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EXPERIMENTING RIGID AND ELASTIC CLAMPING METHODS OF ACOUSTIC SCREENS

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Abstract

The paper investigated a series of acoustic waves propagation modes in closed environments. Also, a series of experiments have been conducted in order to reduce noise with the help of acoustic screens. Screening a source of noise in an industrial enclosure has revealed a series of results described in our research. There have been used two methods of clamping the acoustic screens walls on a metal frame: rigid and elastic. The acoustic screens used in the experiments were made of Oriented Strand Boards. The experiments were carried out for two variants of walls positioning: a three-walled variant and cover and a five walls variant (a cabin). The number of walls is important in determining the differences between sound pressure level values for the two types of experiments. The experiments have revealed that the rigid clamping is more suitable while the noise attenuation can be more efficiently achieved when using acoustic screens composed of several walls.

Key words: acoustic screen, elastic clamping, industrial noise, rigid clamping

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1. Introduction

Noise pollution generated by industrial activities is a very important environmental issue, especially when it comes to industrial enclosures with processing equipments, where impact noise is being produced and noise levels frequently exceed the legal requirements for human exposure to noise (Bratu et al., 2011; Chatillon, 2007; Cobo et al., 2004; Dupont et al., 2009; Ioan and Ursu, 2010; Tomozei, 2011a; Tomozei et al., 2011bc, 2012; Tomozei et al., 2016). The level of noise generated by the functioning of the equipments, machineries and installations on the structures, buildings and the surrounding areas may be influenced on the long-term (Dupont et al., 2009; Li and Wong, 2005; Peters and Nutt, 2010; Pinte et al., 2009; Tomozei et al., 2011b, 2012).

Industrial noise can be controlled by eliminating factors generating noise or by using materials to reduce noise on the propagation pathways. Noise transmission in enclosures can be controlled by the acoustic treating of enclosure to limit the inside and outside noise propagation (Dascalu and Negrea, 2016; Dupont et al., 2009; Liu and Herrin 2010; Petrovici et al., 2016; Sagartzazu et al., 2008; Serizawa and Hongob, 2002; Tadeu et al., 2007; Tomozei et al., 2011a; Tomozei. 2011b; Zhang et al., 2008).

The measurements, the analysis and the evaluation of noise are very important in estimating the potential effects of noise upon health, safety, comfort and work efficiency (Barron, 2003; Boiko et al., 2003; Kumar et al., 2014; Li and Wong 2005; Liu and Herrin 2010; Mak and Leung, 2013; Mitran et al., 2012; Pinte et al., 2009; Panainte et al., 2009; Platon and Hionis, 2014; Serizawa and Hongo, 2002; Tadeu and Godinho, 2003; Tomozei, 2011a; Tomozei et al., 2011bc, 2012; Ye et al., 2017; Zhang et al., 2008).

The attenuation of the acoustic waves propagation in industrial environments is a problem that can be studied in different environments and which can be offered different solutions. One method

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of attenuating the propagation of sound pressure level is by using acoustic screens (Barron, 2003; Li and Wong 2005; Liu and Herrin 2010; Pinte et al., 2009; Tadeu and Godinho, 2003; Tomozei, 2011b; Tomozei et al., 2011c, 2012).

The acoustic screens are used to ensure a less noisy environment in a working area, by mounting them between the protected area and the noise source. This method attenuates direct waves but allows the passage of reverberate and refracted waves from the upper edges of the screen (Barron, 2003; Liu and Herrin 2010; Pinte et al., 2009; Tadeu and Godinho, 2003; Tomozei, 2011a; Tomozei et al., 2011, 2012).

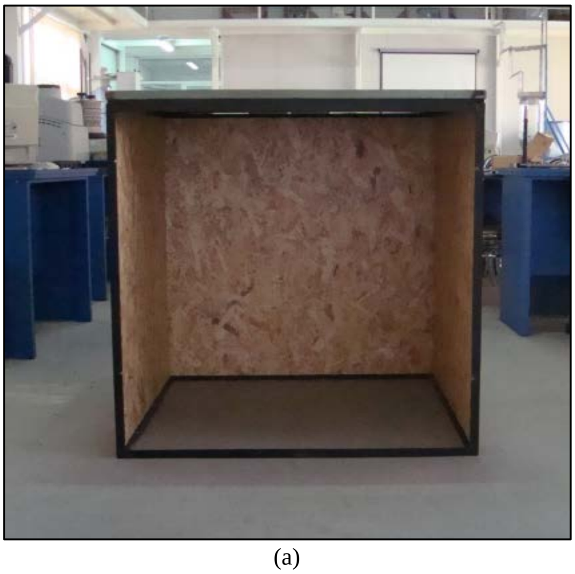
In some cases, the presence of massive acoustic screens between the sound source and the area to be protected is not advisable. Modular acoustic screens should be used in such situations as they can be arranged in such a way as to form the desired contour. With their help, any forms of noise sources can be used in order to obtain low noise areas (Li and Wong 2005; Liu and Herrin 2010; Pinte et al., 2009; Tadeu and Godinho, 2003; Tomozei, 2011a; Tomozei et al., 2011bc, 2012). Acoustic screens offer an efficient solution for many industrial applications as well as for noise control equipment. They are used in indoor applications as mounted elements on the walls and/ or ceilings. When it is necessary to reduce the level of noise in a certain point, sound-absorbing and sound-insulating panels can be placed. By placing such a panel, noise reduces in almost all frequency range while the largest attenuation registers for frequencies above 2400 Hz. When mounting such a panel, attention should be paid not to obstruct the technological process of the equipment and to allow its supervision (Barron, 2003; Boiko et al., 2003; Liu and Herrin 2010; Pinte et al., 2009; Tomozei, 2011a; Tomozei et al., 2011bc, 2012). The present paper presents one method of reducing noise propagation in an industrial enclosure.

2. Methods and materials

The experiments in the present study were performed with acoustic screens composed of several walls and two ways of clamping the walls to the screen's frame. The walls of the acoustic screen used in the experiment were made of Oriented Strand Board – OSB, with a depth of the panel of 2 mm while the extent of the screen was 1m/1m. The proposed method assumed using working variants where the walls had to be attached to the metallic framework through rigid and elastic clamping. In the case of elastic clamping measurements the walls were attached to the metallic frame with the help of silicone sealant, which was distributed on the metallic frame, and the walls were attached to the OSB through compression. Rigid clamping experiments were performed by attaching the OSB walls to the metallic frame with the help of screws.

The experiments were performed for two types of the walls settlement, a variant with three walls and lid and a variant with five walls (cabin). These two variants were chosen due to the number of walls useful in identifying the probative differences between the values of the sound pressure level for the two types of experiments. This way, we were able to use more techniques of clamping the walls for each experimental variant. OSB (Oriented Strand Board), the material chosen for the tests, allowed experimenting with two types of clamping.

The metallic framework was made of cubic shape and had sides of 1m. The positioning of the walls on the metallic frame, and the modality of attaching them to the same frame varied. The modality of experimenting with three walls and lid is shown in figure 1.a. In Fig. 1.b, one may notice the modality of placing the microphone at a height of 0.6 m and at a distance of 1 m from the acoustic screen.



(a)

(b)

Fig. 1. The image of the testing variant with acoustic screen composed of three walls and lid (a) and the modality of placing the microphone at 0.6 m (b) (Tomozei, 2011a)

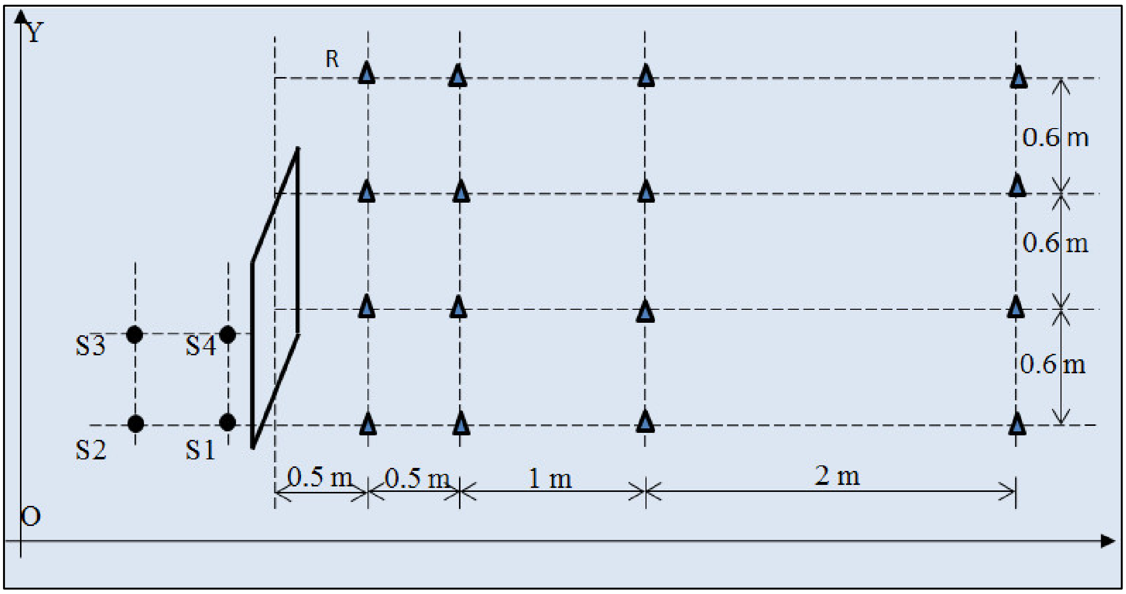


Fig. 2. The graphical representation of the measurement points location, side view:
S – four location points for the noise source (S1 – 0/0; S2 – 0/0.5; S3 – 0.5/0.5; S4 – 0.5/0);
R ( ) – 16 location points for the receiver (microphone)

The noise source used for measurements was of small size and generated a noise level of about 90 dB. The noise source was an unstandardized mechanical device (a gear wheel that, in rotation, achieved an elastic metallic lamella). Noise source was omni-directional and suffered no variation of power and frequency.

The recordings were made with a noise monitoring station, which permitted the recording of the sound pressure level values in real-time. The measurements were made after a previously settled plan in which 16 points were established for the placing of the microphone (the receiver) and four points for locating the acoustic screen towards the noise source. The microphone was located at four points on the horizontal and at different distances such as 0.5 m, 1 m, 2 m and 4 m from the acoustic screen while on the vertical, the microphone was located at four points and a height of 0 m (on the floor), 0.6 m, 1.2 m and 1.8 m.

The positioning of the acoustic screen from the noise source was at 0 m (near the noise source, but not glued to the screen) and 0.5 m, both at ground level as well as at a height of 0.5 m. Hence, 16 points of measurement for each of the four points of locating the acoustic screen towards the noise source have resulted. The graphical representation corresponding to the measurements carried out is shown in Fig. 2.

There were also made measurements of the noise level generated by the functioning of the noise source (placed in the same place, in the lab hall) without acoustic screen. Measurements were performed to analyze the propagation of the sound pressure level in enclosure. The enclosure in which the measurements have been done is a laboratory hall for practical teaching activities. Inside this enclosure there is a number of equipments and facilities (laboratory stands) which are used in laboratory work. On the central part of the enclosure there are tables of study, and on the sides of laboratory there are stands and equipments used for studying different stages of the technological process. The laboratory hall was built on a structure of steel, with walls made of sandwich panels with a metallic outside.

The lab hall is equipped with four large windows located on each length of the enclosure, and two access doors. The windows are fitted with vertical drapes, the furniture is made of laminate wood and the chairs are made of wood on metal structures. Most of the working equipment components in the enclosure are metallic. The roof was built on a metal structure s well and made of the same type of metal framework. The height of the hall varies and there is no ceiling between the walls and the roof.

3. Results

The measurement results of the sound pressure level (SPL) for the two types of experiments, the three walls and lid variant respectively, the cabin variant, are presented below (Tables 2-9). Table 1 emphasizes the references values of sound pressure level (SPL) determined by positioning the noise source in the points 0/0, 0.5/0, 0/0.5 and 0.5/0.5 to establish the values of the acoustic wave propagation without sound barrier.

The comparison has been achieved by comparing the values recorded on each type of clamping and for the positioning of the acoustic screen measured from the source of noise. Thus, SPL values are represented comparatively for each positioning of the acoustic screen towards the noise source.

Table 1. The reference values for the sound pressure level (dB) measured in the four points of locating the source of noise without acoustic screen (Tomozei, 2011a)

Position of the microphone from noise source		***SPL value in the point 0/0 (dB)***															
		0/0				***0.5/0***				***0/0.5***				***0.5/0.5***			
		0.5 m	***1 m***	***2 m***	***4 m***	***0.5 m***	***1 m***	***2 m***	***4 m***	***0.5 m***	***1 m***	***2 m***	***4 m***	***0.5 m***	***1 m***	***2 m***	***4 m***
The microphone position on the vertical (m)	**0**	88.8	86.5	83.8	80.9	86.6	84.4	82.3	80.2	88.7	86.6	86.1	84.6	86.8	86.1	85.5	84.7
	0.6	88	86.4	83.5	80.5	86.2	83.8	82.5	80.3	87.6	86.9	86.2	84.9	87.2	86.6	85.6	84.9
	1.2	86.1	84.6	82.6	80.2	86.5	83.1	81.8	81.1	88.3	86.6	86.1	84.2	87.1	85.9	85.1	84.4
	1.8	83.9	83.4	81.8	80.2	85.7	82.7	80.7	79.9	87.7	86.5	85.9	83.7	86.9	85.4	84.5	83.8

Table 2. Comparative values of sound pressure level (dB) for the experimental variant with three walls and lid in the case of the elastic/rigid clamping of the wall, point 0/0 (Tomozei, 2011a)

Position of the acoustic screen from noise source		***SPL value in the point 0/0 (dB)***							
Position of the microphone from noise source		***0.5 m***		***1 m***		***2 m***		***4 m***	
System of clamping		***elastic***	***rigid***	***elastic***	***rigid***	***elastic***	***rigid***	***elastic***	***rigid***
The microphone position on the vertical (m)	**0 m**	80.3	79	80.1	78.6	78.4	77.8	78.4	77.1
	0.6 m	79.4	78.9	79.1	78.5	78.2	78.1	77.9	77
	1.2 m	79.4	79.1	79.2	78.3	78.6	78.1	78	77.3
	1.8 m	80.1	78.2	79.2	79	78.8	78.1	77.9	77.3

Table 3. Comparative values of sound pressure level (dB) for the experimental variant with three walls and lid in the case of the elastic/rigid clamping of the wall, point 0.5/0 (Tomozei, 2011a)

Position of the acoustic screen from noise source		***SPL value in the point 0.5/0 (dB)***							
Position of the microphone from noise source		***0.5 m***		***1 m***		***2 m***		***4 m***	
System of clamping		***elastic***	***rigid***	***elastic***	***rigid***	***elastic***	***rigid***	***elastic***	***rigid***
The microphone position on the vertical (m)	**0 m**	79.8	78.5	79.4	78.6	78.8	77.7	77.6	77.2
	0.6 m	80	78.7	79.7	78.7	78.7	78.1	78.2	76.9
	1.2 m	79.9	79.2	79.6	78.6	78.9	78	77.9	77.3
	1.8 m	80	79	79.4	78.7	78.7	77.8	77.9	77.4

Table 4. Comparative values of sound pressure level (dB) for the experimental variant with three walls and lid in the case of the elastic/rigid clamping of the wall, point 0/0.5 (Tomozei, 2011a)

Position of the acoustic screen from noise source		***SPL value in the point 0/0.5 (dB)***							
Position of the microphone from noise source		***0.5 m***		***1 m***		***2 m***		***4 m***	
System of clamping		***elastic***	***rigid***	***elastic***	***rigid***	***elastic***	***rigid***	***elastic***	***rigid***
The microphone position on the vertical (m)	**0 m**	79.1	78.2	79.6	78.2	77.9	77.7	77.4	77.2
	0.6 m	79.2	78.7	79	78.7	78.5	78	77.6	77.3
	1.2 m	79.9	79.1	79.2	78.7	78.6	77.9	77.6	77.5
	1.8 m	79.8	79.1	79.5	78.7	78.5	78.1	78	77.4

Table 5. Comparative values of sound pressure level (dB) for the experimental variant with three walls and lid in the case of the elastic/rigid clamping of the wall, point 0.5/0.5 (Tomozei, 2011a)

Position of the acoustic screen from noise source		***SPL value in the point 0.5/0.5 (dB)***							
Position of the microphone from noise source		***0.5 m***		***1 m***		***2 m***		***4 m***	
System of clamping		***elastic***	***rigid***	***elastic***	***rigid***	***elastic***	***rigid***	***elastic***	***rigid***
The microphone position on the vertical (m)	**0 m**	79	78.3	79.5	78.6	78.2	77.6	77.6	77
	0.6 m	79	78.7	78.6	78.5	78.3	77.5	77.7	76.7
	1.2 m	79.3	79	79	78.4	78.6	77.7	77.5	77.2
	1.8 m	79.7	79	79.4	78.6	78.2	77.8	77.6	77.3

Table 6. Comparative values of the sound pressure level (dB) for the cabin variant in the case of the elastic/rigid clamping of the wall, point 0/0 (Tomozei, 2011a)

Position of the acoustic screen from noise source		***SPL value in the point 0/0 (dB)***							
Position of the microphone from noise source		***0.5 m***		***1 m***		***2 m***		***4 m***	
System of clamping		***elastic***	***rigid***	***elastic***	***rigid***	***elastic***	***rigid***	***elastic***	***rigid***
The microphone position on the vertical (m)	**0 m**	77.8	75.5	75.2	72.4	71.9	69.8	69.7	68.1
	0.6 m	75.5	73	74.3	71.7	71.5	69.7	69.4	67.6
	1.2 m	75.4	73.2	72.4	70.9	71	69.6	69.3	67.5
	1.8 m	73.4	71.4	71.4	70.1	70.3	68.7	69.2	67.6

Table 7. Comparative values of the sound pressure level (dB) for the cabin variant on the elastic/rigid clamping of the wall, point 0.5/0 (Tomozei, 2011a)

Position of the acoustic screen from noise source		***SPL value in the point 0.5/0 (dB)***							
Position of the microphone from noise source		***0.5 m***		***1 m***		***2 m***		***4 m***	
System of clamping		***elastic***	***rigid***	***elastic***	***rigid***	***elastic***	***rigid***	***elastic***	***rigid***
The microphone position on the vertical (m)	**0 m**	75.6	74.2	73.4	71.5	70.9	69.6	68.8	67.2
	0.6 m	75	72.9	72.6	71.2	70.2	69.4	68.6	67.4
	1.2 m	74.9	73.3	72	70.6	70.1	69.1	68.4	67.2
	1.8 m	73	70.7	71.1	69.3	69.8	68.2	68.6	67

Table 8. Comparative values of the sound pressure level (dB) for the cabin variant on the elastic/rigid clamping of the wall, point 0/0.5 (Tomozei, 2011a)

Position of the acoustic screen from noise source		***SPL value in the point 0/0.5 (dB)***							
Position of the microphone from noise source		***0.5 m***		***1 m***		***2 m***		***4 m***	
System of clamping		***elastic***	***rigid***	***elastic***	***rigid***	***elastic***	***rigid***	***elastic***	***rigid***
The microphone position on the vertical (m)	**0 m**	75.2	72.5	72.8	71	70.3	68.8	68.1	67.2
	0.6 m	74.7	73.2	72.4	70.9	70.1	68.8	67.9	67
	1.2 m	75.1	74.5	71.6	71.4	69.4	69.3	67.8	67.2
	1.8 m	72.1	72.5	70.7	70.2	69.2	69	67.8	67.3

Table 9. Comparative values of the sound pressure level (dB) for the cabin variant on the elastic/rigid clamping of the wall, point 0.5/0.5 (Tomozei, 2011a)

Position of the acoustic screen from noise source		***SPL value in the point 0.5/0.5 (dB)***							
Position of the micro-phone from noise source		***0.5 m***		***1 m***		***2 m***		***4 m***	
System of clamping		***elastic***	***rigid***	***elastic***	***rigid***	***elastic***	***rigid***	***elastic***	***rigid***
The microphone position on the vertical (m)	**0 m**	74.4	72.8	72.8	70.7	70	68.9	68.4	66.7
	0.6 m	74.5	72.4	72.1	71.2	69.8	68.8	68.1	66.6
	1.2 m	74.8	73.4	71.4	70.7	69.7	68.8	68.1	66.6
	1.8 m	72.6	70.4	70.7	69.4	69.4	68	67.8	66.5

In the graphical representation illustrated in Fig. 3, the variation of the sound pressure level is presented depending on the noise source position and the recording position of the microphone, through the acoustic screen, the noise source in point 0.5/0.5. A single graphical representation has been done because the SPL values recorded for all four points of locating the acoustic screen from the noise source and the two methods of positioning the acoustic screen walls are situated in a restricted range of variation, with a similar range of values. As it can be observed in the data presented above, the variation of sound pressure level can give approximately the same graphical representation for any of the cases studied. The reference values of the sound pressure level (represented in the chart drawn in Fig. 3) were obtained by the functioning of the noise source in the same experimentation position without acoustic screen.

4. Discussions

The reference value given by the source of noise for the first measuring point on the microphone at the point 0/0 was 88.8 dB, at the point 0.5/0 was 86.6 dB, 87.7 dB at the point 0/0.5 and respectively 86.8 dB at the point 0.5/0.5. The sound pressure level generated by the noise source was about 90 dB.

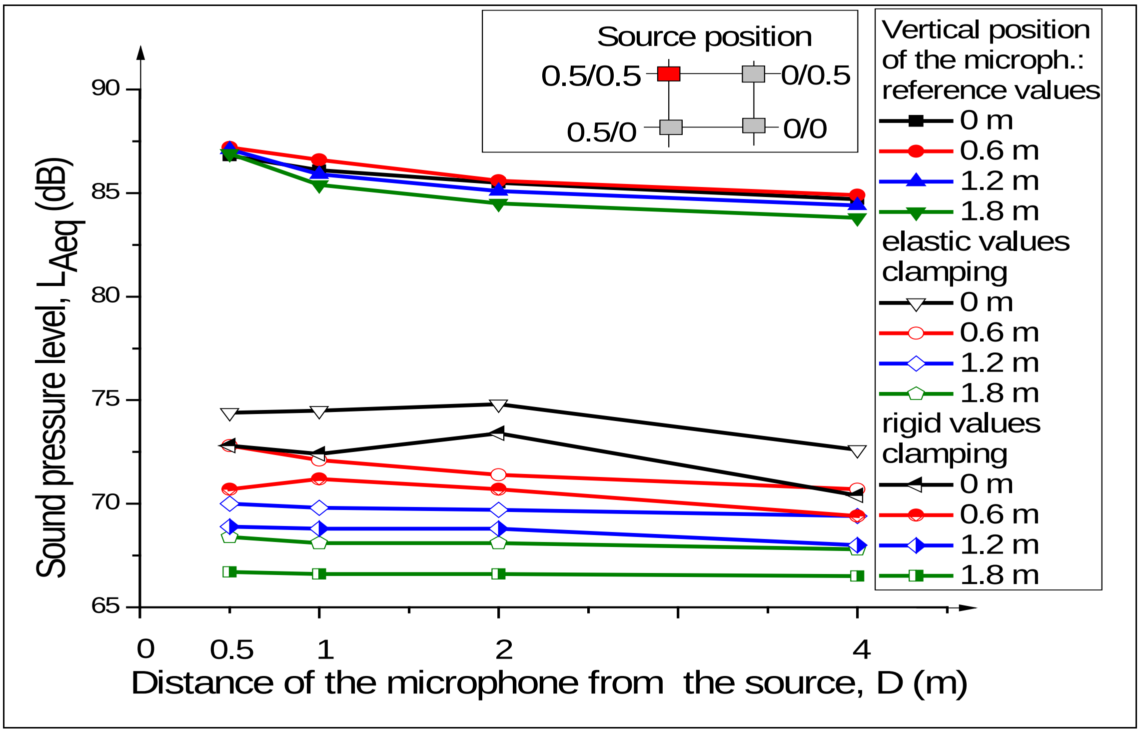


Fig. 3. The graphical representation of the sound pressure level depending on the noise source position and on the recording position of the microphone from the acoustic screen and the noise source in point 0.5/0.5

Analyzing the values of the sound pressure level in the Tables above it can be noted that, for experimental variants where the rigid clamping has been used, the values are lower than in the case of the elastic clamping. The lowest difference registered between sound pressure level values for both types of clamping is of 0.1 dB while the highest is of 2.8 dB. The variation of differences in sound pressure level values between the two types of clamping ranges from 0.3 dB - 2.7 dB at a distance of 0.5 m, between 0.1 dB - 2.8 dB at a distance of 1 m, between 0.2 dB - 2.1 dB at a distance of 2 m and between 0.1 dB - 1.8 dB at a distance of 4 m. The sound pressure level values vary according to the number of walls used in screening. Thereby, the variants with three walls and lid showed small differences than the cabin variants. The variation range of difference in sound pressure level values for variants with three walls and lid ranged from 0.3 dB - 1.9 dB to 0.5 m, between 0.1 dB - 1.5 dB at 1 m, between 0.2 dB - 1.1 dB at 2 m and between 0.1 dB - 1.3 dB at 4 m. At the same time, the cabin variants presented a variation range with more differences among the sound pressure level values between the two methods of clamping the walls. Thus, variation ranges between 0.6 dB - 2.7 dB at a distance of 0.5 m, between 0.2 dB - 2.8 dB at a distance of 1 m, between 0.2 dB - 2.1 dB at a distance of 2 m and between 0.3 dB - 1.8 dB at 4 m.

The values of the sound pressure level are lower in the case of the rigid clamping because the connection between the two structures, the metallic frame and the wall was too tight. One can understand that the amplitude of the acoustic waves that crossed the wall in the case of the rigid clamping is smaller.

At the same time, the experiments emphasized a situation where sound pressure level value in the case of the elastic clamping has proven to be greater than in the case of the rigid clamping. Nevertheless, (the SPL value of elastic clamping is 72.1 dB while the SPL value for the rigid clamping is 72.5 dB), the difference is of only 0.4 dB which does not make it representative. As shown in the graphic above, the difference between the reference SPL values and those of the sound pressure level for both types of clamping is about 12 dB. The propagation on the horizontal of the sound pressure level (for the same height of the microphone location at the two types of clamping) situates within a narrow range of variation, of about 2 dB for each height of the microphone.

The sound pressure level variation for rigid clamping ranges between 79.2 dB - 66.5 dB. Sound pressure level values for elastic clamping are in the range of variation of 80.3 dB - 67.8 dB. One can also note that each of the variation value resulted in the case of the elastic clamping are above the values registered in case of the rigid clamping.

The cabin variant presents the lowest SPL values at a 1.8 m height for the first measuring point given the distance between the noise source and the receiver. At the same height, and on the same point, at the 3 walls and lid variant, the SPL values do not show the same decrease given the reverberant characteristics of the environmental enclosure in which the measurement have been completed. Also, it can be noted that the sound pressure level obtained does not show any significant differences for the four positioning points of the noise source, due to the reduced dimension of the source of noise and the small distance between the positioning points. However, the experiments demonstrate that point 0.5/0.5 offers the best positioning.

5. Conclusions

The variation of sound pressure level values has shown approximately the same type of decrease given the distance from the acoustic screen, regardless of the wall clamping method used. The SPL values from the rigid clamping are lower than the SPL values recorded in the case of the elastic clamping. The experimental results for the two types of wall clamping emphasize values in favour of the rigid clamping. The differences between the SPL values recorded for the two modalities of wall clamping are quite small, sometimes minor. Yet, concerning the attenuation of the acoustic wave propagation, rigid clamping has generated better results.

This study has shown evidence for the importance of the rigid clamping variant which should be used in attaching walls to a metallic frame. Take into consideration that the clamping of the walls to the frame should be done as tightly as possible.

Attaching a metallic frame to a wall is useful in the situation in which the acoustic screen is made up of several walls. This arises from the fact that the differences between the sound pressure level values for the two types of clamping are small.

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