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Research Article

PROPOSAL OF THE SOUND INSULATING MEASURES FOR A VIBRATIONAL SORTER AND VERIFICATION OF THE MEASURED EFFECTIVENESS

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ABSTRACT
The paper describes a specific design of the sound insulating enclosure of a vibrating sorter. Recycling aspects have been taken into account when designing the enclosure, because recycled foam has been applied as a sound-absorbing material. An acoustic camera was used to measure, analyze, evaluate and to localise and identify sound sources. The visualization method was used to locate the critical locations of the device and then quantify them. To evaluate the effectiveness of the proposed enclosure, the measurements of the sound parameters were performed before and after the realization soundproofing measure. The measured results show the requested efficiency of the sound insulating enclosure in terms of noise reduction as well as dust near the sorter.

Keywords: sound insulating measures, vibrational sorter, noise visualization, analysis and measurement.

INTRODUCTION

The possible effects of the formation of undesirable conditions that may cause increased vibration of devices used predominantly in stone quarries are described more specifically in the publications [1÷5].

When designing a noisy machine enclosure, we use structural elements to interrupt the propagation paths by the applications of sound absorbing materials and vibro-elastic material and elements. The enclosure must be designed with regard to the machine running checks, its repairs, disassembly and proper cooling during operation [6]. The design and calculation of acoustic enclosures, cabins and wrappings is given a great deal of attention in the book by Ver and Beranek in Chapter 12 [7].

Before designing the soundproofing measures of the technological devices, it is necessary to know the frequency of the sound that is calculated from the time recording of the sound. Such outputs can be obtained by conventional sound measurement techniques as well as modern technologies for measuring and visualizing sound [8÷11]. Correct vibro-acoustic analysis of individual components of mechanical and electrical equipment is essential based on theoretical and practical knowledge published in books and publications as [12÷20].

The sound insulation materials used for the application of the enclosures in heavy industrial installations are subject to high demands, particularly in terms of high sound insulation, dimensional stability, ease of handling and ability to withstand temperature changes and changes in air humidity. Requirements and recommended procedures for designing workstations and noise measures for workplaces with mechanical devices are given in STN EN ISO 11690-2: 1999 [27] as well as in works by Liptai. R.G. and Zajac [21÷23].

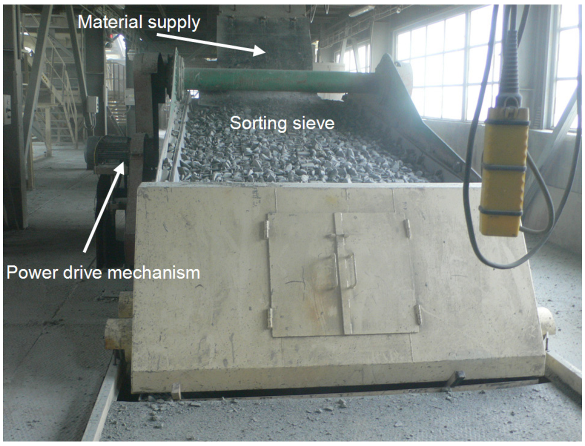

Fig. 1. Vibrational sorter

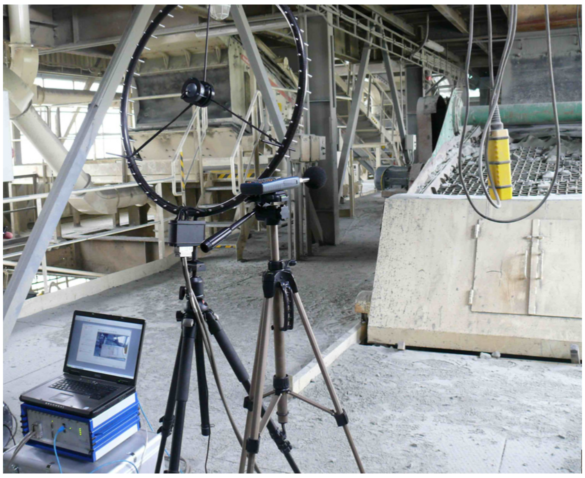

Fig. 3. The location of the acoustic camera and the sound analyzer at the measurement point P6 and K2

EXPERIMENTAL PART

Vibrational sorter (Fig. 1) is a device that serves to separate stone fractions of different sizes depending on the vibrating sieve used. The drive is provided by an electric motor, which is the driving element of the pulley and belt transmissions. The sieve gradient and the oscillation of the entire device cause the fraction to shift over the vibration sieve. The larger fraction is moved to the end into the buffer and the smaller fraction falls through the mesh sieve into the container and the next conveyor belt. The vibrating sorter is attached to the metal floor structure, which transmits oscillation from the floor to the surrounding structures.

MATERIALS AND METHODS

For the sound analysis of the device, we chose a method of measuring A - weighted equivalent sound pressure level and a method of dynamic visualization of sound, which is very advantageous in terms of sound source localization. For measurement we used the Class 1 sound analyzer, Norsonic 140, and a circular microphone acoustic camera were used. This microphone array is designed primarily to identify sound sources of machines and equipment inside industrial plants and buildings.

At the measurement points indicated in Fig. 2 as P1-P6. 1-minute measurements were realized by the sound analyzer at a distance of 1.5 m from the structure of the sorter along its circumference. At the measuring points indicated in Fig. 2 as K1 and K2. 8-second acoustic camera measurements were taken during which all sources of sound that occurred throughout the measuring period were captured. The location of the acoustic camera and the sound analyzer at the measurement point P6 and K2 is shown in Fig. 3. The measurements were performed in two operating modes and in the case of the vibration sorter being on with sorting of stone fraction and without the sorting (no load of stone fraction). The stone fraction was up to 32 mm. These same measurements were made even after the sound insulating enclosure was realized.

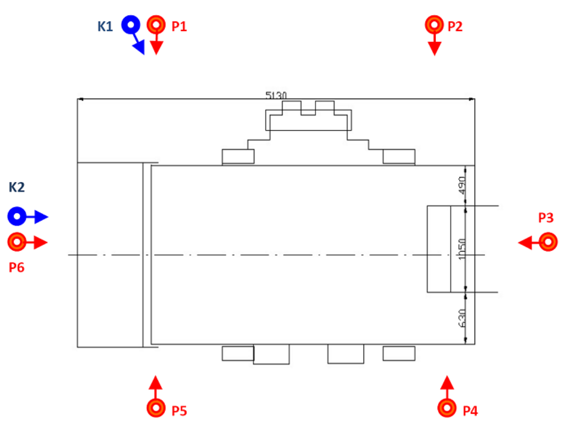

Fig. 2. Measurement points

ANALYSIS AND SOUND SOURCES LOCALIZATION

Acoustic camera measurements help us better locate the devices noise sources. Acoustic images of quantitatively significant sources of noise are shown in Fig. 4 to Fig. 6 during the sorting of stone fraction.

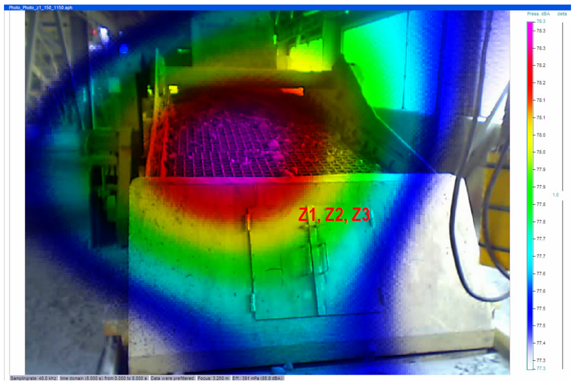

Fig. 4. Acoustic image for the frequency range from 150 Hz to 1150 Hz

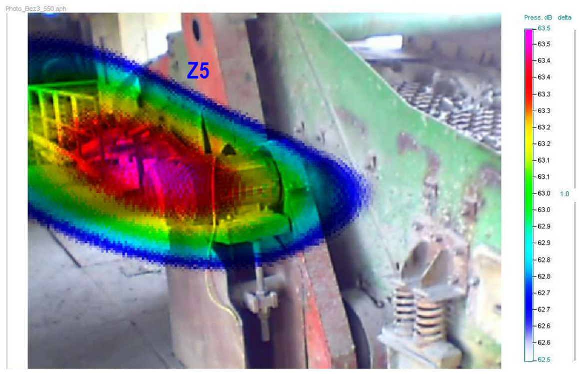

Fig. 6. Acoustic image for the frequency 690 Hz

Fig. 5. Acoustic image for the frequency 890 Hz

Classification of partial noise sources from the loudest to the least noisy is of great importance for the selection of noise measures. Based on the analysis carried out, the noise sources were classified according to significance in descending order:

- Z1 - Noise caused by the supply of material and the fall of the stone fraction on the metal parts and the vibrating screens;
- Z2 - Noise caused by moving the stone fraction to the sorter site;
- Z3 - Noise caused by the oscillation of the whole sorter;
- Z4 - Belt gear elements noise;
- Z5 - Electric motor noise.

The analysis of noise sources shows that the dominant source of noise is the fall of the stone fraction on the sorter construction and the shifting of the material along the site of the sorter. The realization of structural changes for noise reduction is very difficult and inefficient for this kind of noise sources. In addition, there could be an unwanted impact on the operating parameters, functionality and efficiency of the device. For these reasons, the most effective solution is to cover the entire vibrational sorter.

DESIGN OF SOUND INSULATING ENCLOSURE

From the point of view of the function and parameters of the device, we designed a sound insulating enclosure with access to maintenance of the sorting device, see Fig. 7. The design was realized with a flexible housing of wheels that allows movement of the enclosure. The avoidance of undesirable conditions was taken into account, (overheating, resonance, etc.). For realization are used oriented strand boards along the load-bear-

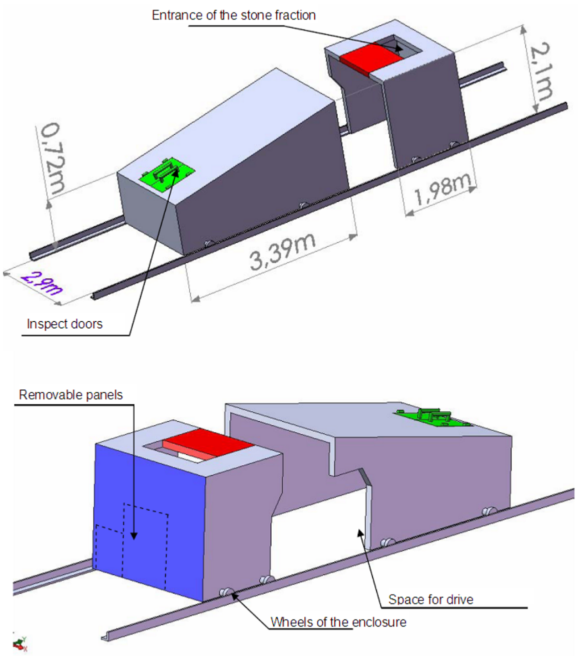

Fig. 7. 3D view of the enclosure design for vibrational sorter

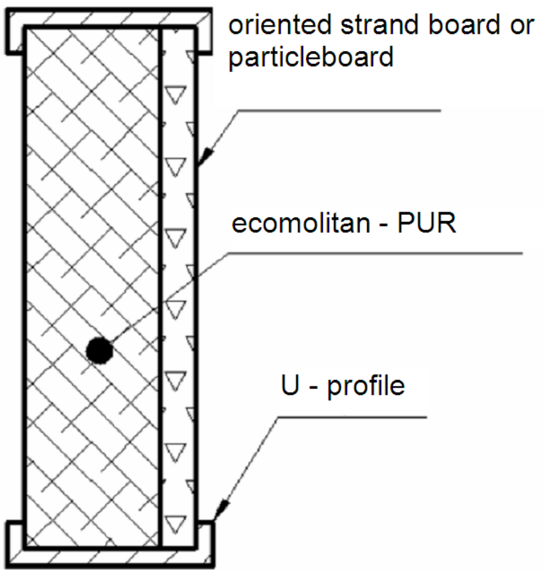

Fig. 8. Cross-section of the sandwich arrangement

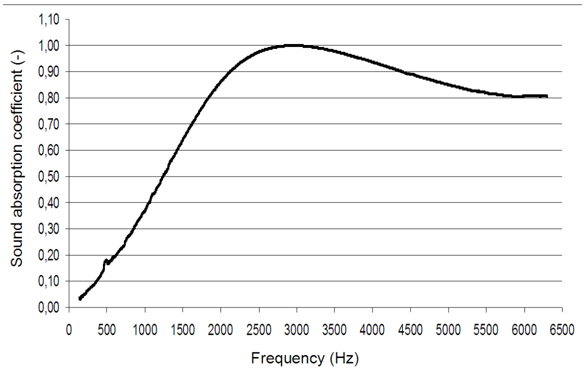

Fig. 9. Sound absorption coefficient of recycled polyurethane foam with recycled car seat cover - thickness of 50 mm

ing structure of the walls and the ceiling cover. The thickness of the inner filler of the sound insulating material for this cover design is min. 50 mm. The cross-section of the sandwich arrangement of the sound insulating cover materials is shown in Fig. 8.

When designing an acoustically suitable material inside the sound insulating enclosure, we also took into account the recycling aspect. In terms of physical parameters, handling and efficiency, we have designed recycled polyurethane foam and recycled car seat covers for this application. The addition of a binder based on liquid cured polymers results in a material that exhibits favorable thermal insulating and sound insulating properties. The sound absorption coefficient was

Fig. 10. Realized sound insulating enclosure

determined by its own measurements by the impedance tube and is graphically illustrated in Fig. 9. The methodology and procedure for measuring and determining the sound absorption of materials are described in more detail [24÷26].

RESULTS AND DISCUSSION

Realized sound insulating enclosure with detailed views of the maintenance door design and the drive cover with the belt gears is shown in Fig. 10. The casing of the drive with belt gear has been designed with openings for natural cooling.

The results of measurements of the A – weighted equivalent sound pressure level of the vibrating sorter without sound insulating enclosure and with the installed sound insulating enclosure in both operating modes are shown in Table 1.

Fig. 11 shows a comparative graph of the values of A – weighted equivalent sound pressure level at the individual measurement points before and after the measures during the operation mode without sorting of stone fraction.

Measurement analysis in idle mode shows a reduction in the A – weighted equivalent sound pressure level between 8.5 ÷ 11 dB after the installation of sound insulating enclosure. In this case, the measurements were influenced by background noise, respectively noise from other technological units.

Fig. 12 is a comparative graph of the values of A – weighted equivalent sound pressure level at the individual measurement points before and after the measures taken during the sorting of stone fraction. Analysis of mode with stone sorting measurements indicates a reduction in the A – weighted equivalent sound pressure level in the range of 3 ÷ 5 dB after the installation of the sound insulating enclosure. When evaluating the effectiveness of sound insulating measures, it is

Table 1. A – weighted equivalent sound pressure level $L_{Aeq.T}$ before and after realization of the measures

Measurement points	Mode without stone fraction sorting		Mode with stone fraction sorting	
	Without enclosure	With enclosure	Without enclosure	With enclosure
	A – weighted equivalent sound pressure level $L_{Aeq.T}$ [dB]			
P1	87.0	76.1	91.6	87.4
P2	87.2	78.4	91.6	88.1
P3	87.5	78.9	92.2	88.4
P4	87.5	76.1	92.1	88.6
P5	89.0	77.3	92.7	88.4
P6	85.9	77.4	90.5	87.8

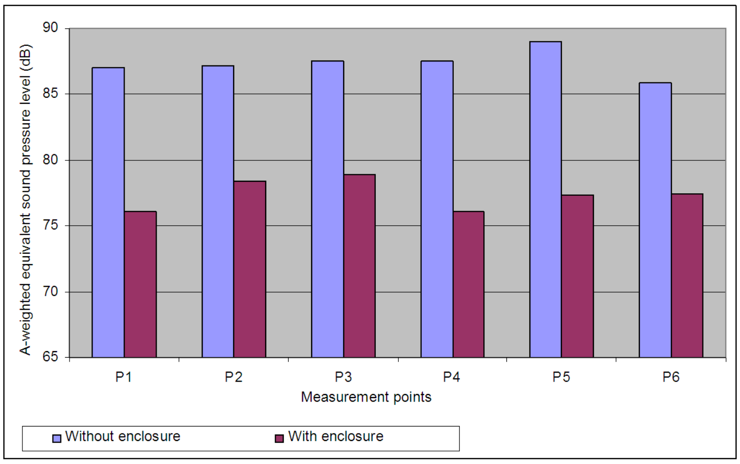

Fig. 11. Graphical comparison of the $L_{Aeq.T}$ - mode without stone fraction sorting

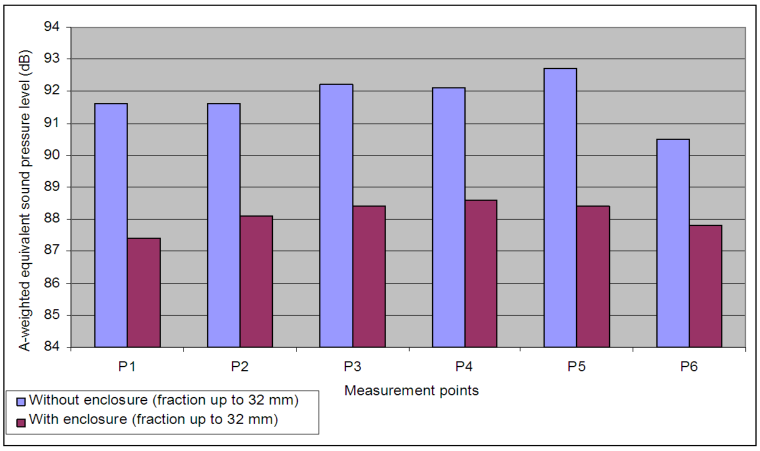

Fig. 12. Graphical comparison of the $L_{Aeq.T}$ - mode with stone fraction sorting

necessary to take into account the noise of other technologies that had to be in operation due to the supply of the stone fraction to the vibration sorter.

Analysis of acoustic camera measurement results was performed using A - weighted frequency spectra. Comparison of the frequency spectra of the sound generated from the measurements in the K1 and K2 measurement points in the operating mode during stone fraction sorting before (Fig. 13 and Fig. 15) and after (Fig. 14 and Fig. 16) the realization of the sound insulating measures.

From the comparison spectra in Fig. 13 and Fig. 14 they show that these sound insulation measures significantly reduced the noise level

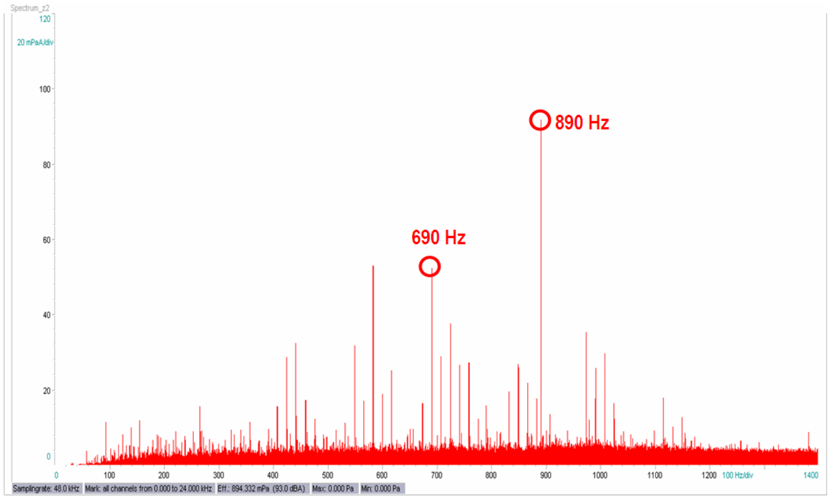

Fig. 13. Frequency spectrum in the measurement point K1 – without enclosure

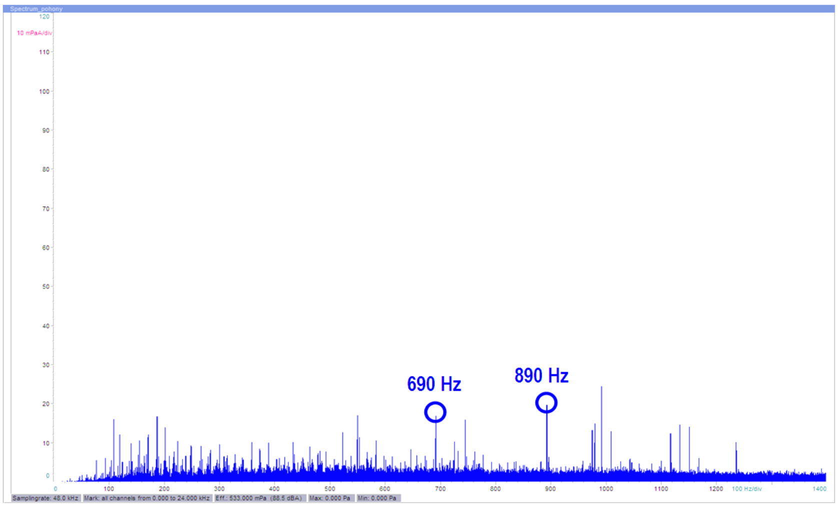

Fig. 14. Frequency spectrum in the measurement point K1 – with enclosure

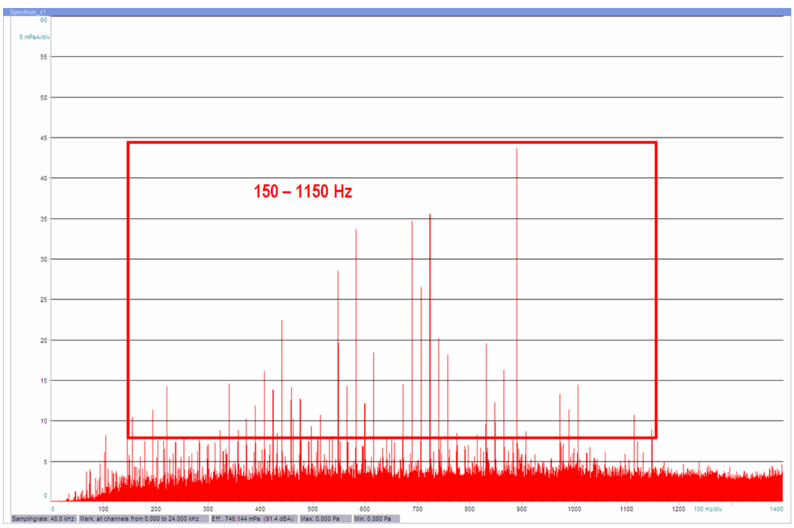

Fig. 15. Frequency spectrum in the measurement point K2 – without enclosure

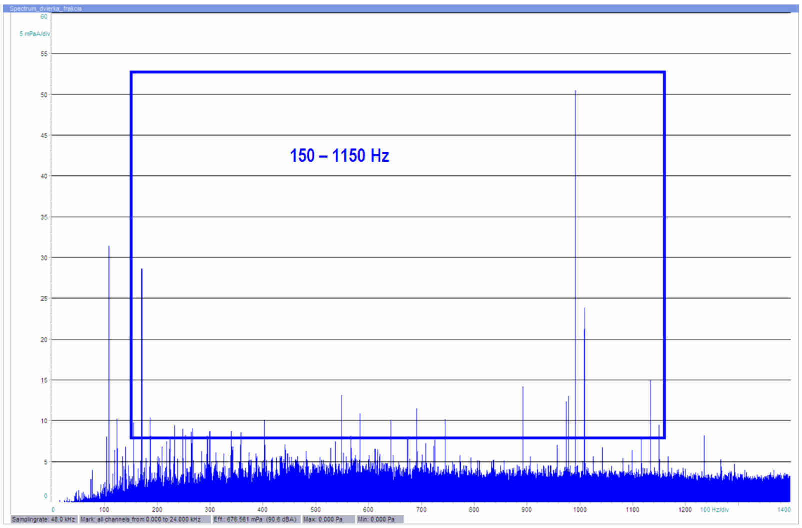

Fig. 16. Frequency spectrum in the measurement point K2 – without enclosure

at the frequencies emitted by the drive unit and belt gear components.

From the comparison in the frequency spectrum in Fig. 15 and Fig. 16, they show that, after covering the vibration sorter and the realization of additional sound insulating measures such as the isolation of the front maintenance doors, this reduced the noise levels of most frequencies. The increase of the sound pressure level occurred in the frequency range of 1000 Hz and at the frequency of 170 Hz, which however may not be related to the sources of noise of the vibration sorter, since other technological sources of noise (conveyors and other sorting devices) which affect the acoustic situation in the surroundings of the vibrating sorter.

CONCLUSIONS

The presented work is focused on the solution of industrial noise sources in the working environment. Resolving noise from industrial sources is a demanding process that requires complex theoretical and practical knowledge in the field of acoustics, which must be based on science and research results. The most appropriate way to effectively reduce machine, mechanical and technological noise levels is to address this factor at the design and production stage. In practice, there are a large number of instances where noise issues are needed to be reduced by technical sound reducing measures on already operated equipment and machines. These noise reduction measures can be applied directly to noise sources, to the noise propagation transmission path, and to the persons receiving the noise. Noise reduction solutions by use of an acoustic visualization technique can serve as an aid to the faster and more efficient localization and analysis of partial noise sources. The concrete realization of the sound insulating enclosure of the vibrational sorter in the operation of a stone quarry was able to reduce the noise levels in its surroundings. A secondary effect of this measure is the reduction in the concentration of solid aerosols in the vicinity of the sorter.

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