19 MINIMIZING NOISE EMISSION OF THE MAIN ROAD HAULAGE EVELS IN THE COAL MINE

19.1 Introduction

Analysis of research towards identifying the main haulage level in the coal mine helped define the sound level from conveyors and pointed out the places where noise is greatest (the results of research and analysis presented in the publication entitled 'Assessment of acoustic working environment in the way of the main haulage levels in the mine coal"). The largest area includes the noise surrounding the conveyor drive Gwarek I and Gwarek II. Along the route the rest of the main haulage level of the sound was normal or slightly above the legal limit, but only in those parts of ad hoc working crew. The next stage involved the detailed study areas provided to indicate the places where the sound pressure is the highest level. Specific studies include a conveyor drive around Gwarek I and II Gwarek conveyor drive. The analysis identified the place where the noise level was the highest:

- First Pioma I drive conveyor - conveyor Gwarek I,
- Second pouring into the reservoir - conveyor Gwarek I,
- Third node on the contact przesypowy conveyor Gwarek II - Gwarek I.

Based on studies conducted noise emissions exceeding the limits of the main haulage level in the coal mine shows a need for further analysis, to identify ways to minimize noise in designated areas.

19.2 Proposals to limit the emissions of the main sources of noise

19.2.1 Reduction or minimization of noise emissions at source

Large capacity drives installed in conveyors and gear dimensions emit sound at high levels. Replacing them with newer models for economic reasons is not very profitable. During the test drive belt area Gwarek I – I Pioma noise level was different for each of the gears. This suggested a bad technical condition of the noisier part of the drive. The study and monitoring of mining supervision of employees confirmed the hypothesis. This gear will be replaced with a new one, which reduces the noise level in the area.

When analyzing the overall sound level from the conveyor Gwarek I and Gwarek II, had different values for comparable equipment section and sidewalks. The difference between the two conveyors was the work of several [dB] for the conveyor Gwarek I. This resulted from several factors. The first of these was the use of bonding of subsequent sections conveyor belt, and only one type of mechanical connector FLEXCO. If the conveyor Gwarek II was the most connections FLEXCO type, which resulted in blows to the runners and constituted an additional source of noise. The use of bonding, in addition to better acoustic conditions, is much more durable. However, it requires more time and employment specialists from outside companies, but the aspect of minimizing the noise emissions should apply this method to connect the tape. Another factor influencing the volume of work is a kind of conveyor rollers used. In the case of a belt Gwarek I, approximately 90% of runners come from the company Pioma. The sound emitted by the original runners were at 75 [dB]. However, in the case of a belt replacements installed Gwarek II, whose work is accompanied by acoustic emission at 83 [dB]. Therefore, to minimize the emission of noise should be used with original rollers.

Another site identified on the route of the conveyor, in which the level of noise was 121 [dB] was the work of a pneumatic pump VOCO. After reviewing the design parameters and the pump manufacturer markets, the origin of the formation of such a high emission was unequivocal. New product is equipped with a silencer, which is located on the exhaust nozzle. At the pump, working near the belt drive Gwarek II, the muffler was replaced by a smooth section of the tube, resulting in increased noise emissions. Replacing the muffler section of the simplest reflex would significantly reduce this level.

19.2.2 Reducing transmission of acoustic energy on the roads of delivery

Acoustic space [2, 4, 7, 8] consists primarily of increased sound absorption in the test pit chodnikowego the corridor. Before taking action to increase sound absorption, an analysis of the acoustic field at a given location. Through the introduction of sound-absorbing materials, part of the acoustic wave is absorbed, thereby reducing the noise level at the site of application. They also correct the unfavorable shape of the acoustic excavation corridor. Schematic of wave propagation is shown in fig. 19.1:
a) The nature of acoustic wave propagation in a segment of the excavation corridor,
b) The propagation of waves after installing sound-absorbing materials in the cover housing.

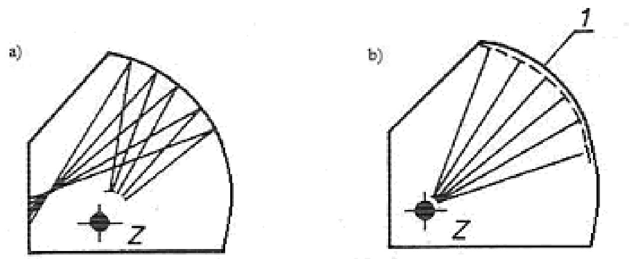

Fig. 19.1 Acoustic wave propagation in the cross-pit [2]

Excavation Corridor promotes concentration of acoustic waves, thus resulting effect is enhanced. The room with the best distribution of the acoustic field can be obtained using a flat ceiling. But in the case of roadways such a solution is impossible. Therefore, the best solution for acoustic roadways is the introduction of sound absorbing pad on the roof ociosy and excavations in places exceeded noise, changing the materials used in the isolation area of excavation or the use of additional cladding material with a higher degree of absorption of acoustic waves. Insulation should be installed in the immediate vicinity of the major sources.
Using the formula for sound absorption can be calculated that using traditional sealing materials it is equal to:

$$A_{obud} = \sum S_i \cdot \alpha_{śr} [m^2] \tag{19.1}$$

where: A_{obud} – absorption of acoustic enclosure [m^2],
S_i – housing area [m^2],
$\alpha_{śr}$ – average sound absorption coefficient ($\alpha_{śr}$ = 0,016 – raw concrete).

$$S \approx \frac{\pi\left[\left(\frac{3}{2}(a+b)\right)-\sqrt{ab}\right]}{2}\cdot L \qquad (19.2)$$

where: S – surface area of sied walls and ceiling ,
a – width of the ellipse – 5,5[m],
b – length of the ellipse – 3,8[m],
L – length strech of sidewalk – 18,5[m],
S ≈ 272,5[m^2].

Substituting the value of S to the formula 1, we calculate that absorption of the excavation is 4.4 A [m^2]. However, it is probable size because you can not accurately calculate the surface area of the segment of the sidewalk. The absorption is also affected by all the elements on the walls and ceiling ociosu: arches susceptible steel mesh and surface texture ociosu.

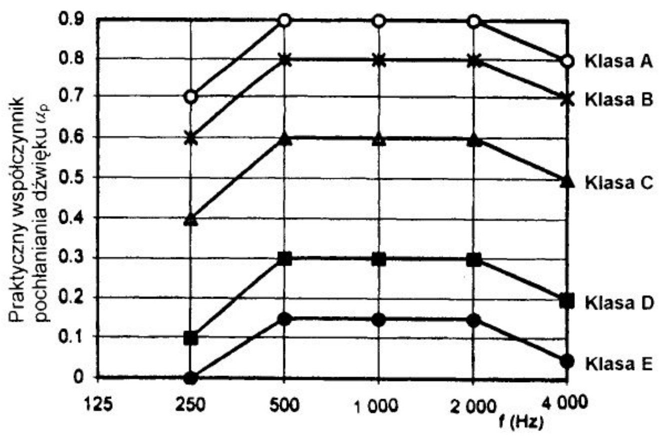

Fig. 19.2 Reference curves illustrating the absorption class [4]

The material taken for the calculation of the raw concrete, used as insulation for rugs. PN-EN-ISO 11654 is below the absorption in the class E, is successively: 0.01 to 125 [Hz], 0.012 for 250 [Hz], 0.016 to 500 [Hz], 0.019 for 1000 [Hz], 0.023 for 2000 [Hz]. This means that it is not classified as a material absorbing sound waves. Classification of sound absorption, according to PN-EN-ISO 11654, is shown in fig. 19.2.

Tab. 19.1 The product range in the class of acoustic

Class absorber sound (in accordance with EN ISO 11654)	**Values alpha w**	**Class absorption**	**Product**
A	0,90- 1,00	Very High absorbent	Rocfon Facett Thermatex ALpha czarny
B	0,80 - 0,85	Very High absorbent	Thermatex Alpha HD
C	0,60 - 0,75	High absorbent	Thermatex Kombimetall Rocfon Cosmos
D	0,30 - 0,55	Absorbent	THERMATEX Symetra
E	0,15 - 0,25	Low absorbent	THERMATEX Acoustic RL

In the case of the use of absorbent materials relevant classes, the total volume of sound in the pit would have been significantly changed. However choosing a material that met the high requirements of materials, which can be used in underground mines. It must therefore be: Intrinsically safe, non-flammable and not forming reaction with the atmosphere of the mine. Tab. 19.1 shows the range of products that can be used to increase the acoustic sidewalk pit mining.

Two products with the best parameters are:

Rocfon Facett, THERMATEX Alpha Black [8] were made of pure wool. They have a smooth, painted white surface. A very high absorption coefficient (fig. 19.3), which allows for significant reduction of noise in industrial facilities. Facett panels are lightweight and easy to cut, which makes them very efficient in the assembly process.

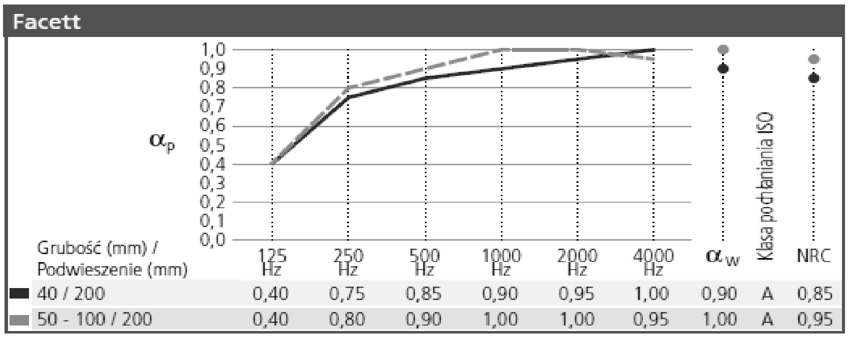

Fig. 19.3 Rocfon Facett acoustic absorption [8]

The basic parameters are: reaction to fire class - Class A1 in accordance with EN 13501-1, moisture resistance and dimensional stability of 100% light reflectance: 59% according to ISO-7724-2.

THERMATEX Alpha Black [7] - is a newly developed, covered with felt, acoustic panel with mineral wool. In addition to the high acoustic requirements also shows different physico-building (fig. 19.4). This, produced by the wet process (wet-felt) plate, is very easy to handle and assembly work.

The basic parameters are: reaction to fire class A2-s1, d0 according to EN-13 501-1, class of fire resistance: F30 - F90 according to DIN 4102 part 2 (in accordance with test certificate), resistance to moisture up to 95% relative humidity, light reflection - 3.8%.

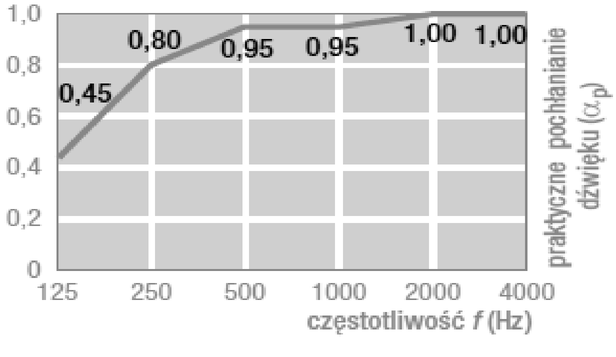

Fig. 19.4 Graph of acoustic absorption THERMATEX Alpha Black [7]

The proposed products of the highest sound absorption, which is a Class A, it is best company Rocfon Facett material. Because, although slightly worse absorption characteristics have greater resistance to humidity. In addition, the material proved to be an underground parking suppressing and halls, where there are severe climatic conditions.

In order to achieve a marked improvement in noise reduction should be used to cover 50% of the mats, since the use of larger quantities of material greatly increases the cost by lowering the minimum difference in sound. According to the manufacturer and the dimensions of the excavation slice computed acoustic absorption of 4.4 [m^2] to rise to 126.7 [m^2]. This solution minimizes almost to zero the concentration of the acoustic wave. The employee will be accompanied by only the direct waves. Reduce the reverberation time and correct adverse acoustical reasons, the shape of the excavation. Value by which the density will be reduced noise from the formula:

$$\Delta L = 10 \log \frac{A_2}{A_1} [dB] \tag{19.3}$$

where: A_2 – acoustic absorption in front of an adaptation [m^2],
A_1 – acoustic absorption after adaptation [m^2].

This value is equal to 14.6 [dB]. With Rocfon Facett for our case material cost will be around 8400 [zł].

Sound-insulated enclosure aimed at reducing the vibroacoustic energy from the source to the environment. They are most effective protection from a group of passive noise protection.

19.2.3 Housing chute

Pouring into the tank has a rectangular shape of the hopper, which receives the output of the main haulage level 850, and the conveyor belt, located on the opposite side, which transports the excavated material from the excavation preparatory to another part of the mine. It is made of steel with a thickness of 25 [mm]. Output falling into the tank directly attacks the steel element (plate). Install the tires inside the basket would be a good solution, but only for a short period of time. The only solution is to attempt to create an additional building materials from outside the tank or an increase in sound-absorbing surfaces by covering the space above the hopper. It is here that comes out of the working environment largest number of sound waves. Therefore, considerations of minimizing noise should include the installation of sound barriers in this place.

The most effective solution would be to create a flap with sound-absorbing materials, which cover largely empty space above the hopper. Surface field created by the upper edges of the hopper has a dimension of 6.25 [m^2]. Construction of the cover should be as lightweight and easy to install, yet resistant to the conditions that prevail in the underground mine. A sample solution (fig. 19.5) may be the frame dimensions of 2,5x2, 5 [m] forming an enclosure made of angle steel with dimensions of 80x80x12 [mm], also equipped with a flat forming ribs formed inside the plane, which will be placed sound deadening material. In addition, will be equipped with four walls of a conveyor belt, including two belts crisscrossed by forming a curtain on a conveyor by means of a screw is fixed to the bracket. Flap design could be suspended by chains to the ceiling zaczepionych excavation. This design will allow for its easy installation and will not interfere directly in the design of the hopper.

Absorption acoustic enclosure [1]:

$$A_{obud} = \sum S_i \cdot \alpha_{śr} [m^2] \tag{19.4}$$

where: A_{obud} – absorption of acoustic enclosure [m^2],
S_i – another area of the housing wall [m^2],

Data:

S_s - check the top of the casing = 6.25 [m^2]
S_{obc} - field edge throughout = 7.5 [m^2]
S_{obek} - field edge of the curtain = 5.1 [m^2]
S_c-field total enclosure = 18.85 [m^2]
S_u-utility box housing = 18 [m^2]
the as - for the material of mineral wool - Rockfon-Industrial = 0.9
α_{obc} - for polyurethane foam - Hanpol - protectorates 20 = 0.78
α_{obk} - for conveyor belt = 0.1
$\alpha_{śr}$ - the average sound absorption coefficient of the material.

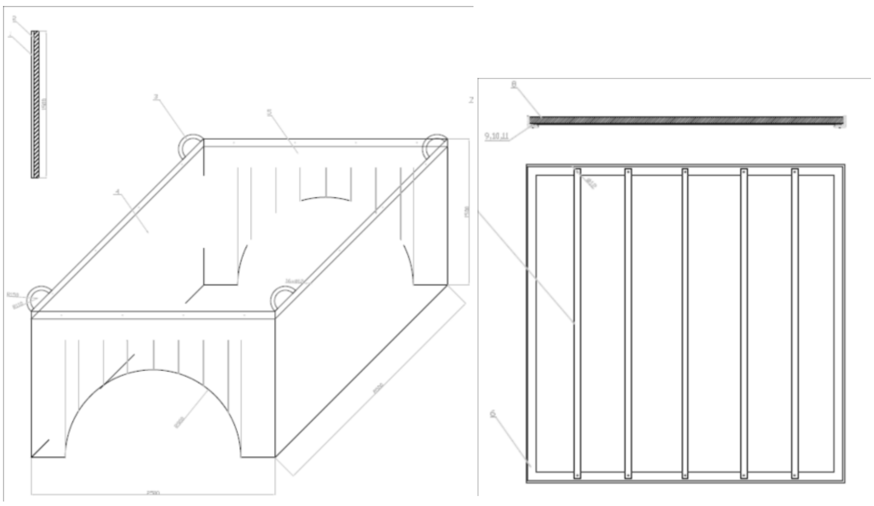

Fig. 19.5 Chute housing scheme

Calculation of sound absorption Case:

$$A_p = 6.25 \cdot 0.9 + 7.5 \cdot 0.78 + 7.5 \cdot 0.1 + 5.1 \cdot 0.1 + 3 \cdot 0.75 = 15 \ [m^2]$$

Sound insulation cover is:

$$D_{obud} = 10 \log \frac{1}{1 - \frac{S_s}{S_c}} \ [dB] \tag{19.5}$$

where: D_{obud} – acoustic enclosure[dB],
S_c – total area of the inner casing [m^2],
S_s – surface of the housing wall [m^2].

$$D_{obud} = 10 \log \frac{1}{1 - \frac{18}{18,85}} = 13,5 \ [dB] \tag{19.6}$$

With the case of a suspended hopper, the level of sound escaping into the work environment will be reduced by 13.5 [dB]. The cost of materials for the presented case will be about 800 [zł].

19.2.4 Cover Flow Rate

Like the chute into the container so, and here are the main cause of exceedences dynamic phenomena that accompany the spoils of the conveyor hitting Gwarek I. Construction of a node on the contact Gwarek I - Gwarek II is the brainchild of mine. It replaces the company przesyp Pioma Lejowa construction. Currently housing przesypowego node is a rectangular block constructed of sheet thickness of 7 [mm]. Falling output hits the chains hanging from a rubber band, then slides the rest of the conveyor. Rubber has the task of slowing output. The design of this type allows for additional installations on the walls of existing housing, which can be obtained form sound-insulating housing.

The best solution is isolated nodes przesypowych their total settlement, where, besides the sound of systems can be installed for trapping dust, and the drainage area Flow Rate [3]. This type of solution is very expensive and requires a stoppage of work on time in service development. Examples of this type of solution picture 19.6 illustrates.

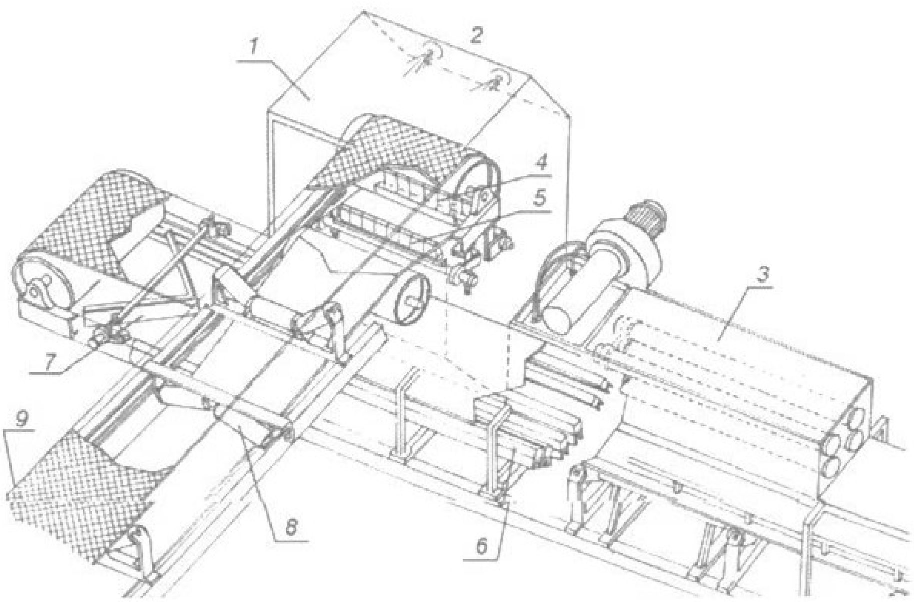

Fig. 19.6 Node with the system and the sound-device dust finder [3]
1 - covered with sheet metal cover insulating regime, 2 - spraying nozzles, 3 - flirt vacuum buck, 4, 5 scrapers to clean the tape, 6 - sliding fender beams, 7 - two-way plow scraper, 8- sets of rollers, 9 - conveyor belt

One solution could be a flap that covers the upper periphery of the existing Flow Rate as for the hopper to the storage reservoir. Accumulation of sensor output, which is suspended at this point rule out the solution of this type. The only solution would be to cover existing walls and adding movable walls in the front, which will allow free access to the interior of Flow Rate at time of output stagnation. Have been made from a conveyor belt covered with polyurethane foam. Calculation of housing absorption was calculated from the formula fourth.

Data:

S_s - Flow Rate box wall = 5.55 [m^2]
S_{SD} - field wall extra = 2.25 [m^2]
S_c - field total housing = 7.8 [m^2]
S_u - utility box housing = 7.3 [m^2]
the as - for the material of mineral wool Isover-Polterm Uni = 0.9
α_{sd} - for polyurethane foam - Hanpol-protectorates 20 = 0.78
α_b - for steel = 0.1
α_t - for conveyor belt = 0.1

Absorption acoustic enclosure is:

$$A_p = 5{,}55 \cdot 0{,}9 + 5{,}55 \cdot 0{,}1 + 2{,}25 \cdot 0{,}78 + 2{,}25 \cdot 0{,}1 = 7{,}53 \ \ [\mathrm{m}^2] \tag{19.7}$$

Sound insulation cover is:

$$D_{obud} = 10 \log \frac{1}{1 - \frac{7{,}3}{7{,}8}} = 11{,}9 \ \ [\mathrm{dB}] \tag{19.8}$$

The use of additional lining of the existing housing will reduce the sound of 11.9 [dB] at cost and effort of about 400 [zł] (excluding labor costs).

19.3 Summary and conclusions

The analyzes and calculations for these cases suggested ways to reduce the sound pressure level in the following areas:

- First Conveyor drive Pioma I - Transport Gwarek I.

The level of employee exposure to noise at the measuring point exceeds the value specified by standards of 8.3 [dB]. Research conveyor drive Gwarek I showed the difference of the sound between drives equal to 5 [dB]. Its cause was the use of the inside of one of the gears. Proposed replacement of the drive, later studies confirmed the relevance of this approach.

- Second Pouring into the reservoir - conveyors Gwarek I.

The level of employee exposure to noise at the measuring point exceeds the value specified by standards of 8.7 [dB]. Increased emissions of sound, however consisted of the entire reservoir area. Using technical means to minimize sound, designed to cover dźwiękochłonno-insulating chute into the tank for a high success rate of about 13.5 [dB]. Its use will permit a norm equivalent sound level values. The cost of materials dlazaprojektowanej housing is about 500 [zł].

In addition, for the entire region surrounding the conveyor drive Gwarek I conducted acoustic analysis of the excavation. It has allowed a method to minimize noise at the shape of the mining pit unfavorable . With the boot side walls and ceiling of soundproofing material class total sound level will decrease from 88.7 [dB] to 74.1 [dB]. Acoustic energy emitted bythe device will be absorbed by the lining, and employees will be accompanied by only the direct sound. Disappears the concentration of the acoustic wave. The cost of materials needed for acoustic excavation of about 8400 [zł].

- Third Node on the contact conveyor Gwarek II - Gwarek I.

The level of employee exposure to noise at the measuring point was 99.3 [dB], and thus exceed the value specified by standards of 14.3 [dB]. Using technical measures to reduce the emission of sound proposed enclosure design Flow Rate soundproof material. Such a solution should reduce emissions by 11.9 [dB], which does not allow to obtain the value of the norm. But comfort will be improved significantly. The cost of this solution is about 400 [zł] plus the cost of implementation. Ways, which will endorse the norm emission sound levels require significant time and financial resources. Is required then the total reconstruction of the junction.

Research and monitoring the work of both conveyors also indicated two solutions that will reduce the equivalent sound level of a few [dB] along the conveyor route, consisting in:

- Change to the original roller company Pioma,
- Replacement of mechanical joints glued joints.

The most effective, and least expensive way to minimize the sound for the drive belt surrounding Gwarek and chute design is proposed for the storage reservoir. The most expensive way, but equally effective is the acoustic excavation corridor.

Noise exposure level in 8 hours working day in the surveyed areas far exceeds the norm, and therefore required is the selection and implementation of solutions aimed at reducing the danger of this factor, which in turn will help to reduce occupational risk.

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