading to exceeding the maximum permissible concentrations to both total and sedimentary dust. The main cause leading to this situation is the downtime of dust removal existing machinery or damage or lack of skeletons related to equipment that generates dust, wear and tear of the technological equipment.

The chamotte grinding line was provided by the company's initial project with three filters Comelf Bistrita type with the flow of 18,000 m³/h each and three blowers. The filters were very old being mechanically shacked, with mechanical maintenance mode rather cumbersome and were out of service. Associated piping was also decommissioned. The clay grinding line was equipped with a system of multi-cyclones and a bag filter type Comelf Bistrita. Cyclones are generally less used dusting equipment nowadays as a result of dust removal efficiency and high hydraulic resistance developed by such equipment. Both cyclones and bag filter are out of service. Cyclones related to other technological flows respectively to dosing mixing and sewerage do not work. Many of dusting machines were broken up, especially in addition to being overcome in realizing that they technically do not pollute excessively.

Considering that the production level achieved is very low compared to that projected (approx. 10% for refractory bricks) the overall level of pollution is very high [1]. Technological flows used in higher capacity and which are the most polluting with powders are: the flow (line) of grinding degreasing and the flow (line) of grinding clay.

2. 1. Line of grinding degreasing

The chamotte obtained in the chamotte workshop stored in silos 1-8 is extracted using vibratory feeders, discharged on bands Tb10 - Tb13, from here, with elevators E3, E5 reach Tb14 bands, Tb15 lines that feed grinding degreaser follows:

* Tb15 feed impact mills M3 and M4
* Tb14 and feed impact mills Tb16 M5 and M6
* Tb14, Tb17 and Tb18 feed impact mills M1 and M2

Impact mills M1, M2, M3 and M4 can be fed from raw material box with the conveyor Tb7. Impact mills are hard materials granulation equipment (chamotte, refractory bricks waste) which perform crushing achieved by moving the rotor and striking two pallets. M1 and M2 mills are distinct lines for spilled material in elevator E1 or E2 on sieves 1 and 2 and from here in the silos of the grinding workshop. Mills 3-6 are grouped M3-4 and M5-6 discharging on the sieve 3 and 4, then a conveyor carries chamotte in silos. Mills make continuous granulation between 1-4 mm the refusal of the sieves being reintroduced to pelleting.

2. 2. Line of grinding clay

Clay stored in the workshop halls grinding is inserted into the processing flow to grapple with the bridge. Clay is discharged from Clam bunkers crushing machines: impact mill and crushing roller. From the impact mill cone through the feeder with clay tiles, the clay reaches the impact mill where it is crushed to 50mm. The material fed into the hopper drum masher is also crushed to 50 mm. From these machines the clay is carried by the conveyors to the main drier or to the disintegrators. Drying is done in the clay rotary dryer with burning oil fuel, the gas dilutes in the connection room, the clay being dried concurrently. The clay is dried to 3.5% moisture. From the dryer the clay reaches the elevator chain, which by sewers with sybarite is overflowed in disintegrators 1-4 depending on scheduling module production. The disintegrators are used to grind the binder clay, which also realizes the grinding by rotation in the opposite direction of two rotors with different diameter bars, Φ = 1,000 mm - large rotor, Φ = 800 mm rotor and small, with independent power.

The disintegrators are grouped into two lines, one in operation and one in reserve on the same line. The material ground to a fineness of max. 10% over 1 mm is spilled on the elevators as follows: disintegrators 1.2 on elevator E3, disintegrators 3.4 on E8, which transport the clay to the sieves 5,6. Fraction usable enters the silos of the grinding workshop, and the refusal to disintegrators 1.2 is recycled.

2. 3. Line of sorting - crushing waste

Incoming waste coming from outside by railway wagons are downloaded on line 13 in four boxes under CFU line (railways of the factory). External or internal waste arriving by car are stored either in boxes or on a concrete platform sorting-crushing station.

Waste are taken over by cup machines and introduced in the swinging bunker feeders where sorting is performed, fine material debris is picked up by conveyors and transported to the warehouse to evacuate to dump industrial waste, and usefulness is over Tb1 band that feeds jaw crusher. Large waste contaminated with melt, slag, etc. are removed manually from the conveyor.

Jaw crusher, type 6A, makes coarse crushing waste after falling on conveyor E7 which discharges on the impact mill, then from here it comes on the vibrating sieve and then by conveyor Tb 4 in silos, separated usable fraction of refusal. From the mills the waste takes the mentioned flow to the line degreaser - chamotte.

All the mentioned flow: funnel, insert strips and sand and feldspar, which are raw materials that do not require processing.

2. 4. Description of installations and solutions adopted

The factory described above is equipped with many machines that nature made materials and technological operations are generating pollutants, especially powders and burning gas. Some of the biggest powder polluters are as follows: granulators, elevators, disintegrators, vibrating sieves, conveyors.

Along the transport of powdery materials on the conveyors we notice places where dust is massively produced by the fall of materials on the conveyors, and from the conveyors to sewers.

In order to reduce pollution from this type of machinery we recommend the use of dust suction devices hood shaped. They must be designed and installed in such a way to allow easy access to the strip.

The airflow sucked from the end of the strip is generally of little value because the air tends to enter inside the hood, even without forced aspiration.

Intake air flow rate is calculated so that the opening of the device to achieve a speed of about 1 m / s.

The elevators, through the building itself are encased on their full height. Due to loss of material from the cups, air entrainment effect creates negative pressure in the opening entry in the elevator head and overpressure on the foot elevator. Due to this mode of distribution of pressure inside the housing there is taken into consideration the fact that the suction at the end of the elevator is made with a lower flow than the suction at the foot of the elevator.

The first and most important measures to be taken to the elevators are repairing and sealing of housing over the whole height of the elevators. Waste from crushers, roller mills, ball mills, has the common particularity that the dust particles they issue have their own quite significant kinetic energy. Due to both these causes and their construction the most effective method of dust removal consists either on casing the whole body of the machine, or closing that part of the machine in which dust is released. Air flows to be sucked from the suction devices are set experimentally, depending on the size of the openings. Shaker dust generators are large machinery. On such machines air flows is determined based on a specific rate on each 1 m^2 of sieve. This flow should be checked so that the air speed by opening the housing to be minimum 1m/s [2].

In order to reduce pollution levels in the company there is required to install two cyclones:

1. Waste cyclone line - grinding, Fig. 1.
2. Clay cyclone line- grinding, Fig. 2.

In view of selection of dust removal equipment the airflow loaded with dust to be vacuumed must be calculated.

Debits are chosen based on the experience of similar installations as well as literature.

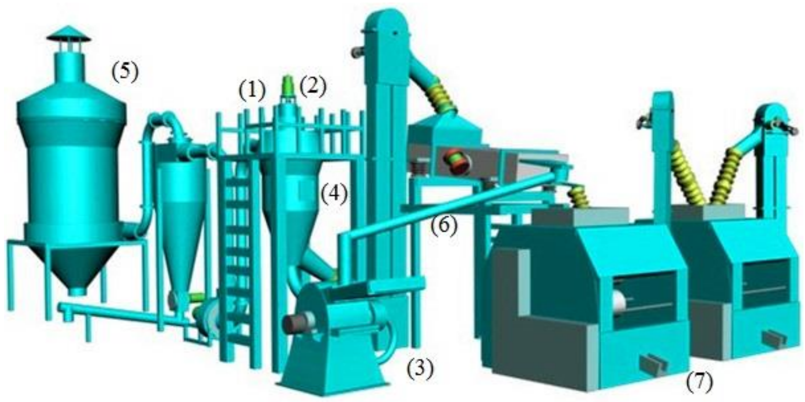

Fig. 1. Waste cyclone line
(1) - main frame; (2) – analyser; (3) – blower; (4) - finished product cyclone separator; (5) - micro mist cyclone separator; (6) - air duct; (7) - breaker

To the calculated debits we always add a reserve of about 3,000 m^3/h, so it results for the installation at point 1 a total capacity of 30,000 m^3/h and for the installation at point 2 a flow of 30,500 m^3/h. The dust removal of the silos at spill on the conveyor lane will be made separately by a small filter (the total flow to be de-dusted is 3,150 m³/h). Each of these dust removal lines consists of metal tubing of black sheet, bag filter, fan and compressed air connection. Dusty air sucked from technological machineries is run through pipes in the bag filter where it is cleaned. From the bag filter the air is sucked by a ventilator and blown outside by a basket sheet smoke stack.

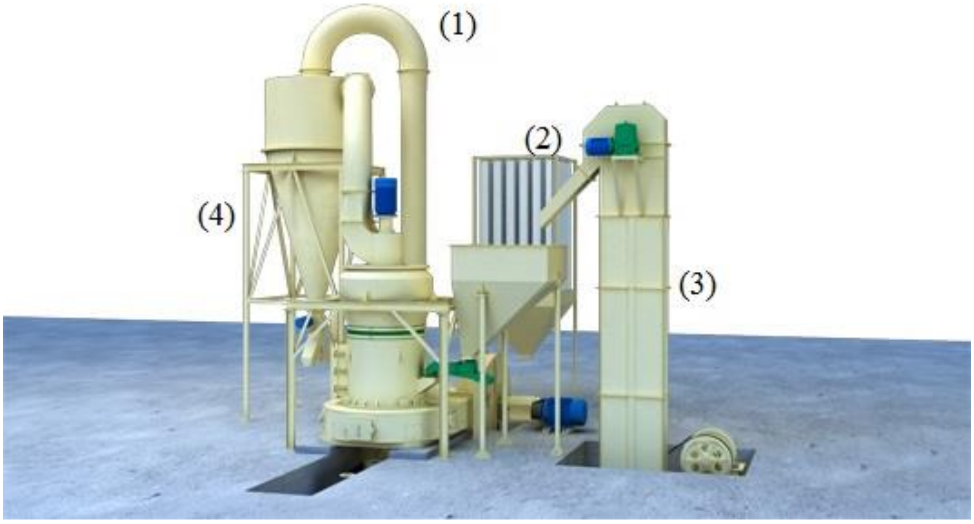

Fig. 2. Clay cyclone line – grinding
(1) – pipe; (2) - bag filtere; (3) – ventilator; (4) - cyclone separator

For the election of the cyclone reactor several variants were analyzed.

Of filters analyzed there were chosen filters Comelf Bistrita due to preferences of specialists from SC Helios SA Astileu, Romania explained by the fact that the company was equipped initially with such filters, and there is a significant experience in maintenance, repair of these filters and some aspects related to the price. Besides sizing (election) of the dust removal installation, dusting network dimensioning will be performed. Sizing pipes will be biased towards the suction flow as well as the best route so the pressure loss to be cut to a minimum.

2.5. Determination of air flow from the generation points of the pollutants

Circulation of appreciable quantities of raw-material containing fine particles requires ensuring the optimum conditions to work in warehouses and also prevent the spread of dust particles outside the halls, casing all of the technological equipment.

A well-executed casing ensures retention of approx. 80-90% of the amount of dust released. This is the case of flows specifically used in refractory industry as: transporters, elevators, impact mills, ball mills, bunkers for materials, equipment that can be theoretically very well cased. To achieve a higher efficiency of these cases and other types of casing (points of falling materials on conveyor belts) it is necessary that the cases aspirate some air. To ensure the necessary effectiveness the air flow drawn from a case must be greater than the amount of air introduced with materials falling so as to maintain a depression to prevent escape of any dust caused also by causes other than overpressure. In this situation the relationship to calculate the airflow is:

$$D = D1 - D2 + D3 \ (m^3/s) \tag{1}$$

where

- D1 – the amount of air introduced into the case by moving materials into the supply chute;
- D2 – the amount of air extracted from the case by the materials dropping out (if applicable);
- D3 – the amount of air to be sucked from the case for maintaining a dynamic depression.

2.6. Determination of the airflow engaged by materials (silos, screeners, sieves, transporters)

$$D = 1{,}108 \sqrt[3]{PA^2} \ (m^3/s) \tag{2}$$

where:

P - power transmited to the air by the falling material (W)

A - section of material valve (m2)

P = 9,81 Mh(W)

M - flow of falling material (kg/s)

h - height covered in the respective uniform motion.

It is believed that the use of this formula is fulfilling because the computing hypothesis states that every particle of material from the valve acts independently on the air as if being completely separate from the other; in reality the material falls as a semi-compact column and the engaging effect is due more to material valve in its totality than to the independent action of each particle and the sum of actions of each particle is higher than the unique valve; assuming calculation considers the particles have the same dimension [6]. In reality, within the valve of material there is a variety of particle sizes, leading to a range of speeds fall. As a consequence there are many small particles falling behind larger particles in the air flow created by them, and not the entire energy of particles is transmitted in the air, some of it is lost in heat after friction with the air.

2. 7. Determination of the airflow to be sucked from the case in order to maintain a certain depression

The amount of air to be sucked from a case for maintaining a vacuum ps (mm H2O), when the total area of housing is poor seals and openings F (m2) is calculated using the equation:

$$D_3 = 2,4\ F\ \sqrt{ps}\ (m^3/s) \quad (3)$$

Although up to the present time complete data there have not been set about depressions carcasses to be maintained in order to prevent escape of air with dust, in the literature (Table 1), there are some data that can serve to determine these flow rates:

Table 1

Computing recommendations

Name of the equipment	**Depression [mm H_2O]**
Roller mill	0.15÷0.20
Jaw crusher Conic crusher Wave crusher Hammer crusher	0.1 0.08÷0.10 0.08÷0.10 2-3
Disintegrator mill Ball mill Tubular mill	6÷7 0.20 0.10÷0.20
Plane sieve Rotating sieve Vibrating sieve	0.10÷0.20 0.10 0.10÷0.15
Disc feeder	0.08÷0.10
Bunker	1.0÷1.5
Place of falling of material on the conveyors	0.20
Elevator	0.20
Transporter	0.10

All these considering, there were determined unit rates to be taken into account in determining the actual flow in the case of machinery present in the flows from S.C. "HELIOS" S.A. Astileu, Romania. The results are shown in table 2.

Table 2.

Unitary flow values to be taken into account in determining the actual flow of the technological equipment

Area	**Uniform flow required in m^3/sm^2**
Jaw crusher	$D_{3.1} = 2.4\sqrt{0,1} = 0.76$
Hammer crusher	$D_{3.2} = 2.4\sqrt{3} = 4.2$

Crusher	$D_{3.3} = 2.4\sqrt{7} = 6.4$
Tubular mill	$D_{3.4} = 2.4\sqrt{0,2} = 1.1$
Vibrating sieve	$D_{3.5} = 2.4\sqrt{0,15} = 0.93$
Bunker	$D_{3.6} = 2.4\sqrt{1,5} = 3$
Place of falling material from the conveyors	$D_{3.7} = 2.4\sqrt{0,2} = 1.1$
Elevator	$D_{3.8} = 2.4\sqrt{0,2} = 1.1$
Transporter	$D_{3.9} = 2.4\sqrt{0,1} = 0.76$

2. 8. Sizing of suction pipe

To establish the air intake pipe diameters loaded with dust we use the formula:

$$d = \frac{1}{53,2}\sqrt{\frac{D}{v}} \quad (4)$$

where:

d- diameter of the pipe in "m", D – the airflow passing through the respective pipeline m^3/h and V airflow speed m/s.

Given the indications of literature and considering that the airflow engaged there is a fair amount of solid particulates we take a 20 m/s speed to ensure the air flow drive of these particles [7].

Suction recipes in these conditions will have the values shown in Table 3.

Tabel 3

Recipes suction values for each of the areas of the technological equipment

Area	Values for the suction recipes
Lines of clay 1and2 Elevator 7	superior vacuum head 1000 m^3/h, d= 130 mm
Lines of clay 1and2 Elevator 3	superior head suction 1000 m^3/h, d= 130 mm
Lines of clay 1and2 Elevator 3	inner heahsuction 1000 m^3/h, d=130 mm
Lines of clay 1and2 Elevator 8	superior head suction 1000 m^3/h, d= 130 mm
Lines of clay 1and2 Elevator 8	inner heahsuction 1000 m^3/h, d=130 mm
TRANSPORTER conveyor	1500 m^3/h, d=160 mm
Vibrating sieve 1	2500 m^3/h, d=210 mm
Vibrating sieve 2	2500 m^3/h, d=210 mm
Silo	2000 m^3/h, d=190 mm
Crushers 1,2,3 şi 4	3000m^3/h d= 230mm
Belt conveyor	

Suction from all these points meets in two branches:

Line 1 of dust removal summing 15.500 m^3 and d = 550 mm; Line 2 of dust removal 11.500 m^3/h si d= 470 mm.

In conclusion, the capacity of the filtration equipment and of the air circulator - must be a minimum of 27,000 m^3/h. [8]

3. Conclusions

The stability of the market for refractory products in recent years has been quite severely disrupted by various internal and external factors, which had repercussions on the economic development of society, including the environmental protection. Specifics of industrial activities in the refractory materials sector generates as the main pollutant particulates emitted into the atmosphere. These powders are captured by various technological installations and only a few are released in a controlled atmosphere through exhaust stacks.

There are also significant quantities of powders emit poor seals, the lack of doors, windows, natural ventilation due to production halls but also due to equipment malfunction dusting. Powders issued by SC Helios SA Astileu, Romania are in largely (70%) powders of large diameter 0.1-1 mm and they lay in close proximity to places of emission. Particulate matter smaller have diameters up to 20 microns, so we can consider that a relatively small fraction of particulate matter with diameters between 0-0.5 mm is the particulate matter. As a result of determinations there was found that the largest amount of dust is discharged into the atmosphere from the grinding, pelleting (all companies), dosing and mixing pressing, pneumatic transport. We observe that the dust removal equipment is not working as designed due to the fact that it is outdated and absolute. As a result it is required for the implementation of a modernization of cyclones, technological flow, which track connections of all noxious equipment to capture installations.

The necessary investments to be made will consist of filters, but its small capacity for storage silos, repair and equipping of the old existing and resize reorganization of production on a minimum number of streams and machinery.

The paper was drafted on the basis of documentation made on the spot, that the observations made in the field, based on technology provided by the company management , and based on determinations of pollutants discharged into the environment. The products of this company are recoverable in activity accompanied by emission is gaseous, solid and liquid. Reduce or eliminate these emissions is imposed by environmental legislation and is the basic condition for further processes, the solution currently practiced is generally discharge to the environment of pollutants and quantities of raw materials.

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