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Prediction of Acoustic Pollution in the Conditions of Reconstruction of Industrial Enterprise

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Abstract

Research objective – forecasting of acoustic conditions in the cleanings of the shop of packaging of vegetable oil ZAO c II «The Dnipropetrovsk oil extraction plant» and analysis of the noise mode of the territories adjacent to the production building with the built-in coolers of hydraulic oil (T10L type). In the analysis of modern references the purpose was set – to find data on existing rules on noise pollution in workplaces of manufacturing enterprises and also about the operating methods and techniques of determination of the expected noise levels in rooms and in the territories adjacent to noisy rooms. Results of this work will allow to conduct researches on forecasting of the acoustic mode in any rooms and in any territories in the conditions of reconstruction both for industrial, and for civil objects on condition of application of additional sources of noise in them.

Keywords: Acoustics, struggle with noise, Sound insulation, Noise characteristic.

1. Introduction

And development of actions of protection against noise the atuyena of design, construction, reconstruction and operation of objects should carry out the analysis and an assessment of the noise mode on all, which атур functional to the atuyena ки and the nature of use атур or to create excessive noise, or to demand protection against noise. The quantitative assessment of the acoustic mode should be carried out on the basis атурн tool measurements for objects which are operated or by results of acoustic calculations for objects which are projected.

2. Object of a research and its technological audit

As object of a research the production building with the room of the block of cleaning of the shop of packaging of vegetable oil acts. Now an object is in a reconstruction stage for the purpose of production modernization. In the course of preparation and carrying out forecasting of levels of noise pollution natural measurements of background noise in the explored room are taken, and also in the territory of the plant at the room of the block of cleaning before installation of coolers of hydraulic oil (T10L type). That fact is the basis for a working hypothesis of a research, that at theoretical calculations of the expected noise levels in production rooms special value has the accuracy of establishment of the noise characteristics of the most production room adjoining to him territories and rooms with the existing noise sources.

3. Purpose and research problems

Research objective – forecasting of acoustic conditions in the cleanings of the shop of packaging of vegetable oil ZAO c II «The Dnipropetrovsk oil extraction plant» and analysis of the noise mode of the territories adjacent to the production building with the built-in coolers of hydraulic oil (T10L type). For achievement of a goal it is necessary to solve a number of problems:

1. Determination of the expected noise level in the block of cleaning of the shop packagings of vegetable oil before installation of the built-in cooler of hydraulic oil (T10L type).
2. Determination of the expected noise level in the territory, to the room of the block of cleaning of the shop of packaging of vegetable oil after installation of the built-in cooler of hydraulic oil (T10L type).
3. Carrying out the analysis of sanitary rationing on noise in Ukraine in workplaces and in the territory of the industrial enterprise.
4. Drawing up the forecast of the noise mode in the block of cleaning of the shop packagings of vegetable oil and in the territory, adjacent to the room of the block, after installation of the built-in cooler of hydraulic oil (T10L type) in comparison with Sanitary standards for working rooms and production territories.

4. Analysis of literary data

In the analysis of modern references the purpose was set – to find data on existing rules on noise pollution in workplaces of manufacturing enterprises and also about the operating methods and techniques of determination of the expected noise levels in rooms and in the territories adjacent to noisy rooms [1-4]. As a result of work it is established that in acting in Ukraine now reference and standard books have enough information for carrying out full and high-quality calculation for forecasting of the acoustic mode in the reconstructed room. Some settlement sizes had to be taken from old sources ([5-7]) on which further there will be references.

5. Materials and methods of researches

In this work with the help of a method of natural measurements the analysis of the existing acoustic conditions in the block of cleaning of the shop of packaging of vegetable oil is carried out ZAO c II «The Dnipropetrovsk oil extraction plant». On the basis of natural measurements the forecast of the noise mode in the explored room is carried out and in the territories adjacent to the production building with the built-in coolers of hydraulic oil (T10L type).
Natural measurements were taken with use of a reception electro-acoustic path. The receiving path for measurements of noise provides measurements of the sound pressure levels in octava frequency bands also contains:
- audio-noise meter of a class of accuracy 1 in accordance with GOST 17187-81 and DSTU 4212-2003;
- the microphone measuring a class of accuracy 1 with the rated range of frequencies from 30 Hz to 18000 Hz in accordance with GOST 6495-89;
- filters strip octava class 1 in accordance with GOST 17168.

6. Results of researches

6.1 CALCULATION of noise levels in investigated and rooms, adjacent to him [8]. The following basic data are indoors necessary for theoretical calculation of noise levels:
- for the separate surfaces of the square of the applied materials of finishing of an interior of the room; the total area of the protecting structures of the room; room volume,
- purpose of the room, etc.
We choose settlement points for the explored room of the block of cleaning of the shop of packaging of vegetable oil in a zone of the reflected sound, but no more than 2,0 m from the protecting designs, at the height of 1,5 m from floor level. Considering the small linear sizes of the explored room (width – 3,7 m length – 15 m), we establish one settlement point in the center of the room. Thus, the settlement point of Design Point1 is removed from the long parties on 1,85 m, and from short on 7,5 m, that is the settlement point is removed from an estimated installation site of a cooler of hydraulic oil on 1,85 m. The established cooler of hydraulic oil has overall dimensions. Octava levels of sound pressure of L, dB, in settlement points of rooms in which is several source of noise, we determine by a formula:

$$L = 10\lg\left(\sum_{i=1}^{m}\frac{\Delta_i * K_i * \Phi_i}{S_i} + \frac{4\Psi}{B}\sum_{i=1}^{n}\Delta_i\right) \qquad (1)$$

Where:
$\Delta_i = 10^{0.1Lpi}$
L_{pi} – the octava level of sound power, dB, determined for coolers by the passport and analogs (in the passport only the size of the corrected noise level is given, equal 88 dBA, and a spectral characteristic we define by analogy with the passport characteristics specified in the Reference book [7]), it is presented in tab. 1.1.

For calculation of sound power in frequency bands use the following technique, described in item 4.4.3 of the Reference book [7]. According to this technique apply dimensionless ranges:

$$H(f/n) = L_p - L_{p\Delta fi} \qquad (2)$$

Where: $L_p - L_{p\Delta fi}$ we determine by tab. 4.2 [7], dB;
To the size of the dimensionless range chosen according to tab. 4.2 [7] we add the size of criterion of noisiness, selected according to tab. 4.1[7] also we receive estimated values of the sound power levels of our fan in frequency bands. According to tab. 4.1[7] we have chosen the following sizes criteria of noisiness of the fan:
- for forcing – 58,0 dB;
- for absorption – 53,0 dB.

Table 1: Spectral characteristics of the fan

№ п/п	Magni-tude L_{Po}	Reference	Compound frequency of an octava strip, Hz								L_A dBA
			63	125	250	500	1000	2000	4000	8000	
1	2	3	4	5	6	7	8	9	10	11	12
1	L_p-$L_{p\Delta fi}$	Table 4.2[9]	6	5	5	9	11	16	22	28	
2	Forcing	(58,0 dB)	64,0	63,0	63,0	67,0	69,0	74,0	80,0	86,0	87,3
3	Suction	(53,0 dB)	61,0	58,0	58,0	62,0	64,0	69,0	75,0	81,0	82,3

S – the protecting surface of the room of S = 578,5 m^2;

K – the coefficient determined by fig. 2 [2] depending on the relation of distance of r, m, between the acoustic center of a source and the settlement point (SP) to the maximum size of a source. As r distance relation from a source to a settlement point to the maximum size of a source is equal 1,57 (1,85/1,182 = 1,57) that size K is equal to 1,2;

Φ - orientation factor, (we accept F = 1 for the uniform radiation of a sound);

Ψ- the coefficient of violation of diffusion of the sound field determined by fig. 3[2];

B - constant of the room, m^2. Defined from expression (2):

$$B = B_{1000} * \mu \qquad (2)$$

where:

B_{1000} - room constant on purity of 1000 Hz, is determined by tab. 2[2]. In our case the room with a small amount of people (… machine halls, generating etc.) and according to the tab. we conduct 2[2] calculation of B1000 on a formula:

$$B_{1000} = \frac{V}{20} = \frac{618{,}75_{M^3}}{20} = 31 \text{ , } m^3$$

When calculating volume of the room the fact that trellised floors turn the volume broken on floors - in one volume is considered. It is also considered that the total amount (693,75 m^3) is reduced due to presence in him of the closed volume of 75 m^3,

μ - Frequency factor, depends on the volume of the room, V = 618,75 m^3, we take according to tab. 3 [2];

m = n - quantity of sources of noise, the next to a settlement point, for which $r \leq 5\, r_{min}$, where: r_{min} - where rmin - distance, m, from a settlement point to the acoustic center of the next to her of a noise source). As we have one source of noise, it is possible to simplify a formula (1) a little:

$$L = L_{p_0} + 10\lg\left(\sum_{i=1}^{m}\frac{K_i * \Phi_i}{S_i} + \frac{4\Psi_n}{B}\right) \qquad (3)$$

where:

$L_{Po} = L_{Pi}$, in a formula (1)

Calculation of the expected sound levels in a settlement point (Design Point1) for a noise distribution case the built-in cooler of hydraulic oil in full of the room, equal V = 618,75 m^3 we conduct in tab.2.

Thus, in column 12 of tab. 2. the expected sound levels in first (Design Point1) a settlement point for a case of distribution of noise from the built-in cooler of hydraulic oil in full of the room, equal to V = 618,75 m3 are determined. Having carried out power summation of the received levels taking into account correction on a scale A we receive the corrected sound level in a settlement point (Design Point1) of L_{A1} = 73,1 dBA. We will carry out the additional, specifying calculation of the expected sound levels in a settlement point (Design Point1) for a case of distribution of noise from the built-in cooler of hydraulic oil in volume of the room of the third floor, equal to V = 183,15 m^3. Calculation is presented in tab. 3.

$$B_{1000} = \frac{V}{20} = \frac{183{,}15_{M^3}}{20} = 9{,}16 \ , \text{m}^3$$

Table 2. Calculation of the expected sound levels in a settlement point (Design Point1)
(for a case of full volume of the room equal to V = 618,75 m^3)

№	Magnitude	Reference	Compound frequency of an octava strip, Hz							
			63	125	250	500	1000	2000	4000	8000
1	2	3	4	5	6	7	8	9	10	11
1	L_{Po}	On an analog	64,0	63,0	63,0	67,0	69,0	74,0	80,0	86,0
2	$K_i*\Phi_i/S_i$	For the Design Point	2,074x10-3							
3	$S_{Guardrail}$		578,5 m^2							
4	B1000		31 m^3							
5	μ		0,65	0,62	0,64	0,75	1,0	1,5	2,4	4,2
6	B		20,15	19,22	19,84	23,25	31,0	41,5	74,4	130,2
7	$B/S_{Guardrail}$		0,035	0,033	0,034	0,40	0,054	0,072	0,128	0,225
8	ψ		0,97	0,97	0,97	0,96	0,95	0,91	0,87	0,79
9	4ψ/B		0,19	0,2	0,195	0,165	0,123	0,088	0,047	0,024
10	∑	n.2+n.9	0,192	0,202	0,197	0,167	0,125	0,09	0,049	0,026
11	10lg∑	10lg n.10	-7,16	-6,94	-7,1	-7,82	-9,03	-10,45	-13,09	-15,85
12	L_1	n.1+n.11	56,84	56,06	55,9	59,18	59,97	63,55	66,91	70,15

Table 3. The expected sound level in a settlement point (Design Point1)
(for a case in volume of the room of the third floor, equal to V = 183,15 m^3)

№	Magnitude	Reference	Compound frequency of an octava strip, Hz							
			63	125	250	500	1000	2000	4000	8000
1	2	3	4	5	6	7	8	9	10	11
1	L_{Po}	On an analog	64,0	63,0	63,0	67,0	69,0	74,0	80,0	86,0
2	Ki*Φi/Si	For the Design Point	4,93x10-3							
3	$S_{Guardrail}$		243,09 m^2							
4	B1000		9.16 m^3							
5	μ		0,8	0,75	0,7	0,8	1,0	1,4	1,8	2,5
6	B		7,33	6,87	6,41	7,33	9,16	12,82	16,49	22,90
7	$B/S_{Guardrail}$		0,03	0,028	0,026	0,03	0,038	0,053	0,068	0,094
8	ψ		0,97	0,975	0,98	0,97	0,94	0,92	0,9	0,89
9	4ψ/B		0,53	0,57	0,61	0,53	0,41	0,29	0,22	0,16
10	∑	n.2+n.9	0,535	0,575	0,615	0,535	0,415	0,295	0,225	0,165
11	10lg∑	10lg n.10	-2,72	-2,42	-2,10	-2,72	-3,82	-5,35	-6,51	-7,95
12	L_1	n.1+n.11	61,28	60,58	60,90	64,28	65,18	68,65	73,49	78,05

Thus, in column 12 of tab. 3. the expected sound levels in first (Design Point1) a settlement point are determined for a case of distribution of noise from the built-in cooler of hydraulic oil in volume of the room of the third floor, equal to V = 183,15 m^3. Having carried out power summation of the received levels taking into account correction on a scale A we receive the corrected sound level in a settlement point (Design Point1) of LA1 = 80,1 dBA.

6.2 RATIONING of noise levels in settlement points. Admissible noise levels in industrial rooms, and on adjacent to them to industrial territories, are determined taking into account following. The studied sources of external noise, as well as

subjects to protection, have a number of specific features which demand the comprehensive account at the solution of a question of applicability of the relevant provisions of the sanitary standards [1,2,3] operating in Ukraine, concerning levels of admissible noise. According to paragraph 3.1.1 and paragraph 5, the table 2 [4] admissible values of octava levels of sound pressure and levels of a sound of the getting noise in workplaces and in territories of the enterprises are given below in tab. 4.

Table 4. Admissible values of octava levels of sound pressure and levels of a sound of the getting noise in workplaces and in territories of the enterprises

Type of work and place	The sound pressure levels, dB, in octava bands of compound frequencies, Hz								$L_{A\ ecv}$, dBA
	63	125	250	500	1000	2000	4000	8000	
Performance of all types of works ((except listed in p.p. 1-4 and similar him) in constant workplaces in production placements on territories of the enterprises.	95	87	82	78	75	73	71	69	80

Considering requirements of DSN [4] that for the noise created indoors by installations of air conditioning, ventilation and air heating, the allowed levels of sound pressure in octava frequency bands, noise levels and equivalent levels of sound pressure in workplaces are established on 5 dB less, authors have taken into consideration the admissible noise levels presented in tab. 5.

Table 5. Admissible noise levels

Type of work and place	The sound pressure levels, dB, in octava bands of compound frequencies, Hz								$L_{A\ ecv}$, dBA
	63	125	250	500	1000	2000	4000	8000	
According to tab. 4	90	82	77	73	70	68	65	64	75

6.3 CALCULATION of the expected sound levels in the territory after installation of the built-in cooler of hydraulic oil. For calculation of the expected sound levels in the territory after installation of the built-in cooler of hydraulic oil it is necessary to carry out power summation of levels of a sound in a point 2 (the result is received by method of natural tool measurements) with sizes of levels of a sound on absorption from a cooler after their reduction by 3,3 dB (decrease comes at the expense of distance from a cooler to a measurement point in the territory). The forecast of the expected sound levels in the room and in the production territory adjoining to him taking into account the measured production noise background and predicted after reconstruction is presented in tab. 6.

7. SWOT- analysis of results of researches

Strengths. Results of researches will help to consider acoustic characteristics at a design stage for any noise sources, possible to application, as indoors, and in the territory of the enterprise.
Weaknesses. Weaknesses of this research are connected with that circumstance that acoustic calculation doesn't allow to consider indirect transfer of noise. This defect is eliminated by carrying out natural measurements of a noise situation in research objects after trial start of all additional and existing noise sources.
Opportunities. Results of this work will allow to conduct researches on forecasting of the acoustic mode in any rooms and in any territories in the conditions of reconstruction both for industrial, and for civil objects on condition of application of additional sources of noise in them.
Threats. The refusal of forecasting of the acoustic mode indoors with an additional source of noise can cause the considerable expenses directed to ensuring standard noise levels in subjects to protection after the full end of reconstruction of technological process (strengthening of the soundproofing ability of the protecting designs, use of sound-absorbing materials indoors with an additional source of noise, etc.).

8. Conclusions

The analysis of the results presented in work shows:

1. Excess of admissible noise levels for the room of the block of cleaning of the shop of packaging of vegetable oil after installation of the built-in cooler of hydraulic oil at the full volume not significantly also is in error limits(to 3 dB for methods of application-oriented acoustics – see p. 12 and p. 13 of the tab.3). It is confirmed by an assumption of the allowed exceeding to 3,0 dB in three octava frequency bands, or in one to 5,0 dB.

Table 6. The forecast of the expected sound levels in the room and in the production territory adjoining to him taking into account the measured production noise background

№	Magnitude	Reference	Compound frequency of an octava strip, Hz								L_A dBA
			63	125	250	500	1000	2000	4000	8000	
1	2	3	4	5	6	7	8	9	10	11	12
1	L_1 (V= 618,75)	p.12 tabl. 2	56,8	56,1	55,9	59,2	60,0	63,6	66,9	70,2	
2	L_1 (V=183,15)	p.12 tabl. 3	61,3	60,6	60,9	64,3	65,2	68,7	73,5	78,1	
3	suction	p.3 tabl. 1	61,0	58,0	58,0	62,0	64,0	69,0	75,0	81,0	82,3
4	point 1 L_1	Data of natural measurements	75,8	71,4	67,1	67,7	67,8	63,4	56,9	47,0	71,0
5	point 2 L_2	Data of natural measurements	88,5	79,8	76,3	77,1	76,8	70,5	64,2	55,1	78,5
6	suction L_2-3,3 dB	p.3 tabl. 1	57,8	54,7	54,7	58,7	60,7	65,7	71,7	77,7	79,0
7	Sum of levels (V= 618,75)	p.1+p.4 tabl.6	75,9	71,6	67,4	68,3	68,4	66,3	67,2	70,2	
8	Sum of levels (V=183,15)	p.2+p.5 tabl.6	88,5	79,9	76,4	77,3	77,2	72,5	74,0	78,1	
9	The sum of levels in the territory	p.5+p.6 tabl.6	88,5	79,8	76,3	77,7	76,9	71,7	72,7	77,7	81,7
10	Norm	tabl.5	90	82	77	73	70	68	66	64	75
11	Excess of norm at the full volume	p.10-p.7 tabl.6	14,1	10,4	9,6	4,7	1,6	1,7	-1,2	-6,2	-
12	Excess of norm at the partial volume	p.10-p.8 tabk.6	1,5	2,1	0,6	-4,3	-7,2	-4,5	-8	-14,1	-
13	Excess of norm in the territory	p.10-p.9 tabl.6	1,5	2,2	0,7	-4,7	-6,9	-3,7	-6,7	-13,7	-6,7

Note: for rooms there is no opportunity to carry out theoretical calculation of the corrected sound levels therefore the column 12 is empty.

2. Excess of admissible noise levels for the room of the block of cleaning of the shop of packaging of vegetable oil ter installation of the built-in cooler of hydraulic oil at the partial volume is essential. For preventive measures it is recommended not to reduce the available room volume. In case of need partitionings the considered placement on parts will be required expensive actions for decrease in the received levels of excess of norm.

3. Excess of admissible noise levels for the territory at the shop of packaging of vegetable oil after installation of the built-in cooler of hydraulic oil are observed in the field of averages (500-1000 Hz) and high frequencies (2000-8000 Hz). There is a number of the known actions for decrease in noise levels for this object of a research. For example,

installation of the muffler. But selection of a deafener (especially it is important for the received range of frequencies at which exceeding is predicted) it is expedient to carry out by results of tool measurements of noise in the territory after start of a cooler of hydraulic oil to operation. And it, in turn assumes that, when mounting the cooler it is necessary to provide a possibility of installation of a deafener as the additional equipment.

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