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Clinker Dust Emissions Elimination in Atmosphere.

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ABSTRACT

During the operation the aerodynamic hypothesis of dust removal was checked by the examination of dust particles dispersion, temperature and the pressure of dust and gas flow. The researches established that instead of the furnace head vacuum the excess pressure is developed. A mathematical model of a real happening aerodynamic process was developed, as well as the mathematical experiment and research planning was performed using the obtained data. It was established that most of the dust removal takes place in the gap between the furnace head and the side. A useful system model was developed to provide the clinker dust return in the refrigerator and to prevent its release into the atmosphere. The developed device is aimed to prevent the accumulation of dust spillage in the air jet chamber and thorough cleaning. The use of such a device of clinker dust return in the refrigerator allows to remove it timely, and the electric vibrator ensures the completeness of dust drop in the fridge, thereby eliminating the accumulation of dust in the chamber and its operation deterioration.

Key words: Large rotary calcinators, seal, dust emission, the discharge end of the furnace, air tightness, cement kiln refrigerator, dust-air mixture.

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INTRODUCTION

The technological process of bulk solids and construction materials production is accompanied by intensive emission of a significant amount of dust in the air. This increases the technological impact on the environment, and also leads to a change in the amount of energy consumption depending on the source of dust emission, thereby the process of building materials production is violated [1]. One of the major sources of dispersed dust is the gaps between the housing of the rotary calcinator with a cooler chamber and a smoke chamber. Apart from dust emissions the outside air is introduced through these gaps at the discharge end of the calcinator and it must be heated in order not to violate the fabrication process [2]. An excess air appears at the charge end of the calcinator as the result of excess air leak-in, which must be removed to provide vacuum in the calcinator body. Therefore a heat carrier shall be added on one case to ensure the correct flow of raw materials firing process and the electric power to increase the power of fans, creating a vacuum in the second case. The performed studies established that a number of cement plants does not have almost any sealing devices and it makes the overrun of heat and energy carriers almost two times more than in the calcinators of western production [3]. The lack of sealing devices is conditioned by the fact that the industry does not manufacture them, and the plants are forced to make their own sealing devices, i.e. the sealing devices of own design. However, such seals do not provide the desired effect on the detention of dust emission in the atmosphere [4].

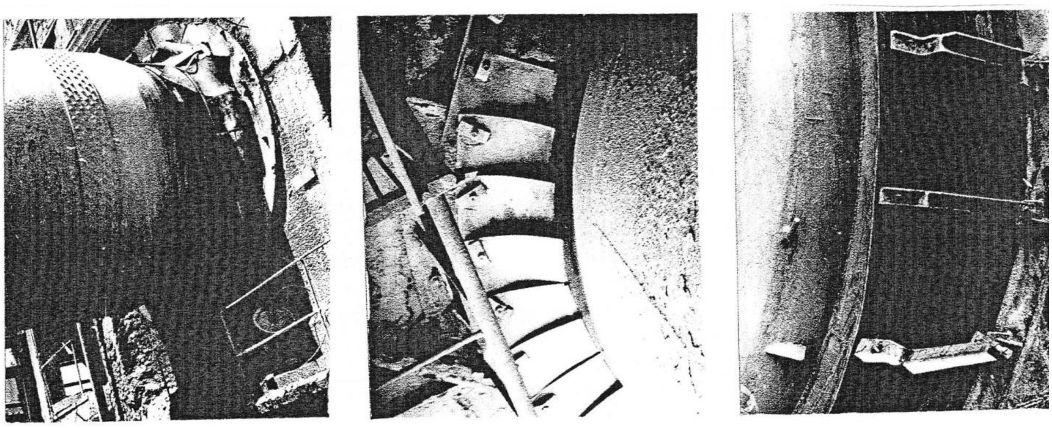

Figure 1: The seals of rotary cement calcinators

The largest emission of clinker dust occurs on dry production calcinators. A number of plants was examined in order to establish the causes of dust emissions. The sealing device on the hot end of the calcinator is designed not only to prevent the suctions of outside air, but also to prevent the release of dust that falls out from the fridge into the mine and into the atmosphere through a poor-quality seal. The greatest amount of dust is emitted from cement production by dry method [5].

MAIN PART

The concentration of dust, the particles dispersion, the temperature and pressure of the solid and gas flow was examined to test the aerodynamic hypothesis of dust emission. It has been established that an excess pressure is created in the furnace head instead of vacuum.

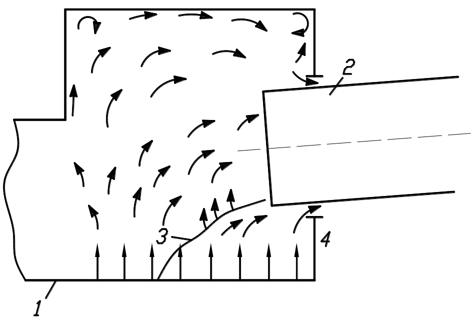

Figure 2: The dust air mixture motion pattern in the refrigerator of a rotary calcinatory

The wall region 4 has a reduced gas velocity, and if we take into account the cohesive forces between the wall and the particles, the phenomenon of solids buildup on the refrigerator walls becomes clear. On the other hand, the developed turbulence of the gas flow prevents the accumulation of dust on the walls. There is an optimal wall dust thickness corresponding to the dynamic equilibrium in which the amount of dust carried away by the flow is equal to the amount of dust settling on the wall at a unit of time. This thickness is small (according to rough calculations for the side walls, it does not exceed the half of the logarithmic inner layer). Nevertheless, due to the large area of the total refrigerator wall surface, the amount of deposited dust may be considerable and it may not be negligible. The developed turbulence and, consequently, the local pressure differences is one of the slit dust emission causes. The elimination of dust buildup on the refrigerator machines and the subsequent involvement of dust into the main stream will reduce material waste and increase the refrigerator efficiency. This may be achieved by the vibration of surface with the means of sound or ultrasound. The ultrasonic sound waves will also contribute to the coagulation of particles and its removal from the refrigerator, and the crevice dust discharge will be reduced at that [6].

The dust air mixture structure flow is significantly influenced by the angles, which create the flow vorticity zones the size of which is gradually increased. The angle may be represented as the combination of vertical and bottom walls. As a result, the adhesion forces with the vertical wall and the frictional forces on the bottom wall the flow zone tends to stretching in a horizontal direction. At a certain critical size the vortex zone breaks down from the wall and carried away by the stream. After that a new vortex zone is formed near the angle top, which grows to a critical size and re-breaks, etc. As a result, there is an accumulation of dust, and the amount of it should be cyclical. The approximate calculations by formulas confirmed the increased accumulation of dust in the corners (about 8% of the dust contained in the refrigerator, is always in its corners). It is necessary to smoothen the corners to prevent this phenomenon, giving them the line shape the equations of which may be obtained from the source. If we take a circular arc with a central angle less than $\pi/4$ as streamlines, it is possible to achieve a satisfactory effect of the corner dust accumulation reduction [7].
The dominant influence on the air dust mixture flow structure flow is made by a calcinator protuberance entering at the angle in the cooling chamber, and the oblique collision of material jet 3. The availability of an oblique impact of the material on the plane 4 generates an intense solid phase flow, whereby the the air dust flow is stratified [5].

The mathematical design of experiments was used to establish and carry out the corresponding experiments. According to the proposed hypothesis, it is necessary to establish the presence of the electrostatic field around the end portion of the furnace casing. The specific points were defined, which were necessary to make the potential measurement to confirm the physical and mathematical calculations and to establish a true picture of the field. According to the preliminary calculations, the potential value of dust reaches its maximum in the end plane and is decreased in the axial direction along the calcinator body. So the first point of potential measurement was taken in the plane end of the calcinator at the distance of 200mm from the furnace surface. The following measurements were carried out at the point located on the same radius and the same end plane but 20mm closer to the furnace axis. The following measurement was performed in a similar manner, but still 20mm closer to the furnace axis. And so on, until the furnace body surface. The next radius on which the measured points were located should be parallel to the former one shall be moved away from it along the furnace axis in the direction of the other end by 30mm. At this radius the control points are similar to the first radius. I.e. the first point of the radius is located at the distance of 200 mm from the furnace body surface. Each next point of this radius is located 20 mm closer to the furnace body. Next radius and its point is located similar to the previous one, only 30mm from the furnace axis towards the other end. The extreme or the last radius at which the magnitude measurements of the potential at the end points were performed, was at a distance of 3000 mm from the furnace end [6].

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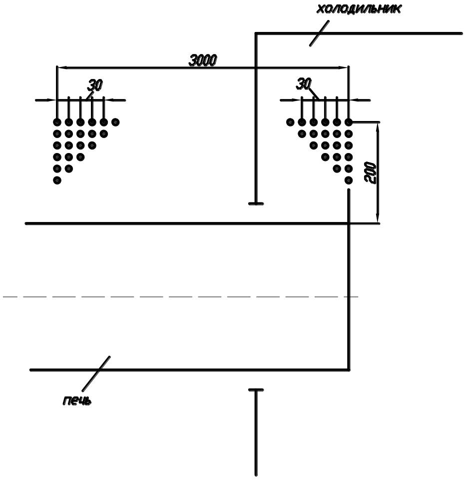

Figure 3: Electrostatic field potentials measurement scheme

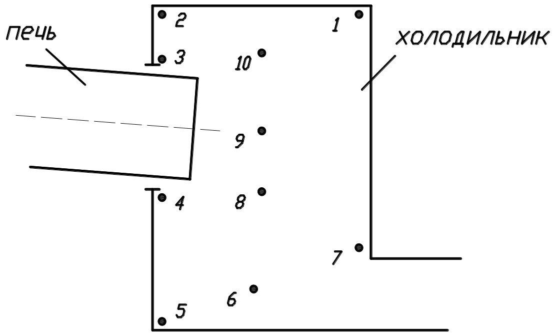

Figure 4: Layout of aerodynamic process control points

The determination of the field actual picture and the use of experiment mathematical planning allows you to select the number and conditions of experiment performance to find out the real reasons for dust removal. The potentiometer will be served as the instrument for measuring. The mathematical planning of experiments is used to establish and carry out the experiments according to the aerodynamic hypothesis.

A number of measurements is performed to confirm the partial or complete validity of this hypothesis. These measurements gave a complete and realistic picture of the aerodynamic processes which take place in a furnace. This in its turn serves as the basis for mathematical planning of the experiment and its implementation. According to the proposed hypothesis the following physical characteristics of air dusty stream are measured in several specific points: the concentration of dust particles, the dispersion of flow particles, the temperature and pressure. The location of specific points is shown in Fig.4 [7].

The dust concentration is measured by a special ICP-1 unit, in which the air dust mixture is sucked up from any portion of the refrigerator via a special hose. The dispersion of particles flow was measured visually using the device, the control point particles were delivered using a special device. The temperature and pressure in all points was measured respectively with a thermometer and a manometer. A real mathematical model of the performed aerodynamic process was developed, as well as the mathematical planning of the experiment and research was performed at the use of the obtained data. It was established that the dust removal takes place mainly in the gap between the furnace head and the furnace sidewall. As a result of the dust flow study coming out of the gap at the hot end of the calcinator, its following features were presented:

- uniform distribution along the generating furnace;
- lack of sticking or settling on the furnace wall, i.e. the presence of a constant gap with the furnace surface;
- constant speed;

- Different concentration of dust by thickness (in the direction normal to the furnace axis), i.e. the flow is composed of several dust layers with different concentrations with the greatest concentration in the first layer of the furnace [8].

The overpressure appears due to the "blocking" the furnace flow area. This effect is manifested in the ability loss to discharge furnace gases by smoke exhausts in the required amount to the atmosphere due to the extreme pressure across the refrigerator-pipe gas channel associated with various phenomena in aggregates located at the gas flow path. In this case the part of the gases and dust is discharged through the gap of a furnace body - the refrigerator shaft.

CONCLUSION

According to the above mentioned research a useful system model was developed to return the clinker dust in the refrigerator and to prevent its release into the atmosphere [9]. Due to the fact the that the existing rotary cement calcinators by the virtue of their structural features and technological process have an axial and radial movement, which do not allow the connection without their gaps with the cooling chamber, resulting in 100 mg clinker dust emission per m3 of gases, i.e. a per day emission reaches up to 43.2 kg for the furnace with the diameter of 5 m through the available gap, which can reach up to 250 mm under the pulsing furnace operation of the refrigerating chamber. This clinker dust settles in a sealing device and gradually deforms and breaks it and the dust penetrates into the atmosphere. The dust penetrating into the pneumatic jet chamber may include a large fraction (a stuck together clinker), which is not always blown with a stream into the refrigerator from a pneumatic jet chamber and its accumulation is started, and under some unfavorable conditions the section is decreased and the locking of a pneumatic jet chamber occurs [10].

The developed design is aimed to prevent the accumulation of dust drop into a pneumatic jet chamber and a thorough cleaning. The device of clinker dust return in the refrigerator containing a daisy type device with the conical hopper placed at the bottom and attached to the refrigerating chamber body and a vertical pipeline with shutter attached to the conical hopper with adjustable weights for its opening and closing and an electric vibrator located under the pneumatic jet chamber. Under the influence of the electric vibrator the body of the pneumatic jet chamber accumulates dust, dust drops and large particles which are destroyed and may be easily removed by air flow into the fridge, thereby avoiding the pneumatic jet chamber locking and providing its full cleaning and the dust return into the refrigerator.

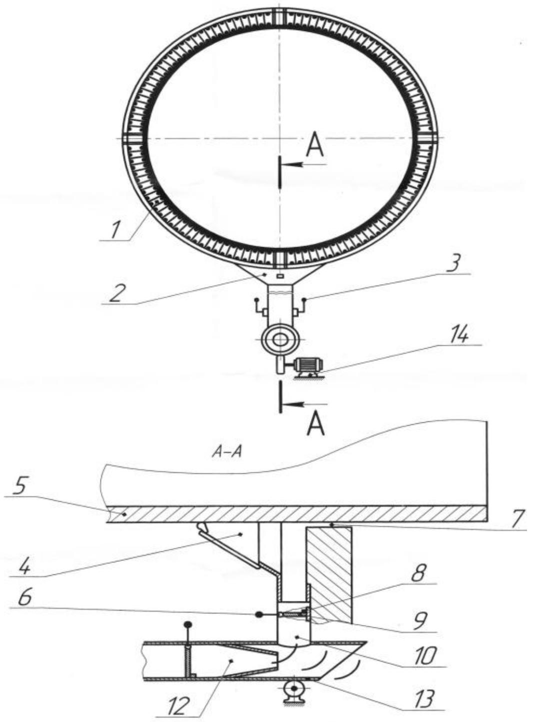

Figure 5: The devices of clinker dust return into the fridge

- The rotary cement calcinator 1 comprises a sealing device 2 with a conical hopper located at the bottom 3 attached to the refrigerating compartment housing 4 and forming the inner space of the sealing device 5. The conduit 6 is attached to the conical hopper which has a valve 7 with a threaded and loaded arm 8 and the abutment 9. The lower part has an air damper 10 into the cone 12, located at the chamber 13, under which the vibrator 14 is installed [11].

- The removal of solids (clinker dust) from the interior space of a daisy type sealing device occurs as follows. During the operation of a cement rotary furnace 1 the solids (clinker dust) via a gap 11 between the rotating furnace and the refrigerating compartment 4 under the gas pressure comes into the inner space of a daisy type sealing device daisy type 5 and there from are poured into a conical hopper 3 and then come to the damper 7 which is pressed under the action of a loaded threaded lever 8 to the abutment 9, when the mass of discharged solid particles forms a discharge moment with a flap, which is more than a load moment, the flap turns and the discharged mass of solids enters the conduit 6 and then into the chamber 13. The discharge of chamber 13, is blown by the air flow from the nozzle 12 in the fridge and simultaneously activates an electric vibrator 14 which prevents the compaction of in the chamber 13 drops [11].

CONCLUSION

Thus, the use of such clinker dust (solids) return devices in the refrigerator allows to remove it, and an electric vibrator ensures the complete reset of dust into the cooler and eliminates the dust accumulation in the chamber and the deterioration of its performance. The use of the clinker dust return device in the refrigerator has the following advantages:

- it ensures the complete removal of dust drops in the refrigerator;
- it reduces the air flow to clean the pneumatic chamber;
- it reduces the spill treatment (removal) term;
- it eliminates the possibility of clogging due to sediments in the pneumatic chamber.

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