Optimization of a small-sized reverberation room

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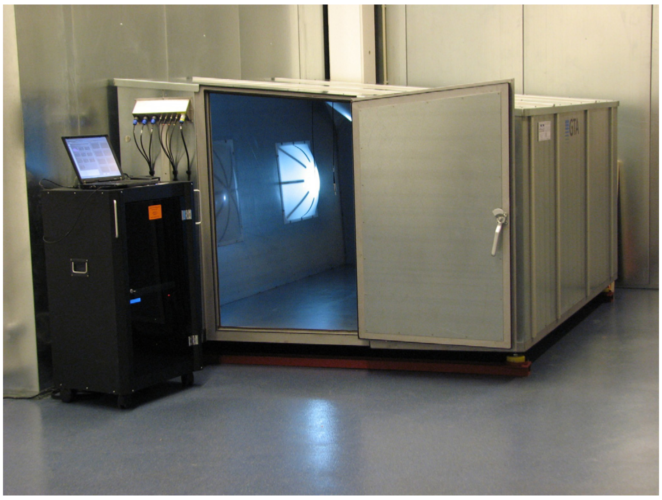
Introduction:

Small-sized reverberant rooms are broadly used in the automotive industries for absorption measurements. The usage of these rooms has different advantages like e.g. smaller needed sample size, a higher frequency range up to 10kHz in comparison with large reverberant rooms (~200m³). One disadvantage is e.g. the lower limiting frequency of ~ 400-500Hz (depending on the volume of the room). A special tailored small-sized reverberation room for absorption measurements has been installed at Airbus site Hamburg. First acoustic measurements showed the need for optimization of decay time.

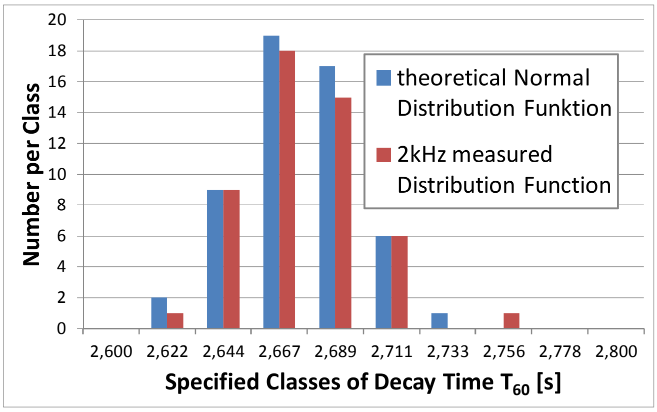


Picture 1: General view of the small reverberant room

Optimization:

Different improvements were made. One important point was the door sealing. By optimizing the type and location of the sealing, the decay time increases in the high frequency range. Some statistical tests (like C^2-tests, t-tests, F-tests…) were made to see the differences between theoretical and measured statistical distribution function (see Picture 2). The small reverberant room and the microphone positions were optimized in order to get normal distributed decay times of every microphone signal.

Further investigation of the diffusers were also conducted. By dampening the diffusers, the decay time increased in the mid frequency range. This has major impact on the calculation of the absorption coefficient. In non-optimized small-sized reverberation rooms it is usual, to get absorption coefficients above 1. It is commonly understood that this effect is caused by the so-called edge effect.

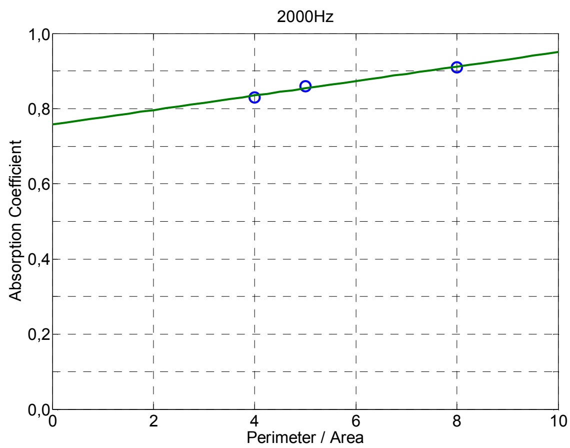


Picture 2: Theoretical and measured distribution function of the decay time at 2kHz tierce of one microphone position.

The investigations for optimization of the reverberation room showed that the edge effect is not the only source for this acoustical behavior. A sample of PUR–foam (50mm thickness, density ~ 30kg/m³) has been measured several times at different states of optimization of the reverberant room. In original state, the measured absorption coefficient was in some 1/3 octave bands above 1 (see Picture 4, green curve). By dampening the diffusers, the measured absorption coefficient was decreased (see Picture 4, blue curve). This is not a consequence based on the edge effect.

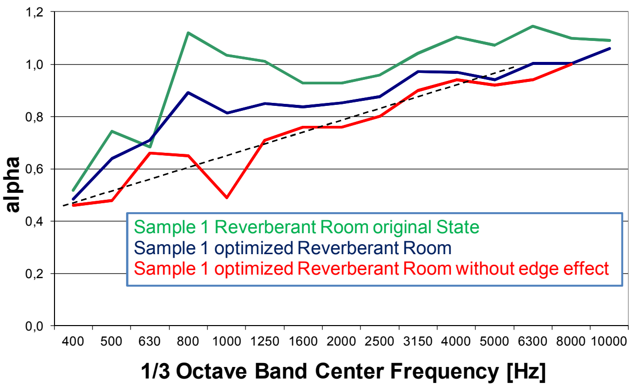
Edge Effect:

To determine the edge effect of the sample, a procedure as described in [1] was used. The sample of 1x1m was divided in four 0.5x0.5m samples. Three different frame sizes were used to change the ratio of perimeter / area. The ratios of the three frames are 4 (1x1m), 5 (0.5x2m) and 8 (4x 0.5x0.5m). Absorption measurements were made for each configuration.



Picture 3: Elimination of the edge effect, by changing the ratio of perimeter/area the absorption coefficient can be found at 0 of the abscissas (here 0.76).

A curve fitting algorithm for each 1/3 octave band was made to determine the absorption coefficient for the unlimited absorber. As an example the 2kHz 1/3 octave band is shown in Picture 3. The calculated absorption coefficient can be found at 0 of the abscissas. In this case it is an absorption coefficient of 0.76 of the unlimited absorber. The influence of the edge effect due to the measurement can be seen in Picture 4. The red curve shows the absorption coefficient of the unlimited absorber without the edge effect.



Picture 4: Measurement of one sample measured at different states of optimization. Green curve: before optimization, blue curve: with sound-deadening diffuser, red curve: with sound-deadening diffuser and without edge effect

Conclusion:

Different absorption measurements were made due to different states of optimization. By sound-deadening the diffusers, the measured absorption coefficient decreases significantly (comparing green and blue curve in Picture 4). Additionally, by taking the edge effect into account, the absorption coefficient will be reduced (as an example in Picture 4, at 800Hz, the absorption coefficient changes from 1.12 to 0.65).

Literature

[1] Esche, V. Experimentelle Untersuchungen zu Einfluß-parametern und Größe des Kanteneffektes
Acustica, 1967/68, Vol. 19, No. 6

[2] Messung der Schallabsorption im Hallraum
DIN EN ISO 354:2003