Possibilities of verifying the parameters of the absorbing elements using the loudspeaker

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Summary
This paper deals with other option of determination of the acoustic absorbing materials parameters. Simplified procedures are often used to design new absorbing elements. These procedures are based on an ideal model or previous experience. The result is often quite inaccurate. To verify the absorption coefficient α, measurements in the reverberation chamber or impedance tube are required. Both of these methods require expensive and special equipment, which is not available to everyone. For measurement in the reverberation chamber it is necessary to have approx. 10 m^2 of the measured sample. In the impedance tube there are measured only small circular samples and the coefficient α only for the perpendicular impact of sound waves. Thus, these methods are not suitable for designing prototypes of new absorbing elements. For this reason, other possibilities for determination of important parameters on a relatively small prototype sample were investigated. The result of this research is an experiment describing a possible measurement method. This method is based on change of the loudspeaker impedance due to placing prototype of the absorbing element into a common baffle.

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1. Introduction

The experiment is based on knowledge of change of impedance characteristic due to mounting the loudspeaker in different types of baffle. The impedance characteristic of standalone speaker has one significant peak in its resonance frequency range and at high frequencies the impedance slightly increases due to the inductive character of the loudspeaker coil. If the loudspeaker is placed in a closed baffle, its resonant frequency shifts higher. To extend the usable frequency range of the speakers towards lower frequencies, the type of baffle called bassreflex baffle is used. This is a baffle with a built-in Helmholtz resonator [1]. This is a resonant circuit equivalent to the mechanical oscillation of the mass on the spring. The mass is the volume of air in the resonator neck and the spring is a compliance of air cavity (Figure 1). The resonant frequency of the resonator can be tuned through the dimensions of neck. This is reflected in the impedance characteristics of the loudspeaker as another significant resonance peak (Figure 2). All these variants can be easily measured using the basic equipment and also can be calculated from equivalent model of the electrodynamic loudspeaker and the baffle. The simplified circuit is shown in Figure 3.

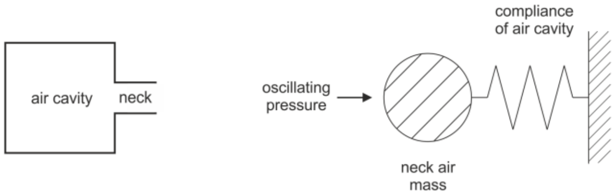

Figure 1. Helmholtz resonator

Circuit can be described as a lumped element model and it is possible to solve it mathematically quite simply, unlike the reverberation chamber [3].

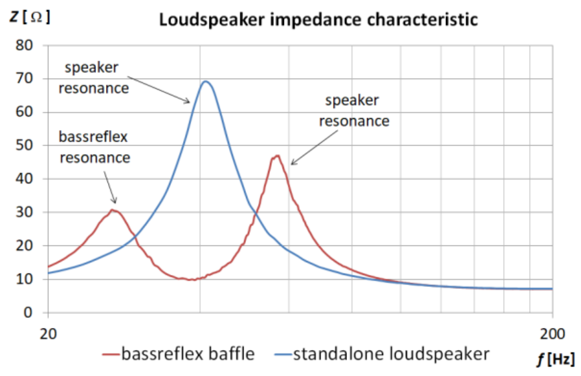

Figure 2. Influence of bassreflex baffle

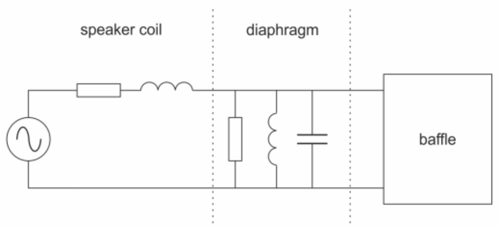

Figure 3. Loudspeaker lumped element model

2. Bottle experiment

If the prototype of the resonant principle of absorbing element is placed in the baffle, we can expect another peak in the impedance characteristic at its resonant frequency. This was verified by the first of several experiments. Hole with 28 mm diameter was drilled into 18 mm thick back plate of the enclosed baffle. This created a bassreflex baffle. A 0.5 liter glass bottle was then glued into the hole. The bottle works as a Helmholtz resonator. For the first measurement experiment a standard 12" diameter loudspeaker was used. The block diagram of the measured situation is in Fig. 4 [2].

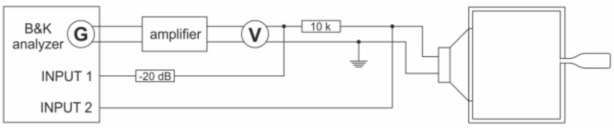

Figure 4. Block diagram of bottle experiment

Two peaks are well visible on measured impedance characteristic. The first peak in impedance curve is the loudspeaker resonance, the smaller peak is the resonance of the bottle (160 Hz). Based on this experiment, we can say that the above described theory is correct.

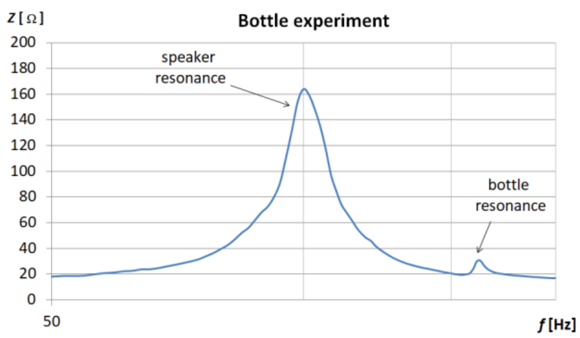

Figure 5. Bottle experiment

2.1. Influence of the speaker and the baffle

The research has also investigated the influence of the loudspeaker and baffle. The resonant frequency of the loudspeaker should be outside the predicted resonance of the element being examined. The whole structure of the loudspeaker diaphragm must be airtight, as well as the whole baffle. The used enclosed baffle allows the installation of a 275 x 295mm partition.

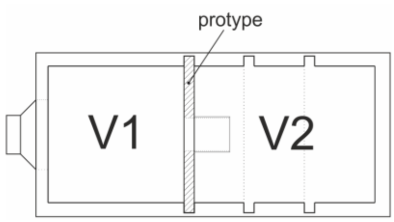

Figure 6. Measuring baffle

It is possible to achieve different volume configurations easily by moving the partitions. The influence of volume ratio V1 and V2 was mainly examined. Volume V1 is between the loudspeaker and the prototype element. V2 is the volume of the element air gap. A higher V2:V1 ratio guarantees a more pronounced resonant peak of the element on the impedance characteristic.

3. Examples of measured elements

Several measurements were made on different acoustic elements. The above described configurable baffle and 175mm bass loudspeaker with a 41Hz resonant frequency was used. The first group of measured elements were Helmholtz resonators with different diameters and lengths of the neck. Thanks to the construction of the baffle, it was possible to change the air cavity of the resonator in 3 steps – 6, 14 and 22 liter.

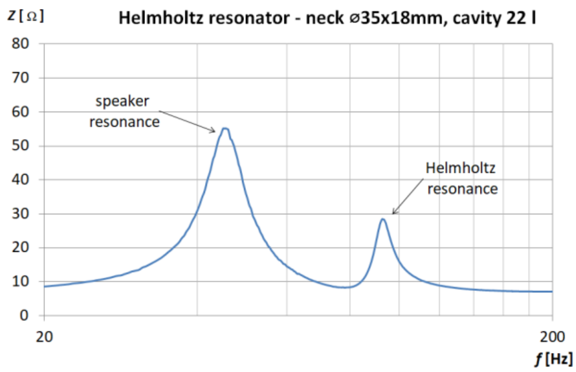

Figure 7. Example of Helmholtz resonator measurement

Another group was called panel absorber. These elements absorbing by the bending of the fixed plate or due to oscillation of the flexible mount plate or a combination of both. An aluminum 0.2 mm thick plate and a 1.5 mm fiberglass plate were measured. Both materials were measured mounted flexibly in the window sealing or fixed in the frame.

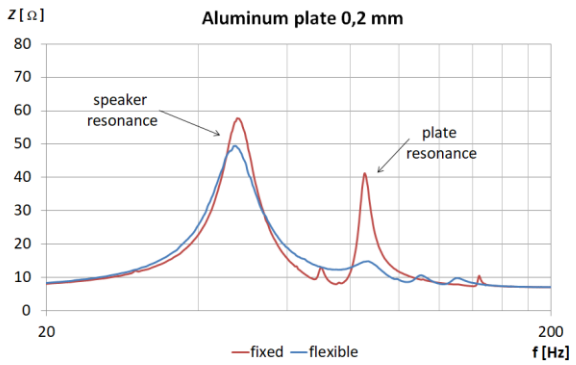

Figure 8. Example of panel absorber measurement

4. Conclusions

On the basis of the measured examples described above it can be seen that the proposed method allows a quick and accessible detection of the resonance frequency of the absorbing element. The element is shown as another resonance peak in the impedance characteristic of the measuring loudspeaker. Thanks to the small surface sample, it is possible to produce a self-made prototype, which is often easy to construction and cost-effective. Compared to the impedance tube measurement method, larger samples can be used. This is important especially for panel absorbers, because their function depends on their size. Also the combination of omnidirectional and perpendicular impact of the sound wave is measured - this condition better corresponds to real use. The method probably can not be used to measure elements based on foam materials, because they often absorbed in a wide frequency range, and this is shown in the impedance characteristic only as a very small shift of the curve.

The research will continue by comparing the results from measurement in the reverberation chamber and this method. The measurement baffle for standard 600x600mm ceiling or wall-mounted panels will be designed, based on experience from this project.

Acknowledgement

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