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TRANSMISSION LOSS OF DOUBLE PARTITIONS CONTAINING RESONANT ABSORBERS

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INTRODUCTION

The demand for better sound insulation of facades against traffic noise, combined with an increasing awareness of energy conservation in buildings, has also brought forward triple and even quadruple glazing units on the market in the Nordic countries. However, the quite small internal losses in such units, in combination with relatively narrow spacings between the glazing panels, give poor low-frequency sound insulation and also pronounced dips in the sound reduction index curve.
Such effects may have small consequencies on the weighted sound reduction index R_W but will be important when using an index based on the A-weighted sound pressure level such as the D_A-value commonly used in Norway. The D_A-value is the difference in the A-weighted level between the outside and the inside of a room, using normalized values for the facade area, room volume and reverberation time together with a generalized spectrum for the external noise. Poor sound insulation properties in the lower frequency range can have a pronounced effekt on the D_A-value evaluated using road traffic noise as the source.

The presented work is a pilot study on the feasibility of using resonant sound absorbers of Helmholtz-type along the edges of a partition as a means of increasing the sound insulation at low frequencies. The particular subject for study has been an experimental double glazing window construction with a fixed wooden frame.

DESIGNING ABSORBERS FOR WINDOWS

Specially designed windows for high sound insulation , e.g. for use in recording studios, usually have some absorbing material in the form of mineral wool incorporated along the edges. In buildings near the high density traffic such designs have also been observed but special damping treatment is not normally used in ordinary glazing units with an airspace of 12 to about 80 mm.

Resonant absorbers are expected to have many advantages as compared to the above mentioned porous absorbers. They may be designed without introducing the problems associated with moisture as with traditional porous materials. Furthermore, the absorption cross section can easily be made large at low frequencies reducing the effect of the "double wall" resonance and the first lateral eigenmodes of the airspace between the glazing panels.
Designing Helmholtz resonators to reduce the influence of these resonances poses a well known problem connected to the coupling of two resonant systems. The resonator may be tuned to obtain a very low response at the common resonance frequency but a subsequent high response at the coupled mode frequencies could render the net effect very small when considering a broader frequency range.

The coupling between the lowest lateral modes of the airspace and a resonator with the opening situated at one of the edges, can be treated as a special case of coupling a resonator to a room, Fahy and Schofield [1]. The actual position of the resonator will in this case be important. The results obtained will

depend on both the loss factor of the two systems and the effectiveness of the coupling.
Designing a resonator for increased damping at the double wall resonance frequency is slightly easier because the actual position of the resonator is not critical. The main part of the work reported here has been concentrated on improving the sound insulation in the frequency range around the double wall resonance frequency.
In general, the relative bandwith of these resonators has to be relatively large, 0.1-0.5. A high absorption over a large bandwith again necessitates a large resonator volume. In the measurements shown below we have also used series-coupled resonators to obtain a larger bandwidth.

An important prerequisite for doing this work is an efficient method for measuring and adjusting the resonators. A two-microphone method for measuring the acoustic impedance and absorption, Chung and Blaser [2], was extremely convenient in this respect. This method also enabled us to experimentally determine the end correction factors of the required slot shaped resonator openings. The measurements were performed in a tube using scale models 1:2 and 1:3.

EXPERIMENTAL RESULTS

All sound insulation measurements reported here were conducted on an experimental double glazing unit consisting of two 3 mm panels separated by an airspace of 97 mm. The unit had an area of $(1.19 \times 1.19) m^2$, filling completely a special test opening between two sound transmission rooms. At one of the edges a total of four resonator volumes could be coupled to the airspace between the panels and the resonator section occupied about 17% of the total area. The net area of the panels were then $(0.90 \times 1.12) m^2$. The double wall resonance frequency was 100 Hz and the four lowest eigenfrequencies of the airspace were approximately 150, 190, 250 and 310 Hz.
Figure 1 shows the results of a first measurement using four resonators tuned to cover the frequency range up to about 400 Hz. As seen a more smooth sound reduction index curve was obtained, increasing the D_A-value by 3 dB.

Better results in the middle and higher frequency ranges can be achieved using a moderately thick porous absorbent placed along the edges. Figure 2 shows the effect of adding strips of 25 mm thick, 80 kg/m^3 mineral wool on three edges. No significant improvement, however, is observed around the double wall resonance frequency. One remark should be made concerning the curves representing the "without absorbent" condition. Due to some changes in the frame construction these are not identical in Figure 1 and 2.
The added porous absorbent was kept in place in the remaining experiments reported here and the effort was consentrated on improving the sound insulation around the double wall resonance frequency.
Figure 3 shows the effect of adding one series-coupled double resonator, resonance frequencies at 105 and 175 Hz, and furthermore the effect of adding four double resonators covering the frequency range up to 400 Hz. Due to the porous absorbent the effect of at least two of these resonators is marginal but as indicated on the curves, the total effect of the resonators is to increase the the reduction index at 100 Hz by 12 dB and the D_A-value by 5 dB.

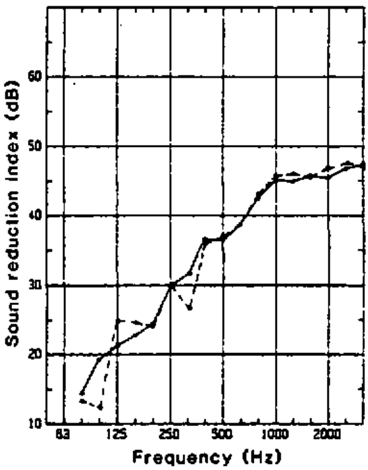

Figure 1.
Sound reduction index for the double glazing unit.
---, without absorbents, D_A=29.9 dB
——, with four resonators, D_A=32.9 dB

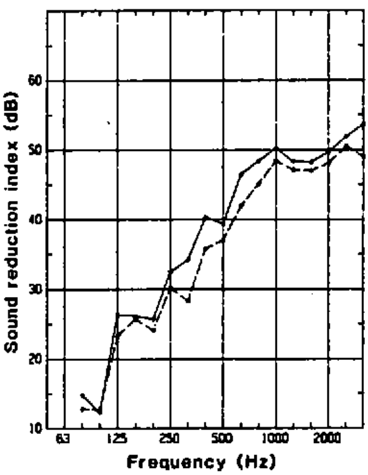

Figure 2.
Sound reduction index for the double glazing unit.
---, without absorbents (see text), D_A=30.6 dB
——, with mineral wool on three edges, D_A=30.8 dB

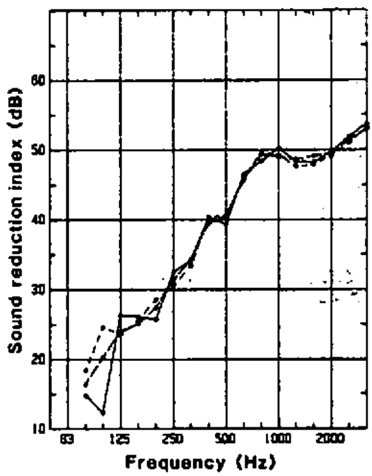

Figure 3.
Sound reduction index for the double glazing unit.
——, with mineral wool on three edges, D_A=30.8 dB
– –, mineral wool + one double resonator, D_A=34.9 dB
---, mineral wool + four double resonators, D_A=36.3 dB

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CONCLUSIONS

Helmholtz resonators can easily be dimensioned to increase the sound reduction index of the order of 10 dB, in a frequency band containing the double wall resonance frequency. For windows, this frequency normally lies in the frequency range 100-200 Hz, making the volume required for a resonator quite large, typically about 10-15 % of the volume of the airspace in a double glazing unit. For a window with a fixed frame the resonator volume could either be incorporated in the frame itself or be a part of the wall construction.

REFERENCES

[1] F.J. Fahy and C. Schofield 1980 J.Sound and Vibration 72, 365-378. A note on the interaction between a Helmholtz resonator and an acoustic mode of an enclosure.

[2] J.Y. Chung and D.A. Blaser 1980 J.Acoust.Soc.Am. 68, 907-913. Transfer function method of measuring in-duct acoustic properties. I. Theory.