About the connection between measurements in the alpha-cabin and the theoretically reachable differences in level of absorbing materials

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Introduction

The alpha cabin (Rieter Automotive) is a reverberation chamber „en miniature“ with a volume of about 6 m^3 . It is used for the measurement of the sound absorption characteristics of materials with a size of about 1m² . For this the reverberation times in the cabin are measured with and without the material sample and from these the absorption coefficient can be calculated with help of the sabine formula

$$\alpha = 0{,}163 \cdot V \cdot \left(\frac{1}{T_1} - \frac{1}{T_0} \right).$$

The questions to be answered in this investigation were:

1. **What level differences can be obtained if an absorbing system of about 1m²** (for example a noise undershield of a passenger car) **is placed below a compartment of a noise source** (for example an engine compartment) [1]**?**
2. **In which way do these level differences depend on the open slits between the absorber plate and the compartment of a noise source?**
3. **Do these level differences depend on the materials respectively the kind of absorbing system (resonant absorbers, porous absorbers, etc)?**
4. **How good is the correlation between alpha cabin measurement and level difference?**

Measurement arrangement for the determination of the level differences

In order to answer these questions a spheric loudspeaker emitting white noise was put inside a cubic box of 1m³. The floor plate of the box had been removed (an idealised engine compartment open at the bottom). Various absorbing materials (foams, felt, „Kammerabsorber/ Kästchenabsorber“, microperforated absorbers [2]) were put onto the floor plate, which was positioned with variable distances *d* of 50 , 75, 100 and 150mm below the box . With two microphones, placed with a distance of 1.5 and 3.5m apart the side wall of the box, the third octave sound level was measured. After this, the measurement was repeated without the absorbing material on the plate. Figure 1 shows the arrangement for the measurement of the level differences in the semi anecoic room.

Comparison of α - ΔL

The difference ΔL of the sound levels caused by these materials were calculated and compared to the absorption coefficients α measured in the alpha cabin.

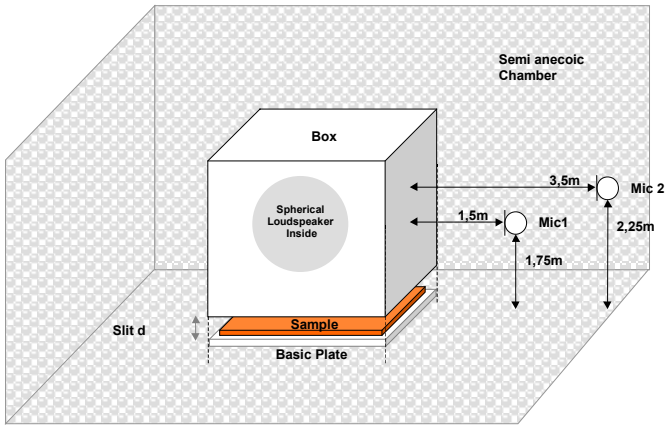

Figure1: Measurement arrangement for the determination of the level differences

Figure 2 shows for example the alpha cabin measurement of microperforated aluminum foil mounted on a grid with 30mm height (triangles) compared to the level difference (squares) caused by this material in a 3,5m microfone distance to the box . The slit between floor plate and box was 100mm .

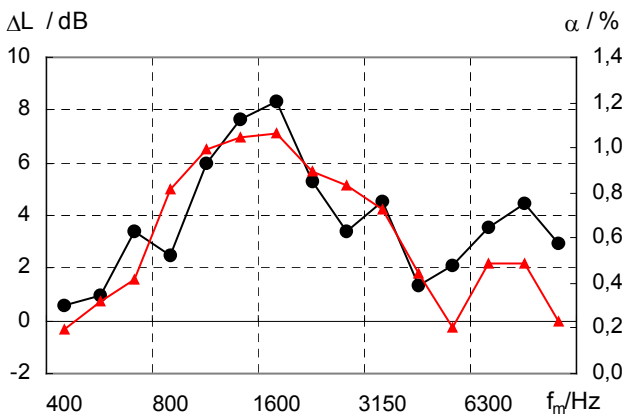

Fig. 2: Level differences (left scale) at a slit distance of 100mm (black circles) and results of the alpha cabin measurement (red triangles, right scale) of microperforated aluminum foil on 30mm cotton felt

On comparing the results of the absorption measurement in the alpha cabin directly to the obtained level differences it follows from this a correlation as shown in figure 3. In this example the measured values of microperforated aluminum foil on cotton felt are shown. Such correlations were obtained by all of the investigated absorbing systems, irrespecitive of their absorbing principle (resonant absorbers, porous absorbers, microperforated absorbers). All these

absorbers showed an improvement of the achieved level differences if the slit height was reduced.

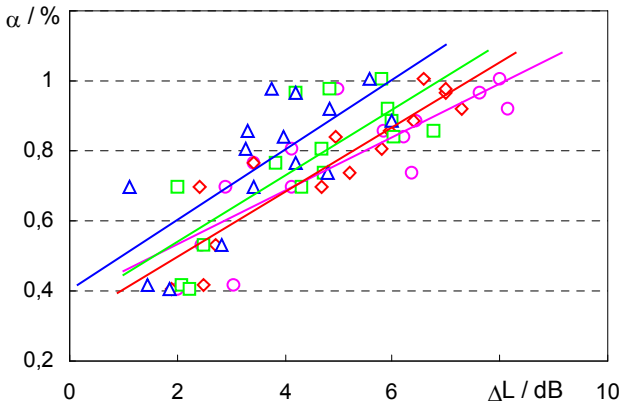

Fig 3: Absorption coefficient versus level difference at slit heights 50mm (circles), 75mm (rhombs), 100mm (squares) und 150mm (triangles). Samples: microperforated aluminum foil mounted on 300mm cotton felt.

From all of the investigated absorbers good ones and bad ones had been used in order to see, if there was a preference of the effectivenes of a specific absorbing principle. Fig. 4 shows various absorbers (height each 30mm) compared at a specific slit distance (here 75mm). You can see the results for polyurethane foam (squares), cotton felt (circles), microperforated aluminum foil on a spacer grid (rhombs) and microperforated plastic plates on a spacer grid (triangles) [2]. Low absorption coefficients lead to lower level differences as shown here with the microperforated plastic plates and high absorption coefficients lead to higher level differences, in this example the polyurethane foam. All absorbers show a level difference range of about 4dB at a fix absorption coefficient.

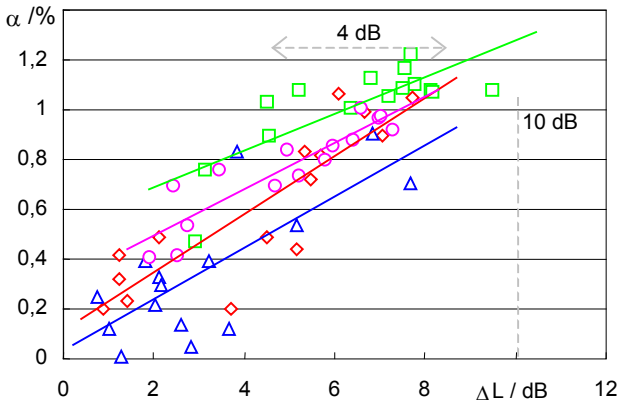

Fig. 4: Comparison of the materials PUR-foam (squares), cotton felt (circles), microperforated aluminum foil on a spacer grid (rhombs) and microperforated plastic plates on a spacer grid (triangles). Slit height of the measurement box: 75mm. Microfone distance: 1.5m

This dependence could be confirmed with a lot of „good“ and „bad“ absorbers out of all absorbing principles.

Finally we put together the results of all measurements. This can be seen in Fig. 5 for microfone distance 1.5m and Fig.6 for microfone distance 3.5mm.

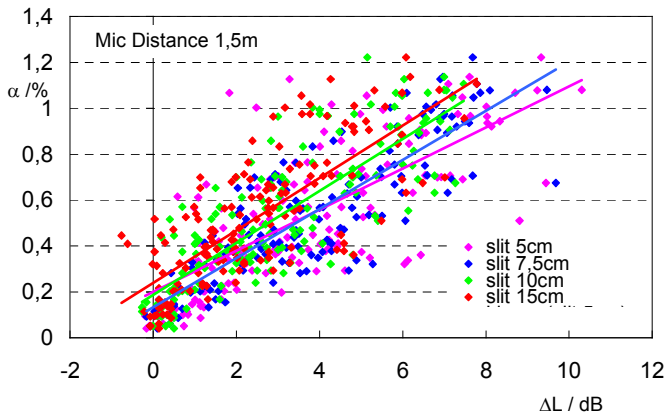

Fig 5: Absorption coefficient versus level difference at slit heights 50mm (circles), 75mm (rhombs), 100mm (squares) und 150mm (triangles). all variants of various absorbers. Microfone distance: 1.5m

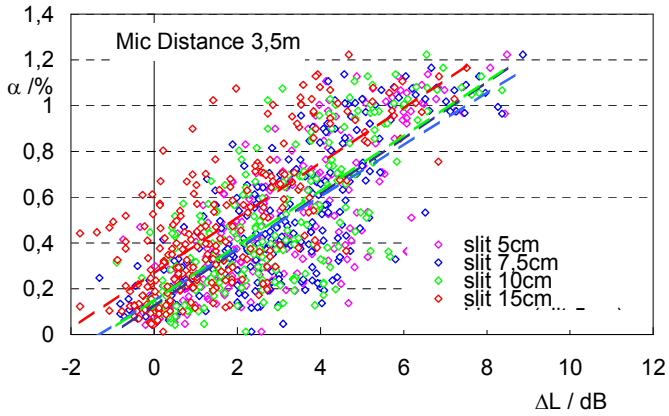

Fig 6: Absorption coefficient versus level difference at slit heights 50mm (circles), 75mm (rhombs), 100mm (squares) und 150mm (triangles). all variants of various absorbers. Microfone distance: 3.5m

The improvement of the level differences at a smaller slit distance in Fig. 3 is also visible in Fig. 5 and 6. Unfortunately negative level differences occure at low absorption coefficients if the slit is wide. The level difference range of about 4dB mentioned in the discussion of Fig.3 can also be found here.

Conclusion

The improvement of the level difference which can be obtained if an absorbing system of about 1m² is placed below a compartment of a noise source can be up to 10 dB.

The mean values increase with the level of the absorption coefficient and decrease with the height of the slit between the compartment and the absorber plate.

The range of the level differences at a specific absorption level is about 4 dB. At low absorption levels also negative level differences may occure.

A dependence on the kind of absorber could not be found

Literatur

[1] Patsouras, D., Pfaffelhuber, K.: Wie leise kann man ein Fahrzeug mit Motorkapseln machen ? In: Fortschr. der Akustik DAGA'02, Verl.: Dt. Gesell. für Akustik e.V., Oldenburg, CD-Rom, 2002.

[2] Patsouras, D. , Pfaffelhuber, K.: Gezielte Schallabsorption im Motorraum durch den Einsatz mikroperforierter Strukturen. In: Fortschritte der Akustik, DAGA 2001, Verl.: Dt. Gesellschaft für Akustik e.V., Oldenburg, 480-481, 2000.