Acoustic Safety Management at the Locksmith's Workplace Mechanic-Repairman to Replace the Filter Material in the Technological Process of Obtaining of Apatite Concentrate

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Abstract. In this work, measures are being developed to reduce the noise level at the workplace of a mechanic-repairman to replace filter cloth. Based on the results of production control and a thorough assessment of working conditions, the source of noise was determined to be the VDN-17 fan. The analysis of Russian and foreign studies in the field of the negative impact of noise on the human health and methods of dealing with industrial noise has been carried out. As a result, a technical method of reducing negative impact of noise was selected and the acoustic efficiency of the muffler for the VDN-17 fan was calculated.

1 Introduction

According to the Federal State Statistics Service, the percentage of workers employed in harmful and hazardous conditions to the total number of employees in 2018 decreased in relation to 2017 by 2% [1].

The Federal State Statistics Service data for 2018 showed that the most harmful and hazardous activities are: mining - 54.7% and manufacturing - 43.2% [1]. Thus, workers employed in the mining industry are constantly exposed to harmful factors, one of the most dangerous is exposure to occupational noise, which leads to diseases of the cardiovascular system and hearing impairment. According to the results of the study [2], it was revealed that the mining industry ranks first in the prevalence of hearing diseases. This is confirmed by many studies of scientists and the Federal state statistics service, according to data for 2018, the working conditions of employees of the mining and processing industry are characterized by the presence of harmful factors: chemistry - 10.1%, noise - 35.9%, as well as the severity of the labor process - 38,5% [1], [3]. Analysis of the impact of harmful and dangerous factors shows that workers in the mining industry have an average and high risk of developing occupational diseases [4].

According to the data of the state mining supervision for 2018, the total number of workers employed at hazardous production facilities in the mining industry was 226 thousand people, and the volume of rock mass production increased by 5% compared to the previous reporting period, respectively, accidents and injuries to workers occur. As can be seen from Appendix 3, the number of injured workers is decreasing every year, but the number of accidents has been stable over the past 4 years. According to the report of the Federal Service for Environmental, Technological and Nuclear Supervision for 2018, the number of deaths decreased by 1.6 times compared to 2017 [5]. A study based on accident statistics over a ten-year period found that 85% of all injuries are associated with mining equipment, and 90% of fatalities with mobile equipment, including hand tools. Truck operators and repairmen are at the highest risk [6].

This research examines the workplace of a repairman for replacing filter cloth (hereinafter referred to as a repairman in the Polar Division). This profession in various fields of industry is often associated with the negative impact of the following factors: industrial noise, vibration, microclimate parameters, exposure to harmful substances, the severity and intensity of the labor process [3,6, 7]. The constant exposure to occupational noise has a negative effect on the state of the nervous system, such as irritability, headaches, fatigue, sleep disturbance, memory impairment and, accordingly, this leads to occupational diseases [8].

The aim of the study is to develop measures to reduce the noise level at the workplace of the mechanic-repairman to replace the filter cloth. To solve it, following main tasks:

1. Analysis of noise affecting the mechanic-repairman;
2. Analysis of noise sources;
3. Development of measures to reduce noise exposure;

have been accomplished.

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2 Methods

2.1 Noise reduction techniques

When considering industrial noise as a biological factor, it was found that the noise affecting the employee's body leads to a decrease in performance.

Hearing loss from exposure to noise is the second most common condition in the mining industry. In the study [9], it is proposed to reduce the noise level from two rotating cutting drums by increasing the rigidity of the outer plates, which is the most practical and durable. This method was able to organize noise reduction by 3 dB. The most effective is the fight against noise at its source [10].

The author in the article argues that the effect of increased noise entails an increase in the costs of an employee's efforts to perform work. The use of various noise absorbers is proposed, including their designs. The results of the study [11] claim that every 5-10 years the increase in noise emission is about 5 dBA. According to the results of the analysis, diseases most often occurred in persons with a long work experience. The author proposes to use noise protection structures in order to combat occupational diseases. We are talking about the development of noise-absorbing panels on the basis of the laboratory of the Department of Technosphere Safety of the Federal State Budgetary Educational Institution of Higher Professional Education IzhSTU named after M.T. Kalashnikov ".

According to the Ministry of Labor and Social Protection, sensorineural hearing loss is detected in 30-40% of all recorded occupational diseases. The article [12] discusses active headphones with the ability to adjust the sound volume, that is, to amplify quiet sounds and at the same time to make excessively loud sounds quieter, and they can also have built-in walkie-talkies for the convenience of employees' communication.

Thus, it is possible to implement both technical and organizational measures to combat the negative impact of noise. The most effective technical measure is to tackle the source of the noise, but this is often a complex process. The most common is the use of collective means of protection, such as installing noise-absorbing panels, this is also a very costly process. The most frequent and inconvenient for workers is the use of personal protective equipment, such as headphones or ear plugs [13].

2.2 Analysis of noise sources based on production control fata at the workplace of a mechanic-repairman to replace filter cloth

In industrial shops, many machines and devices are used that generate high levels of noise, which is the main cause of hearing loss.

At the workplace of a repairman, according to the results of production control, an increased noise level was revealed at the marks of disk and belt vacuum filters. This is due to the fact that these control points are located near the noise source - the fans of the VDN-17 drying drums. Centrifugal blowing fans of single inlet type VD are designed to supply air to the furnaces of steam boilers [14]. The overall and connecting dimensions of the smoke exhausters are shown in Appendix 6, and the technical characteristics in table 1.

Table 1. Technical characteristics of VDN-17 draft machine

Types of machines	Power, kWt	Rotation frequency, min^{-1}	Productivity, m^3 / h	Total pressure, Pa	Weight, kg
VDN-17	160	980	73000	282	3100

2.3 Method and calculation of an active silencer made of basalt fiber

One of the methods of collective protection is the use of mufflers, which are used to reduce aerodynamic noise. According to the principle of operation, noise mufflers are: active type (due to the sound-absorbing material), reactive type (due to the reflection of a part of the sound energy back to the source) and combined [15].

The paper proposes to use an active type muffler, which is effective at medium and especially high frequencies. An active muffler in the form of a rectangular channel will be located at the outlet of the VDN-17 fan along the perimeter of the pipeline. the fan is fastened to the unloading chamber in the form of a rectangular pipe with an internal width of -850 mm and a length of 635 mm. To prevent the absorbing material from blowing out, coverings with metal mesh, perforated material, etc. are used.

The muffler is a thin-walled rectangular parallelepiped with a length of 850 mm, a width of 632 mm and a depth of 1100 mm, the inner part of which is sheathed with a heat-resistant mesh with a wire thickness of 1.6 mm to prevent material blowing out.

The calculation of noise reduction (acoustic efficiency) when using an active silencer for a rectangular duct is carried out according to the following formula (1):

$$\Delta L = 1{,}1\varphi(\alpha)\cdot P\cdot l/S \qquad (1)$$

where $\varphi(\alpha)$ - conditional sound absorption coefficient of the muffler lining, depending on the sound absorption coefficient α of the used adsorbent (table 2);
l and P - respectively the length and diameter of the cross-section of the muffler channel, m
S - channel cross-sectional area, m^2 [16].

Table 2. Values of the conditional sound absorption coefficient of the muffler lining depending on the sound absorption coefficient α of the used absorbent

α	0,1	0,2	0,3	0,4	0,5	0,6	0,7	0,8	0,9	1
$\varphi(\alpha)$	0,1	0,2	0,35	0,5	0,65	0,8	1,2	1,6	2,0	4

Using formula 1, we calculate the acoustic efficiency of an active muffler for VDN-17:

$$\Delta L=1{,}1\varphi(\alpha)\cdot 2(0{,}85+0{,}632)\cdot 1{,}1/0{,}85\cdot 0{,}632 \qquad (2)$$

$$\Delta L = 6{,}68\ \varphi(\alpha) \quad (3)$$

When choosing a sound-absorbing material for an active muffler, it is necessary to take into account properties such as: flammability, hazardousness to the health of workers, service life, etc. The maximum operating temperature of glass wool is 500 ° C, slag wool - 300 ° C, basalt fiber - 1000 ° C. Based on practical data for the use of active mufflers, depending on the operating conditions, a material was chosen - basalt wool. They were selected on the basis that gases with an elevated temperature of about 900 ° C pass through VDN-17.

During operation of the VDN-17 blower fan, intense noise is emitted into the working space, the frequency characteristic of which is shown in table 3.

Table 3. Frequency response of noise from VDN-17

Index	Measurement area	Average geometric frequencies of octave bands, Hz						
		125	250	500	1000	2000	4000	8000
Noise from the VDN-17 fan	Injection	112	117	116	113	111	107	101
	Suction	108	113	112	109	107	103	97
	Around the body	103	107	106	103	100	95	89

Since the muffler is installed at the fan outlet, it is necessary to calculate in two zones: discharge and around the casing.

3 Results

The initial data and results of calculating the effectiveness of measures for installing a silencer made of a semi-rigid "PP-80" basalt slab in accordance with GOST 9573-2012 with a sound absorber thickness of 30 mm in the injection zone are summarized in table 4.

Table 4. The results of calculating the effectiveness of measures to install a silencer made of basalt fiber in the injection zone

Index	Average geometric frequencies of octave bands, Hz						
	125	250	500	1000	2000	4000	8000
Sound Pressure Level from the VDN-17 fan, dB	112	117	116	113	111	107	101
Sound absorption coefficient *α*	0,08	0,3	0,64	0,89	0,95	0,81	0,73
Conditional sound absorption coefficient *φ(α)*	0,08	0,35	0,96	1,96	3	1,64	1,32
Silencer acoustic efficiency, dB	1	3	7	14	22	12	10
Sound Pressure Level of VDN-17 fan after installing a silencer on it, dB	111	114	109	99	89	95	91
Standard values of the Sound Pressure Level, dB	87	82	78	75	73	71	69
Exceeding the norms after installing the muffler, dB	24	32	31	24	16	24	22

First, it is necessary to determine the sound absorption coefficient of the semi-rigid basalt slab PP-80 from the reference data. Using table 2, we calculate the value of the conditional sound absorption coefficient of the muffler lining depending on the sound absorption coefficient α. Then we calculate the acoustic efficiency of the muffler depending on the geometric mean frequency using formula 3. For example, at 125 Hz, the acoustic efficiency of the muffler will be:

$$\Delta L_{(125)} = 6{,}68\ \varphi(\alpha)_{(125)} = 6{,}68 \cdot 0{,}8 \approx 1 (\text{dB}) \quad (4)$$

where $\varphi(\alpha)_{(125)}$ – the conditional sound absorption coefficient of the muffler lining, which depends on the sound absorption coefficient α of the semi-rigid basalt PP-80 slab.

Thus, the sound pressure level of the VDN-17 fan after installing a muffler on it in the discharge zone at 125 Hz:

$$L_{p2(125)} = L_{p1(125)} - \Delta L_{(125)} = 112 - 1 = 111 (\text{dB}) \quad (5)$$

where $L_{p1(125)}$ – the sound pressure level of the VDN-17 fan before installing a muffler on it in the discharge zone.

Exceeding the standard values of sound pressure levels after installing a muffler at 125 Hz:

$$\Delta = L_{p2(125)} - L_{stand\ (125)} = 111 - 87 = 24 (\text{dB}) \quad (6)$$

where $L_{stand\ (125)}$ – the standard value of the sound pressure level at 125 Hz.

Similar calculations for the geometric mean frequencies of the octave bands of 250, 500, 1000, 2000, 4000 and 8000 Hz were carried out in the excel program, the results are shown in Table 4. For the geometric mean frequencies of the octave bands of 31.5 and 63 Hz, calculations were not performed, since it was previously said that the active type muffler is effective at medium and high frequencies.

Based on the calculation results, we will build the noise characteristic in the injection zone before and after the installation of the muffler (Fig.1).

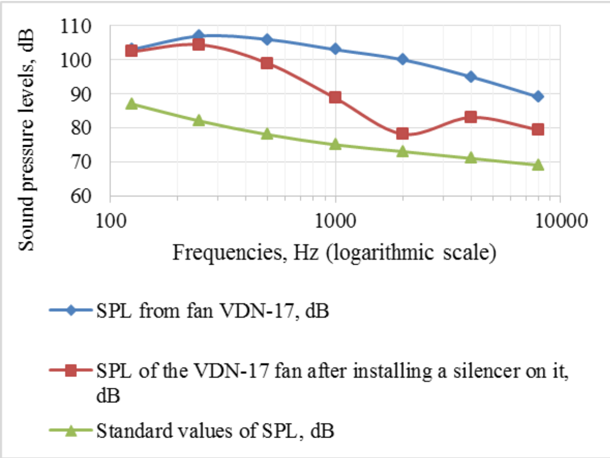

Fig. 1. Noise characteristics in the discharge zone before and after installation of the muffler

Similar calculations were carried out to assess the effectiveness of measures to install a silencer made from a semi-rigid " PP-80" basalt slab in accordance with GOST 9573-2012 with a sound absorber thickness of 30 mm in the measurement zone around the body, the results are shown in table 5.

Table 5. Results of calculating the effectiveness of measures for installing a basalt fiber muffler in the measurement zone around the body

Index	Average geometric frequencies of octave bands, Hz						
	125	250	500	1000	2000	4000	8000
Sound Pressure Level from the VDN-17 fan, dB	103	107	106	103	100	95	89
Sound absorption coefficient α	0,08	0,3	0,64	0,89	0,95	0,81	0,73
Conditional sound absorption coefficient $\varphi(\alpha)$	0,08	0,35	0,96	1,96	3	1,64	1,32
Silencer acoustic efficiency, dB	1	3	7	14	22	12	10
Sound Pressure Level of VDN-17 fan after installing a silencer on it, dB	102	104	99	89	78	83	79
Standard values of the Sound Pressure Level, dB	87	82	78	75	73	71	69
Exceeding the norms after installing the muffler, dB	24	32	31	24	16	24	22

Based on the results of the calculation, we construct the noise characteristic in the measurement zone around the body before and after the installation of the muffler (Fig.2).

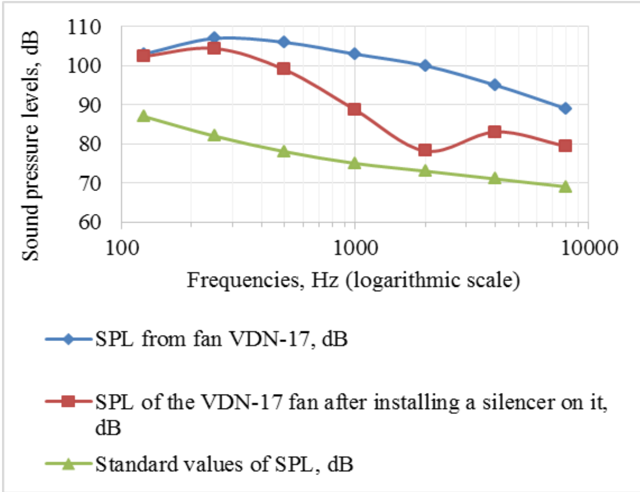

Fig. 2. Noise characteristic in the measuring area around the body before and after installing the muffler

As a result of the calculation, the acoustic efficiency of the muffler made of basalt semi-rigid slab PP-80 was determined and the sound pressure levels in the measurement zones were calculated: injection and around the body. Based on Figures 2 and 3, it can be seen that the muffler is most effective in the high frequency range.

The muffler is made in the form of a rectangular channel and is installed at the outlet of the VDN-17 fan. In Figure 4, the number 8 denotes the VDN-17 fan, and the location of the muffler is indicated in green.

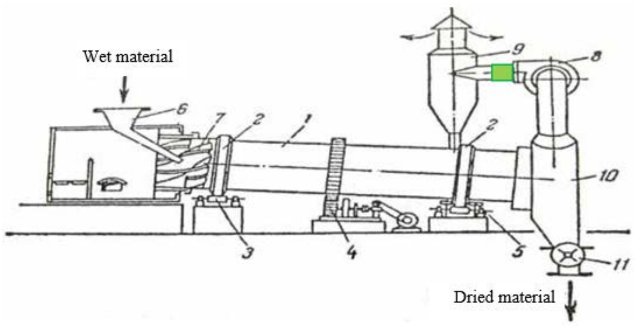

Fig. 3. Principle of operation of the drying drum (1 - drum; 2 - bandages; 3 - support rollers; 4 - transfer; 5 - support rollers; 6 - feeder; 7 - blades; 8 - fan; 9 - cyclone; 10 - unloading chamber; 11 - unloading device)

4 Discussion

The study is dedicated to the development of measures to reduce the negative impact of industrial noise on the fitter-repairman to replace the filter cloth, during which the sources of noise generation were identified and methods of dealing with it were proposed.

During the work, on the basis of statistical data and scientific research, it was revealed that the mining industry is the most harmful and hazardous. World practice shows that workers in this industry belong to groups of increased risk of negative impact of industrial noise, which leads to diseases of the hearing organs, nervous system and others [17, 18].

This work confirms the relevance and necessity of developing measures to reduce the negative impact of increased industrial noise on workers in the mining industry.

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