Improved shielding effect of noise screens by means of actively controlled headpieces

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Introduction

Due to the dominant effect the upper edge of the noise barrier has on the diffracted field , research on diffraction at the edge with the purpose of improving the shielding effectiveness has been the subject matter in recent years. In the last presentation [2], the surface impedance of a rigid cylindrical headpiece was actively minimized numerically to prevent the power transport along the headpiece as much as possible. This study was based on the theoretical study of Möser [1]. It was possible to deflect the incident sound by means of a secondary sound field. Only with small number of secondary source and sound pressure minimizing, the acoustical shadow region was more pronounced in both near- and far-field compared to the passive case with rigid surface. For a relatively wide frequency range it was also possible to find optimal conditions for the secondary sources and for the error microphones.

In the present paper the effectiveness of the active local control of the sound field at the headpiece surface is measured in an anechoic chamber. This experimental study is aimed at investigating the effects of main parameters of the active control on the sound field in the acoustical shadow region, which have been provided in the numerical study.

Experimental setup

The efficiency of the active headpiece of a noise barrier was measured in an anechoic chamber with a volume of 1850 m^3 ($11m \times 16m \times 10.5m$). The measuring setup was built up on the carrying net of the chamber. For practical reasons a rectangular headpiece is chosen and attached to a wall made of chip board (16 mm thick). One secondary loudspeaker is inserted in the centre of each of the three surfaces of the headpiece, also made of chip board (16 mm thick)(Figure 1). The cover plate of each secondary loudspeaker was removed only when the loudspeaker was used to control the sound field. Absorbing material (polyester wadding) was injected into the interior side of the headpiece in order to avoid standing waves in the cavity. To reduce the diffraction from both side edges of the barrier the side walls are sealed up with rubber. The upper edge of the side walls is covered with foamed material. In order to prevent the sound propagation over the bottom edge of the wall, a chip board is placed on the carrying net.

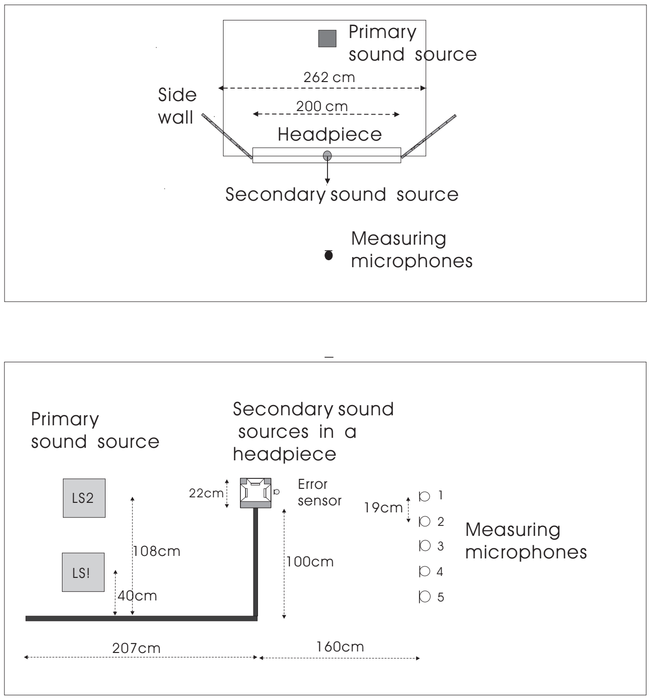

Figure 1: Measuring set up in anechoic chamber; top view(above), side view(below)

Active control setup

The sine wave is emitted by a primary loudspeaker and operated manually by phase shift, attenuator and power amplifier . The phase and amplitude of the secondary signal is adjusted in such a way that the measured sound pressure level at the error microphone reaches a minimum.

Measurement conditions

Measurement is made only along the axis of the sound sources(s. Figure 1 top view(above)). In each experi-

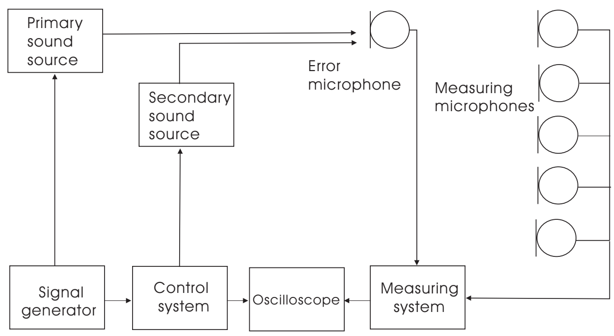

Figure 2: Active control setup

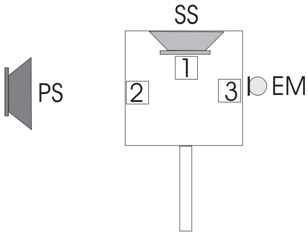

Figure 3: Position of the control element 1-3; primary source(PS), secondary source(SS), error microphone(EM)

ment, the sound pressure at the centre of a surface of the headpiece was minimized with one secondary source. As output signal, a sine wave of 250 Hz to 2 kHz, in 1/3 octave steps was chosen which correspond to the ratio of $l/\lambda = 0.16 \sim 1.29$, l being the height of the rectangular headpiece. Under two different incidence angles of the primary sound source, LS1 and LS2, the sound level behind the barrier was measured at the measuring positions.

Experimental Results

Figure 4 shows the measured improvement at microphone 4 achieved by an actively minimized surface impedance of the rectangular headpiece, versus incidence sound frequency (Hz), as well as results calculated with a cylindrical headpiece of radius b for comparison:

$$Improvement = 10lg\left(\frac{|p_{without-active}|^2}{|p_{with-active}|^2}\right), \qquad (1)$$

Each curve in the figures represents the Improvement (dB) of a different control position. For example 's1m3' in the legend indicates that the secondary source is placed at position 1 and the error microphone at the position 3(s. Figure 3). The optimal positions for the secondary source (toward the primary source or above) and for the error microphone (above or toward the shadow zone) found in the numerical calculations, have also been proven to be efficient in the measurements. These are the red, pink and green curves in the Figure 4. In these cases improvement is, at large, between 2 and 10 dB and reaches up to 30 dB at 500 Hz in the Figure 4(c). Effects of the practical measuring conditions on the improvement, such as, frequency response of the loudspeakers, measuring direction and beam pattern of the error microphone, reflection at the bottom and at the side walls can be seen through the different tendency between the measured and calculated improvement and through the negative result in Figure 4(a)(red curve 's2m1') or in (c)(green curve 's2m3').

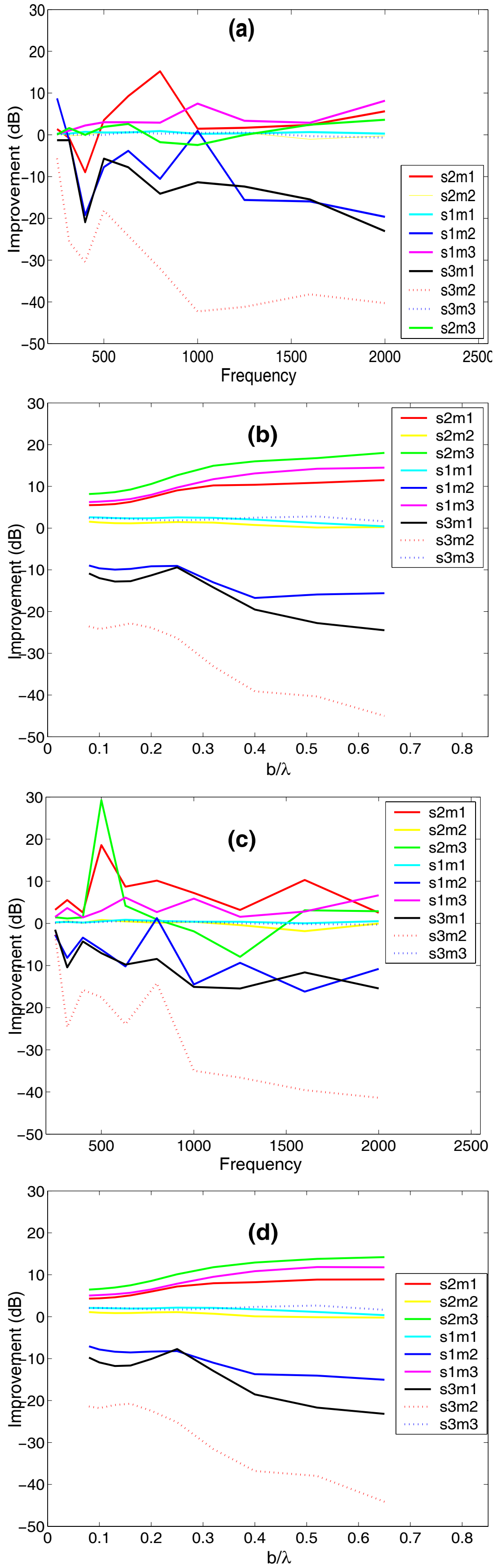

Figure 4: Improvement (dB) by means of active control of the headpiece at the measuring microphone 4; Primary sound incidence LS1:measured(a), calculate with cylindrical headpiece(b), Primary sound incidence LS2:measured(c), calculate with cylindrical headpiece(d)

References

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