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CONSTRUCTIVE STUDY FOR IMPEDANCE TUBE

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Abstract: Noise barriers are typically used to reduce noise near to the highway or near to the building construction. Factors that characterize the barrier effectiveness are the position and geometry of the barrier, its height and materials which is made from. Considering the interaction of noise with the surface of the barrier we can distinguish three principles: reflection, resonance and absorption of the waves. Determination of sound-absorbing nature of these materials is one of the most important acoustic characteristics. In conclusion, this paper may be considered as guidance in choosing a proper absorbing material using an impedance tube.
Keywords: impedance tube, constructive study.

1. GENERAL PRINCIPLES FOR ACHIEVING THE IMPEDANCE TUBES

In the European standardization the determination of the absorption coefficient of a material is carried out using a tube of impedance. Sample made of test material, which determines the rate of absorption is mounted on one side of the tube impedance, while at the other end is mounted a generator (speaker), which generates the sound vibration (random, type: pseudo-random sequence, nicks) transmitted to the inside of the tube. The sound wave interaction with a sample reflected wave (Pr) with the reverse direction to the direction of propagation of the generating source. The function of knowledge (H_{12}) which determines the absorption coefficient is carried out using two microphones, which collect sound pressure level inside the tube and transmits through a purchase by the PC for processing.

2. DETAILS FOR PLAYING SYSTEM

Impedance tube used for this determination should have a smooth surface on the inside, with a constant diameter along entire length of the tube (standard deviation shall not exceed ± 2% of the diameter), and exceptions are the ports for the microphones. The material used for the tube impedance must give a very good rigidity, to mitigate significant vibration transmition, generated by all mobile loud-speakers to microphone.

2.1. Frequency Domain

Frequency range, in which the device will work for the determination of the absorption coefficient, can be considered as:

$$f_l < f < f_u \tag{1}$$

f_i - the lower frequency limit;
f - frequency domain of the device work;
f_u - the upper frequency limit.

Constructive conditions for high frequency limit agreed in an impedance tube:

$$d < 0.85 \times \lambda_u \tag{2}$$

d - tube diameter;
λ_u - upper wavelength.

2.2. The Determination of Sound Speed

The sound speed is function of the inside temperature, given by relation:

$$c_0 = 343.2 \times \sqrt{\frac{T}{293}} \tag{3}$$

In which the constant in front of this relation is the air velocity for the normal temperature (0°C), and T – temperature in °K.

2.3. The Distance between the Points of Measurement

The distance between the microphones depends on the length of the wave propagated inside tube. Minimum distance between two points of measurement can be determined by high frequency measured between 2 measuring points

$$s < 0.45\lambda_u \quad (4)$$

Having s - the distance between the microphones, and the maximum distance not to exceed 5% of the length of the lower frequency wave, as

$$s < 0.05\lambda_l \quad (5)$$

λ_l – lower frequency wave.

2.4. Determination of Transfer Office between Two Locations

Determination of the transfer function is accomplished by acoustic pressure ratio between two points, determined by the pressure of the temporal Fourier transformation. Using the corresponding standard [1] (ISO-10534-1:1996), and the transfer function method [2] (ISO 10534-2:1998), the notations are: S_{12} and S_{21} - Product spectrum between two measurement points, the S_{11} and S_{22} - The product the same as point and the acoustic ratio pressures have:

$$H_{12} = \frac{S_{12}}{S_{11}} \quad (6)$$

$$H_{12} = \frac{S_{22}}{S_{21}} \quad (7)$$

$$H_{12} = \left[\frac{S_{12}}{S_{11}} \times \frac{S_{22}}{S_{21}}\right]^{0.5} \quad (8)$$

2.5. Predetermination of the Calibration Factor

The calibration procedure is done through successive steps between two measurement points:

- changing the microphones between the measuring points

$$H_c = (H_{12}^{I}/H_{12}^{II})^{0.5} \quad (10)$$

- determining the H_c, by inverting the direction of the transfer function

$$H_c = (H_{12}^{I} \times H_{21}^{II})^{0.5} \quad (11)$$

2.6. Reflection inside the Impedance Tube

The symbols, that need to use for the reflection inside the tube, are:

r - reflection factor;

H_i – the transfer function of the incident wave;

H_r – the transfer function of the wave reflected;

X_n - the distance between sample and microphone;

S – the distance between the microphones. The formulas for the reflection are:

$$r = \frac{H_{12} - H_i}{H_r - H_{12}} \times e^{2jk_0 x_n} \quad (12)$$

$$H_i = e^{-jk_0 s} \quad (13)$$

$$H_r = e^{jk_0 s} \quad (14)$$

2.7. The Coefficient of Acoustic Insulation

This determination shall be reduced by the square of the module element of reflection of a whole (considered absolute absorption)

$$\alpha = 1 - |r|^2 \quad (15)$$

3. THE CONSTRUCTIVE ELEMENTS

3.1. The Tube Impedance Length

In the choice of the length of the tube should be taken into account a distance sufficient for the formation of flat waves. So it is recommended to form complete wave plane, choose a distance of at least two diameters between speaker and microphone, the last situation repeats between the sample and the first microphone.

3.2. Acoustic Center of Microphones

The acoustic centre of the microphones is achieved through the definition of the minimum distance between two (tip pressure).

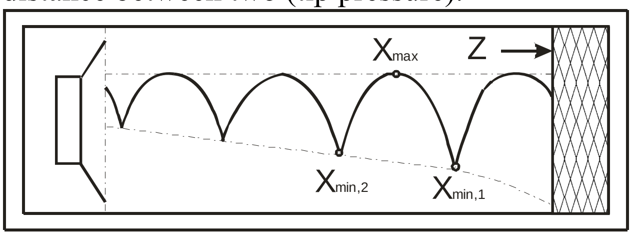

Fig. 1. Acoustic Center of Microphones

The relations with which need to determine the center position are:

$$X_{min,n} = \frac{(2n-1)\lambda_c}{4} \quad (16)$$

$$X_{max,n} = X_{min,n} + \frac{\lambda_c}{4} \quad (17)$$

The symbols of relations are given as in the figure 1.

3.3. Signal Processing Equipment

In order to avoid major differences in data collection should be of the same type of microphone. Their diameter must not exceeding 20% of the points of measurement distance.

Signal Generator must be able to cover the necessary frequency and can print a big dynamic loudspeaker 65dB.

Microphones and amplifiers used do not have operational differences greater than 0.2 dB at temperature differences (4) the device design.

The device is designed for the determination of absorption coefficients of materials, in the band 50-1500 Hz and brings an innovation in terms of the number of microphones mounted on the tube impedance, continuous monitoring of acoustic vibration generator and a system of continuous calibration microphones mounted on the device.

4. THE APPLICATION OF THE DEVICE DIMENSIONS

4.1. The Tube Inner Diameter

Pick the inside diameter of the tube, so that the condition to be met relationship (2)

$$0{,}85 \times \frac{c_0}{1500} = 0.194 \qquad (18)$$

4.2. The Distance between the Microphones

Using the relationship (4) the maximum distance is determined between the first 2 microphones according to the maximum frequency and relationship (3) determines the minimum frequency can be measured by these two points.

$$\frac{0.45 \times c_0}{1500} = 0.1 \qquad (19)$$

Taking into account the fact that distance must be less than or equal to the result of the relationship (19) we chose the value of s_1 is 0.085m.

$$\frac{0.05 \times c_0}{0.085} = 201.7 \qquad (20)$$

Of relationships (19) and (20) show that between the two measurement points can be made in the field of frequency measuring 150 - 2000 Hz bandwidth. Difference is supplemented by the introduction of a measuring point is situated at a distance greater than the first microphone. For the accuracy of the data we will take into account the lower frequency with lower limit 10Hz to measure (50 Hz).

$$\frac{0.05 \times c_0}{40} = 0.42 \qquad (21)$$

Indicating that the value of 0.42 for s_3

Learning distance necessary for measuring the frequency below which we determine high-frequency can be measured in the range s_3

$$\frac{0.45 \times c_0}{0.42} = 367.5 \qquad (22)$$

So between the first 2 microphones are measurements in the range of 1500-200 and 360-40Hz between the first and last microphone. Taking into account the fact that in the first period as the intersecting at the rate of 16% with the second interval, we can consider appropriate to the installation of the intermediate point as which it intersects the two areas in a higher proportion, mounted Mic3 at 0.21 (s3)

$$\frac{0.45 \times c_0}{0.21} = 735 \qquad (23)$$

$$\frac{0.05 \times c_0}{0.21} = 81.6 \qquad (24)$$

So according to the above relations (23) and (24), we will be able to make measurements in the range of 80 and 735.

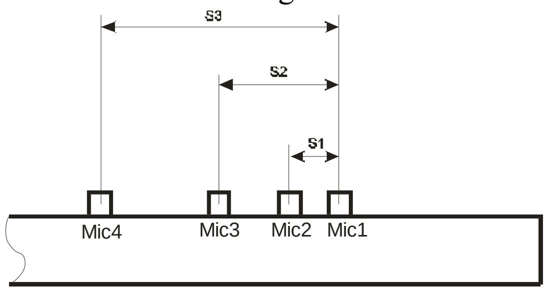

Fig.2. The Microphones Distances

4.3. The Tube Length

In determining the length of the tube should be taken into account by the formation of wave plane from the generator and its Reformation from the sample to the microphone. Assuming enough 2-3 diameter distance between the sample and the first microphone and the minimum distance between the 3 diameters and last speaker microphone, we can determine the total length of the tube.

$$L > 6 \times d + s3 \qquad (25)$$

$$6 \times 0.12 + 0.42 = 1.14 \qquad (26)$$

4.4. Choosing of Speaker

The speaker must meet the following conditions: - loudspeaker membrane must be as rigid, to withstand the pressures and any non-uniform wave of noise inside the tube; - graph of response to be more linear, preferably not more than ± 3 dB per octave; - to cover the increasing need of the variety; - to require a lower volume as well as enclosure.

With these conditions fulfilled, as chosen SBX1320 produced by firm "Somogyi audio line" with the following characteristics: - Maximum frequency range: 50-7000; SPL: 85 dB/w/m; Power rating: 40W; Diameter: 0.123m; Membrane: KEVLAR

4.5. Choosing Microphones

Microphones used must meet the following requirements: be of an FFT, signal/noise ratio as above; and have a graph of response as a linear frequency domain in both used and in scale.

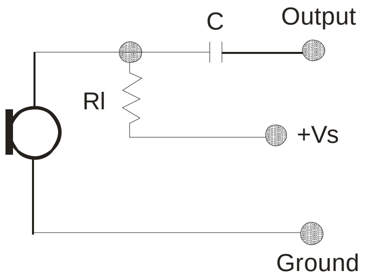

Fig. 3. The Electrical Microphone Scheme

The microphone was chosen with the following electrode MIKpoj62 and technical specifications will be used in accordance with the scheme in principle proposed by the manufacturer.

5. CONCLUSIONS

1. In conclusion this device brings an innovation in terms of the number of microphones mounted on the tube impedance control of sound and vibration generator system calibration microphones mounted on the device.
2. Using microphones that keep time characteristics, we can utilize the system for determining the proposed explanation without changing the location of the proposed standard microphone
3. In the case of uses of microphones with the weaker performance, we can utilize the system for determining the proposed, but is required to use the calibration system by changing the location of microphones, before starting the process for the determination of the coefficient of absorption and after.
4. Control system of vibration generator allows us to use a speakerphone keeps not answering feature all over the frequency range.

REFERENCES

[1]. ISO-10534-1:1996 - Wave Ratio Method;
[2] ISO 10534-2:1998 - Transfer Function Method.

STUDIU CONSTRUCTIV PENTRU TUBUL DE IMPEDANȚĂ

Rezumat: Barierele de zgomot sunt tipice pentru reducerea zgomotului lângă căile de rulare sau în apropierea construcțiilor. Considerând interacțiunea zgomotului cu suprafața barierelor se disting trei proprietăți: reflexia, rezonanța şi absorbția undelor, proprietăți ce sunt utilizate în această lucrare pentru a determina gradul de absorbție al sunetului pentru diferitele materiale în tubul de impedanța, ce duce la adoptarea unei soluții constructive inovative, care să corespundă cerințelor.

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