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Evaluation of the Efficiency of Dust and Gas Collecting Units of Woodworking Shops in Shipbuilding Industry

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Abstract. The bigger the number of shipbuilding enterprises the more the negative impact on the environment they have. Such enterprises have many sources of air pollution. At each of the organized sources of air pollution it is necessary to clean the emissions regardless of the hazard class of the discharged substances. It is important that the standards of pollutants, regardless of their hazard class, are respected at each of the sites of industrial enterprises. Woodworking shops are located at shipbuilding enterprises, where wood dust is released during wood processing. In this work, the effectiveness of the operation of dust and gas collectors of Shop №2 at AO Vostochnaya Verf was evaluated. The purpose of this paper is to evaluate the efficiency of the cyclones of the Shop №2 and determine their effectiveness. The subject of research is the performance of dust and gas collecting units of the Shop №2. Research methods used in the standard are in accordance with current regulations. The article details the installations for cleaning waste gases from harmful impurities and wood dust. The relevance of this article lies in the importance of evaluating the performance of dust and gas collectors that clean the air from dust particles released during woodworking at a construction company Studies have shown that the effectiveness of the cyclones of the Shop №2 is in the range from 54 to 60%. The obtained measurements showed that the simplicity of the cyclone design allows to maintain the efficiency declared by the manufacturer for many years.

1. Introduction

Due to the rapid development of industrial enterprises and their negative impact on the environment, the deterioration of the environment is increasing every year. There is more waste and harmful substances that are released into the environment.

Atmospheric air is a vital component of the environment. It is a natural mixture of atmospheric gases [1]. By polluting the atmospheric air, a person endangers his life, the life of living organisms and the environment in general [2, 3].

Protection of atmospheric air from pollution is one of the priority directions of the environmental policy of the Russian Federation. Due to the influence of winds, harmful substances are transported over long distances. Smog and fog exacerbate the situation by stagnating pollutants in the ambient air and preventing them from dispersion. This factor has a negative impact on the environment and living organisms [4, 5].

With an increase in the number of industrial enterprises, the mass of emissions of pollutants, which have a negative effect on the atmospheric air, increases. Shipbuilding enterprises, like any other industrial enterprises, have a negative impact on the atmospheric air [6].

A high proportion of air pollutants produced during the ship construction and repair is volatile organic substances and solid inorganic wastes. Volatile organic substances include ethanol, acetone, cyclohexanone, butyl acetate. They are released during paintwork and have a negative effect on humans and the atmospheric air. Solids include wood dust, inorganic dust, chromium (IV) oxide, manganese and its compounds, and many others [7, 8].

2. Relevance

There is a large number of shipbuilding and ship repair enterprises around the world. Their number increases every year, because special ships can easily and relatively fast transport goods that cannot be delivered in another way. For example, bulk cargo, liquefied cargo, oil products, and various equipment are transported on ships. However, in order to put into operation any sea vessel, special enterprises are needed for their construction and repair [9].

According to the Russian Federal Law "On environmental protection" everyone has the right to a favorable environment, everyone is obliged to preserve nature and the environment, to take good care of natural resources, that are the basis of sustainable development, life and activities of people living on the territory of the Russian Federation [10]. Therefore, the enterprise must comply with the rules related to the reduction of environmental pollution [11-14].

There are woodworking shops in any shipbuilding enterprise. Wood is processed mechanically. In this process, wood dust is a point-source emission. Wood dust, just like any other industrial dust, has a harmful effect on humans and the environment [15].

AO Vostochnaya Verf is an enterprise engaged in the construction and repair of ships with a tonnage of up to 4.5 thousand tons. There are two shops on the territory of the enterprise where wood dust is generated.

To trap wood dust special dust and gas collectors are installed in AO Vostochnaya Verf.

It is important to remember that dust and gas collectors are the equipment that operates with a certain power and efficiency. Therefore, their operation determines the efficiency of filtering dust particles. Since these facilities must operate smoothly and provide high-quality air purification from wood dust, the evaluation of their efficiency is very important for the environmental activities of the enterprise.

The relevance of this article lies in the importance of the efficiency evaluation of dust and gas collectors that clean the air from dust particles released during woodworking at a shipbuilder. If you do not clean the shops from dust and do not catch it in special cyclones, then it can harm humans and the environment. Compliance with environmental legislation regarding the protection of atmospheric air makes it possible to reduce the negative impact on the atmosphere and preserve the environment. Therefore, it is very important and necessary to evaluate the efficiency of dust and gas collectors [16-17].

3. Purpose and objectives

The purpose of this paper is to evaluate the efficiency of the dust and gas collectors of the Shop №2 of AO Vostochnaya Verf, Vladivostok.

The tasks of the article are:

1) measurement of dust concentration in the cyclones of the Shop №2, collection of data on cyclones;
2) calculations based on the measurement data carried out on cyclones in the Shop №2;
3) evaluation of the efficiency of dust and gas collectors and creation of a further plan of measures for working with the facilities;

To solve the set tasks the following studies were carried out:

1) measuring dust concentration in the cyclones of the Shop №2, collecting data on cyclones of the Shop № 2;
2) analyzing the data from measurements made in cyclones in the Shop №2;
3) evaluation of the efficiency of the dust and gas collectors was carried out, and a further action plan for work with the units of the Shop №2 was proposed.

4. Theoretical part

AO Vostochnaya Verf belongs to the third hazard class in accordance with the Decision dated 28 Sep. 2015 by the Russian Government "On approval of criteria for classifying objects that have a negative impact on the environment as objects of I, II, III and IV categories." [18]

The main activity of the enterprise is the construction, repair and modernization of ships and vessels of all classes and purposes with a tonnage of up to 4.5 thousand tons.

There are 72 emission sources registered (of which 57 are organized, 15 are unorganized) on the territory of the enterprise, releasing 54 pollutants into the atmosphere with a total mass of 17.573078 t/year [19].

Woodworking at AO Vostochnaya Verf enterprise is carried out in the Shop №2 and Shop №7.

In this paper, the performance of the dust and gas collectors of the Shop № 2 was considered.

In the process of gluing workpieces from chipboard, plastic and lumber, pollutants (ethenyl acetate (vinyl acetate)) [19], enter the atmosphere in an organized manner through a ventilation pipe (source 0039).

Wood dust is released as a result of the operation of woodworking machines and wood processing. As a result of the operation of processing machines, the amount of wood dust (code 2936) emitted from the source of emission is 0.1496250 g/s or 0.249169 t/year; the number of the source of air pollution, which receives emissions from the source of emission, is 0036.

The number of the source of air pollution, which receives emissions from the source of emission, is 0057. Data is in the Table 1.

Table 1. Amount of wood dust released into the atmosphere.

Pollutant name	Intensity of emission, g/s	Total emissions produced, t/year	Emissions without purification, t/year	Purified emissions			Total emissions released into the atmosphere, t/year
				Amount of emission subject to purification, t/year	Captured and purified t/year	Captured and purified t/year	
Wood dust (code 2936)	0,0341000	0,284615	0,068486	0,316130	0,186999	0,129130	0,197616

Compiled by the author based on [19].

Table 1 shows that a part of wood dust is emitted without purification (0.068486 t/year), the rest is emitted into the atmospheric air after purification (0.129130 t/year). In total, 0.197616 t/year of wood dust is released into the atmospheric air.

5. Practical value, suggestions and results of introductions, results of experimental studies

The equipment used for the measurements: electric aspirator PU-4E, pressure tube NIIOGAZ in accordance with GOST 17.2.4.06, glass liquid thermometer in accordance with GOST 28498, dust collection tubes, multi-range liquid micromanometer MMN-2400, manual anemometer MS-13, aspiration psychrometer MV-4V, SOSpr-26-2-0 stopwatch.

Measurement and calculation progress.

Cyclone flues are equipped with special sampling points, nozzles that are necessary to determine the actual efficiency of the dust and gas collectors. The locations of the nozzles and their number are determined in accordance with the requirements of GOST [20].

Since the flue has a rectangular cross section, measurements were made along the vertical and horizontal measuring sides. The calculation was made according to the formula:

$$D_e = \frac{2A*B}{A+B}, \quad (1)$$

D_e - diameter of the gas duct, m.

A and B - internal dimensions of a rectangular section, m.

Then the volume of gas consumption was determined. We measured the temperature and pressure of the gas at the aspirator, the air density under normal conditions.

The measurements were carried out with a steady gas flow. The measuring section in the gas duct was selected in accordance with GOST 17.2.4.06-90. A full pressure cavity was connected to the micromanometer nozzle with a "+" sign, and a static pressure cavity was connected to the nozzle with a "-" sign.

The tube coefficient (taken from the tube passport) and the angle of the micromanometer were taken into account. Measurements were carried out at each cyclone before cleaning and after cleaning.

Then the following calculations were carried out:

1) Dynamic gas pressure P_{din}, Pa,

The indicators were measured (p β Кт), and then the dynamic gas pressure in the gas duct was calculated using the formula. At each point, at least three measurements of indicators were performed to calculate the dynamic pressure; the measurement results were used to determine the dynamic pressure and calculate the average dynamic pressure for a given measurement point. Simultaneously, the gas temperature and vacuum (pressure) in the gas duct, as well as the atmospheric air pressure, were measured.

The determination of the gas flow rate was carried out as follows:

1) The gas density and the velocity of gas and dust flows were calculated. After that, the dustiness of the gas and dust flows was determined.

Sampling for dustiness was carried out at those points where the velocities of gas and dust flows were measured. Sampling was carried out by the method of internal filtration - the dust collector was located inside the gas duct.

Since the filtration is internal, cartridges with fiberglass packing were used as a dust collector. The cartridges were preliminarily brought to constant weight in an oven at 105 °C.

1) The gas volume flow rate was calculated.

2) Then the flow rate of the sampled gas through the aspirator was calculated taking into account the diameter of the inlet section of the tip.

Then, dust was taken using a dust-collecting tube, with a cartridge inside its tip. The sampling time lasted 10 minutes. When taking a sample, a dust-collecting tube with a replaceable tip is inserted into the gas duct so that the inlet of the tip is at a certain point of the measuring section and is directed by the hole towards the gas flow.

After all the indicators were calculated, the efficiency of the facilities was calculated. The efficiency of the cyclones is the purification efficiency, which shows in percentage terms the ratio of settled dust to dust contained in the incoming air stream.

The efficiency of the facilities, %, was calculated by the formula:

$$\frac{ƶ_{out}*V_{out}}{ƶ_{in}*V_{in}} * ƶ_{вх} *100\%, \quad (2)$$

$ƶ_{out}$ - concentration of dust at the outlet of the treatment plant, g/m^3;

V_{out} - volumetric gas flow rate at the outlet of the treatment plant, m^3/s;

$ƶ_{in}$ - dust concentration at the entrance to the treatment plant, g/m^3;

V_{in} - volumetric gas flow rate at the entrance to the treatment plant, m^3/s.

Calculation data on the operation of cyclones before cleaning is presented in Table 2.

Table 2. Calculation data on the operation of cyclones before cleaning.

Cyclone number	Dynamic pressure P_d, Pa	Air flow density ϱ_w, kg/m^3	Gas velocity, m/s	Sectional area S, m^2	Gas volumetric flow rate V, m^3/	Selected gas consumption by electric aspirator V_p, l/min	Concentration ƶ, g/m^3	Ejection per second W, g/s
Cyclone C-950	23,3	1,28	18,9	0,1590	3,0	8	0,1778	0,53
Cyclone C-1500 №476	6,37	1,29	9,84	0,25	2,46	11,18	0,1931	0,48
Cyclone C-1500 №47, vent 1	6,0	1,29	9,55	0,25	2,39	10	0,0034	0,008

Calculation data on the operation of cyclones after cleaning is presented in Table 3.

Table 3. Calculation data on the operation of cyclones after cleaning.

Cyclone number	Dynamic pressure P_d, Pa	Air flow density ϱ_w, kg/m^3	Gas velocity, m/s	Sectional area S, m^2	Gas volumetric flow rate V, m^3/sec	Selected gas consumption by electric aspirator V_p, l/min	Concentration ƶ, g/m^3	Ejection per second W, g/sec	Efficiency, %
Cyclone C-950	14,4	1,26	15	0,1809	2,7	6,1	0,0798	0,21	60
Cyclone C-1500 № 476	1,25	1,29	4,4	0,6079	2,67	5	0,0758	0,20	58
Cyclone C-1500 №47, vent 1	6,0	1,29	9,55	0,6079	2,67	5,5	0,0014	0,0037	54

Tables 2 and 3 show that the efficiency of cyclone C - 950 is 60%, cyclone CN-1500 №476 is 58% and cyclone IN - 1500 No. 47, vent 1 is 54%. The efficiency is not high, but in accordance with the passports of these installations, it is within the normal range.

6. Conclusions

Currently, there are a lot of enterprises that use dust collection facilities. These installations do not allow dust of various origins (wood, metal, etc.) to enter the atmospheric air, and also protect workplaces from dust. At the Shop №2 of AO Vostochnaya Verf the analysis of the dust and gas collectors' performance 2 was carried out.

The efficiency of the cyclones of these installations was calculated. The measurements showed that the simplicity of the cyclone design allows maintaining the operating efficiency declared by the manufacturer for many years. The efficiency of collecting dust particles is within the normal parameters of facilities operation. However, this installation is more than 20 years old, and the enterprise should consider the option of replacing them with new and improved facilities with a higher efficiency of collecting dust particles.

7. References

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