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Prevention of air pollution swimming pool in the area of elevator construction using aspiration equipment

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Abstract. The purpose was to study the efficiency of the use of aspiration equipment of the BC type and its efficiency of use today in comparison with the advanced achievements of aspiration technology in the elevator industry for the process of creating air dilution and removing grain dust during the operation of equipment using the example of a modern silo elevator with a capacity of 20,000 tons, in grain production, including acceptance and storage of air-conditioned grains. In order to achieve the purpose of the study and answer the research questions about the effectiveness of the installations of battery cyclones of the BC type, a calculation was made on the amount of grain dust emitted for a period of 365 days of elevator operation in 3 shifts according to the "Temporary method of calculating planned indicators for the protection of atmospheric air of grain processing enterprises and elevators", in accordance with the "Calculation Method aspiration installations and explosion-discharge devices", series 14, issue 1 "Industrial safety of explosive grain storage and processing facilities".

1 Introduction

Agriculture in Russia is a major branch of the country's economy. Russia ranks first in the world in wheat exports. In particular, the grain food industry is one of the main sources of income of the country when exporting agricultural products [1, 3]. Due to the promising development of the agricultural industry, where grain export is a strategically important factor for the state economy, the urgency of building grain storage and processing enterprises is increasing. According to statistics for 2020, the total volume of exports of agricultural raw materials and food reached 30 billion dollars [4-7].

Such an intensive growth in the development of this industry entails an active demand for the construction of elevators. The main concomitant phenomenon in the operation of such an enterprise is the presence of grain dust, which contains harmful substances that affect the health of workers and the population located close to the territory of the elevator

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[2-9]. One of the vital elements of the natural environment around us is atmospheric air [4, 8-11], a particular danger is the presence of grain dust particles in an unloaded airspace, which leads to an explosive situation at the enterprise. To do this, special aspiration equipment should be used at elevators in accordance with the "Safety rules for explosive and fire-hazardous production facilities for the storage and processing of plant raw materials" approved by Rostechnadzor Order No. 475 of November 15, 2016. To date, relatively modern equipment, such as spot local filters, is increasingly used to purify the air from industrial dust during grain transportation at the enterprise and remove it [10, 12]. However, in parallel with new technical discoveries, many enterprises have been actively using battery installations of the BC type, which are part of the aspiration network, for more than half a century [13-16]. This choice is justified by significant factors that are investigated and presented in this article on the example of a modern silo elevator with a capacity of 20,000 tons, in cereal production, which includes acceptance and storage of conditioned grain.

2 Materials and methods

The object of the study is the aspiration equipment of the BC type and its efficiency of use today in comparison with the advanced achievements of aspiration technology in the elevator industry and for the process of creating air dilution and removing grain dust during the operation of equipment on the example of a modern silo elevator with a capacity of 20,000 tons, in cereal production, including acceptance and storage of conditioned grain.

The technological complex includes the following buildings and structures:

1. Device for receiving grain from vehicles for two passes (position 1);
2. A block of two waste bins (position 2);
3. Grain shipment device for motor transport OAT2hSKD5/7-45 (position 3);
4. Control post and PSC (position 4);
5. Grain storage tanks SPD 18/19 — 4 pcs, with a total capacity of 20,000 tons (position 5...8);
6. Conveyor elevated overpasses (position 9...12)

The scheme of the technological process provides for the following operations:

- Receiving grain from vehicles with feeding into any row of grain storage tanks SPD 18/19;
- Pumping grain from container to container, as well as from each row of containers to any row of containers;
- Shipment of grain from grain storage tanks SPD 18/19 to motor transport

Production management is carried out by an automatic process control system (automated process control system) based on personal computers with the installation of equipment in the control room.

Working hours — 3 shifts, 365 days a year.

Air purification in aspiration units is provided at the installations of battery cyclones of the BBCSC Corporation LLC with the use of fans of the company "Plant "FAN"". To reduce the volume of dust emissions to the regulatory limits, aspiration of all dust formation sites is provided. Such places include: the place where grain is shipped from vehicles to the receiving bunkers; the shoes of the noria; the places of loading and unloading of over-silo, under-silo and transporting conveyors around the enterprise. The arrangement of aspiration networks into a common network was made, according to the principle of consistency and simultaneity of equipment operation in order to make more rational use of energy resources (Table 1). Calculation and selection of equipment is carried out on the basis of passport data of the above-mentioned companies.

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Table 1. Layout of aspiration units.

Name of aspirated machines	Otm. installatios	Number of cars	Air suction rate from 1 machine m3/hour	Just suck it off. air m3/hour	Dust separator, fan
1	2	3	4	5	6
Device for receiving grain from vehicles for two passes (position 1)					
Aspiration unit No. 1					
Bunkers devices for receiving grain from vehicles B1	0,000	1	1300x5	6500	Battery installation of cyclones BBTS-500 No.3.1 VCP 7-40-5 fan No. 4.1
Qvent.=6500x1.05+150=6975 m3/hour					
Aspiration unit No. 2					
Noria II-175 No. 1.1 Scraper conveyor №.2.2; No. 2.5; No. 2.11	0,000 -4,550 +10,500 +30,200	1 3	1540 510x3	3070	Battery installation of cyclones BBTS-350 No. 3.2 VCP fan 5-45-4,25 No.4.2
Qvent.=3070x1.05+150=3376 m3/hour					
Aspiration unit No. 3					
Noria II-175 No. 1.2 Scraper conveyor No..2.6; №.2.7; №.2.10	-5,450 0,000 0,000 +30,200	1 3	1540 510x3	3070	Battery installation of cyclones BBTS-350 No.3.4 Fan VC 5-45-4,25 No..4.4
Qvent.=3070x1.05+150=3376 m3/hour					

Aspiration equipment is designed to remove grain dust and gases that are formed during the operation of technological equipment at the enterprise.

Grain dust is a substance consisting of small particles arising from the process of friction of grains against each other and against the walls of equipment when moving in production. Grain dust is multifaceted in its composition. It contains mineral dust (soil), destroyed grain and plant parts, weed seeds, mycelium and spores of fungi, microbes, insects and mites. Grain dust and fungal spores are dangerous for the health of workers and the population of residential territories adjacent to enterprises. It is a source of so-called "grain fever", chronic lung lesions ("farmers' lungs") and other systemic lesions of internal organs when exposed to grain dust (Table 2).

Table 2. Maximum permissible concentrations (MPC) of grain dust.

MPC maximum concentration of grain dust in atmospheric air		
	one - time	average daily
urban population	0.5 mg/m^3	0.15 mg/m^3
rural population	0.5 mg/m^3	0.15 mg/m^3
MPC of grain dust in the air of the workspace		
4 mg/m^3		

The main danger is the easy flammability of this substance in combination with the creation of reduced pressure during grain transportation. It belongs to the 3rd hazard class in terms of toxicity and explosiveness.

The object of the study is the aspiration equipment of the BC type and its efficiency of use today in comparison with the advanced achievements of aspiration technology in the elevator industry. Battery installations of the BBTS type are designed to capture medium-dispersed dust in pneumatic transport systems and aspiration installations.

The principle of operation is to remove dusty air, which enters the cyclones through the inlet pipe and receives a rotational helical motion. Under the action of centrifugal force, dust particles are pressed against the walls of cyclones, lose speed and are deposited down into the collecting cone. With the help of sluice gates, the collected dust is discharged into the dust collector, and the purified air is discharged from the cyclones upwards or sideways into the purified air duct through the exhaust pipes of the cyclones and the collection box.

In order to achieve the purpose of the study and answer the research questions about the effectiveness of the installations of battery cyclones of the BC type, a calculation was made on the amount of grain dust emitted for a period of 365 days of operation of the elevator in 3 shifts according to the "Temporary method of calculating planned indicators for the protection of atmospheric air of grain processing enterprises and elevators", in accordance with the "Calculation Method aspiration installations and explosion-discharge devices", series 14, issue 1 "Industrial safety of explosive grain storage and processing facilities".

The organized sources of emissions are assigned numbers from No. 1 to No. 3, respectively, to the numbers of aspiration units.

The calculation is made according to the formula:

$$m = V \text{ x } Z_K, \text{ g/sec, where:}$$

m - dust emission, g/sec;

V - volume of air emitted by the source, m^3/sec.

Z_K - dust concentration in the air after cleaning, g/m^3.

The concentration of dust in the air after cleaning (ZK) is determined according to Table 10 (Appendix 32) "Methods for calculating aspiration installations and explosion-discharge devices" depending on the dust concentration and air velocity at the entrance to the dust separator.

The device for receiving grain from vehicles for two trips (pos. 1)

Table 3. Aspiration unit No. 1.

Polluting substance	grain dust
Air volume	1,94 m^3/sec
Exhaust duct diameter	0,50 m
Ejection height	2,5 m from otm. 0,000 structures
Working hours	1450 hours/year
Dust separator	battery installation of cyclones BBTS-500
Filter cleaning coefficient	at least 95%

Table 4. Comparative characteristics of aspiration unit No. 1.

Name of the aspirated equipment	Volume of the sucked air, m^3/hour	Dust concentration in the air leaving the equipment, g/m^3
Silos of the device for receiving grain from vehicles for two passes	6500	1,3

The weighted average dust concentration before cleaning is 1.21 g/m^3
The amount of dust in the air before cleaning: m = 1,21x1,94 = 2,35 г/сек
Dust concentration in the air after cleaning — 0.0625 g/m^3
Dust emission after cleaning will be:

$$m = 0,0625x1,94 = 0,12 \text{ g/sec}; 0,63 \text{ t/year}$$

The cleaning coefficient of the battery installation will be - 95 %

Table 5. Aspiration unit No. 2

Polluting substance	grain dust
Air volume	1,54 m^3/sec
Exhaust duct diameter	0,450 m
Ejection height	11,9 m from otm. 0,000 structures
Working hours	1450 hour/year
Dust separator	battery installation of cyclones BBTS-350
Filter cleaning coefficient	at least 96%

Table 6. Comparative characteristics of aspiration unit No. 2.

Name of the aspirated equipment	Volume of the sucked air, m^3/hour	Dust concentration in the air leaving the equipment, g/m^3
Noria II-175 No.1.1	1540	2,0
Scraper conveyor No.2.2; No. 2.5; No. 2.11	510x3	0,8

The weighted average dust concentration before cleaning is 1.28 g/m3.
The amount of dust in the air before cleaning:

$$m = 1,28x0,94 = 1,2 \text{ g/sec.}$$

Dust concentration in the air after cleaning — 0,0513 g/m^3
Dust emission after cleaning will be:

$$m = 0,0513x0,94 = 0,048 \text{ g/sec}; 0.25 \text{ t/year}$$

The cleaning coefficient of the battery installation will be - 96%

Table 7. Aspiration unit No. 3.

Polluting substance	grain dust
Air volume	1,54 m^3/sec
Exhaust duct diameter	0,450 m
Ejection height	11, 9 m from otm. 0,000 structures
Working hours	1450 hour/year
Dust separator	battery installation of cyclones BBTS-350
Filter cleaning coefficient	at least 96%

Table 8. Comparative characteristics of aspiration unit No. 3.

Name of the aspirated equipment	Volume of the sucked air, m^3/hour	Dust concentration in the air leaving the equipment, g/m^3
Noria II-175 No. 1.2	1540	2,0
Scraper conveyor No.2.6; No.2.7; No.2.10	510x3	0,8

The weighted average dust concentration before cleaning is 1.28 g/m^3.
The amount of dust in the air before cleaning:

$$m = 1,28x0,94 = 1,2 \text{ g/sec.}$$

Dust concentration in the air after cleaning — 0,0513 g/m^3
Dust emission after cleaning will be:

$$m = 0,0513x0,94 = 0,048 \text{ g/sec; } 0.25 \text{ t/year}$$

The cleaning coefficient of the battery installation will be - 96%.

During the operation of the enterprise, in addition to pollutants released into the atmosphere, non-feed waste from aspiration units No. 1 is formed...3, which accumulates in a block of two waste bins (item 2). As the waste accumulates, it is shipped to vehicles for export to the landfill.

A summary table of data on organized sources of emissions from aspiration plants is given in Table 9. The amount and characteristics of waste is given in Table 10.

Table 9. Summary table of data on organized sources of aspiration plant emissions.

No. of sources	Air volume in the network m^3/sec	The amount of dust released before cleaning. g/sec	The amount of dust released after cleaning g/sec	Polluting substance	Type of dust separator		Exhaust duct diameter, m	Ejection height, m	Working time of the source, hour/year
					Type of BBCB	Cleaning coefficient %			
1	2	3	4	5	6	7	8	9	10
1	1,94	2,35	0,12	Grain dust	Battery installation of cyclones BBTS-500	95,0	0,500	2,5	1450
2	0,94	1,12	0,048	Grain dust	Battery installation of cyclones BBTS-350	96,0	0,355	11,9	1450
3	0,94	1,12	0,048	Grain dust	Battery installation of cyclones BBTS-350	96,0	0,355	11,9	1450

Table 10. Quantity and characteristics of waste.

Name	Place of waste generation	Hazard class	Physico-chemical characteristics of waste (composition, content of elements, condition, humidity, etc.)	Frequency of waste generation	Quantity of waste, t/year	Waste use (tons/year)	
						Transferred to other organizations	Storage in hoarding hotels, landfills
1	2	3	4	5	6	7	8
Non-feed waste of grain raw materials	The device for receiving grain from vehicles for two trips (pos. 1)	III	Aspiration dust deposited in the installation of battery cyclones	Constantly	40,16	-	Removal to the landfill

3 Results

According to the results obtained, the amount of grain dust removed during the year of operation of the elevator is 40.16 tons. This indicator has a positive effect on the evaluation of the efficiency of battery-operated aspiration units of the BBTS type. Since the isolated grain dust not only prevents a fire and explosive situation, contributes to the preservation of the health of the working enterprises and the population closest geographically from the elevator, but also affects the quality of grain harvested for storage during cereal production. This is a significant advantage of these installations over point-based local filters, the principle of operation of which has a slightly different specificity.

4 Discussion of the results

The local filter is installed directly on the equipment that is subject to aspiration and works in parallel with it, that is, when the product is transported and dust formation occurs, the local filter is also started. Accordingly, the need for air ducts disappears. At the moment when the transport equipment is not working, the local filter is also disabled. In each place, the resulting dust is captured and returned efficiently to the process flow, while maintaining a slight negative pressure in the system. As a result, valuable product is not disposed of, product yield and productivity are increased. This is a number of advantages of a point local filter.

However, since the principle of operation of the local filter does not imply the removal of grain dust, but it is allowed back into the product during transportation while maintaining the yield of the product, but at the same time the quality of the harvested raw materials decreases, this is especially important if the raw materials are processed into cereal or flour milling.

Since local filters work using compressed air, the construction of a compressor room becomes a mandatory point. This problem affects large expenses in economic terms. Point local filters are a modern, highly efficient replacement for centralized aspiration systems.

But the problem lies in the fact that modern companies that produce these filters make them accentuated to the size of new technological equipment. In this regard, not every company can choose a filter for its standard size and switch to its use.

5 Conclusions

Due to the promising development of the agricultural industry of the country, where grain exports are a strategically important factor for the economy of the state, the urgency of building grain storage and processing enterprises is increasing.

In this article, the main negative factors accompanying the operation of the elevator were considered. The definition of grain dust was given as a substance of small particles containing a number of negative phenomena: harm to the health of an employee of the enterprise and settlements included in the area of operation of the elevator, provoking lung diseases; explosion and fire hazard; impact on the quality of the harvested product.

For the aspiration of the enterprise's equipment, a battery-operated aspiration unit of the BBC type was selected. Using the example of a proposed modern silo elevator with a capacity of 20,000 tons, for cereal production, which includes the acceptance and storage of conditioned grain, the efficiency of the operation of BBTS-type installations was considered.

According to the calculation, the cleaning coefficient of battery installations was established, which amounted to 95-96%. The amount of waste for disposal was 40.16 tons/year.

A number of disadvantages and advantages of BBC type aspiration units over modern aspiration equipment have been identified by the example of a point local filter. The disadvantages include: the need for an aspiration network, which includes air ducts of various lengths, which over time are erased from the constant contact of abrasive particles of grain dust with the walls of the pipe; deposition in the chambers of a part of the products together with grain dust; mandatory disposal of collected waste. The advantages include: high degree of purification; the versatility of this aspiration unit for various technological equipment; it is more cost-effective, since there is only electricity consumption, there is no need for a compressor unlike local filters.

Thus, it can be concluded that today battery installations of the BPC type are effective aspiration equipment, despite the undeniable advantages of innovative point local filters, the essential problem of which is their low versatility.

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