Panel Resonator and Slot Absorber silencers for low and mid frequencies

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Introduction

Industrial exhaust and building ventilation systems usually produce a broadband sound spectrum. Conventional silencers made of porous materials often show poor insertion losses in the low and mid frequency range due to their low sound absorption performance within easy to handle slim constructions. To compensate this shortcoming, an increased splitter thickness and a narrow air passage is used frequently, which in turn cause high pressure losses. Nevertheless, there are already slim silencer solutions available for the low frequency range, reducing these pressure losses [1-4]. However, adequate attenuation in the mid frequency range, e.g. from 250 Hz to 500 Hz, in which the blade passing frequency of fans often produces high sound levels, is still a problem regarding the costs. In the following, two splitter type silencers (Figure 1) are introduced providing a very good attenuation performance in the mid and low frequency range with a comparative slim design. The paper demonstrates the construction and the acoustical principle as well as the tuning possibilities and attenuation in the mentioned frequency range on the basis of calculated and measured results.

Figure 1: Silencer splitters as Slot Absorbers with horizontally arranged slots (left) and as Panel Resonators (right).

Slot Absorbers

The effectiveness of porous absorbers behind a sound impermeable, slot-shaped cover (Figure 2) has been already presented in previous publications [5-7] for normal and diffuse sound incidence in a mid frequency range. The absorption performance is based on the oscillating fluid in the slot and an incident plane wave that is transformed into periodical cylindrical waves propagating in the porous absorber (Figure 3). Key tuning parameters are the width of the cover and the slot as well as the thickness of the absorbent layer. The absorption coefficient of some calculated and measured configurations [5] is shown in Figure 4. With splitter type silencers presented here (Figure 1), it was possible to verify their absorptive performance also for grazing sound incidence which is found in exhaust stacks and air conditioning ducts. By variation of the cover and/or slot width, the silencer can be tuned to somewhat lower frequencies (Figure 5). In general the calculation model according to [8, 9] yields to fairly higher insertion losses at the maximum. A separating plate within the splitter is not required since the sound pressure distributions in the air passages are symmetrical due to the dominant plane wave in the observed frequency range. A horizontal arrangement of the slots is favourable because of the reduced flow-generated noise. Examples of application in heating systems led already to promising results [10, 11].

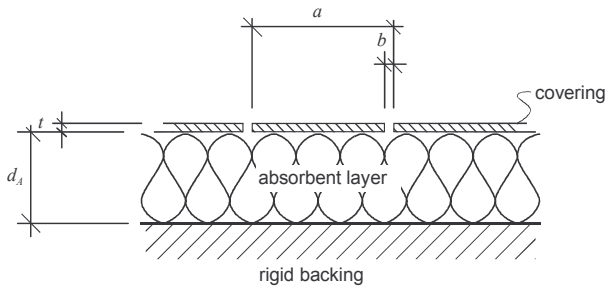

Figure 2: Slot Absorber with parallel slots of width ***b***, cover width ***a***, cover thickness ***t***, absorbent layer d_A.

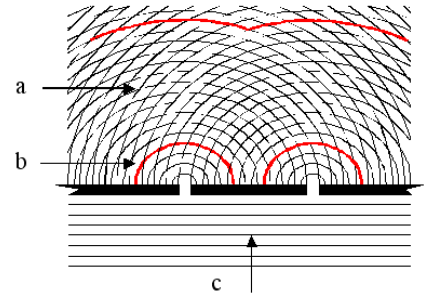

Figure 3: Propagation of an incident plane wave ***c***, transformed to periodical cylindrical waves ***b*** into the absorbent layer ***a***.

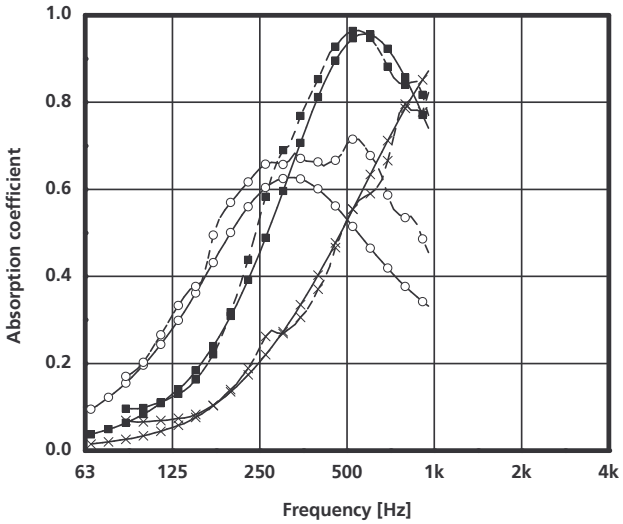

Figure 4: Calculated (—) and measured (– –) absorption at normal sound incidence of Slot Absorbers [5] with ***b/a*** = 20 / 230 mm (O), 10 / 80 mm (■), no cover (x).

Panel Resonators

A further possibility for effective attenuation in the low and mid frequency range can be realized with completely closed Panel Resonator splitters made of steel sheets (Figure 1). For thin and flexible covers, e.g. thin foils, the absorption is based on a spring-mass-resonator, whose resonance frequency depends on the mass per unit area of the cover and the distance between the cover and the backing or half the splitter thickness, respectively. For sufficiently stiff covers, the excitation of bending waves on the panel leads to an additional attenuation. Again, a separating plate within the splitter is not required since the sound pressure distributions in the air passages are symmetrical. In order to obtain a broadband and high attenuation, it is necessary to fill the cavity completely with an absorbent material, as in the well known Compound Panel Resonator CPR [12]. It is possible to tune the Panel Resonator within a broad frequency range (Figure 6) by variation of the panel thickness (mass per unit area), the splitter thickness and panel size. Beside the simple construction, and thus low manufacturing and assembling costs, the silencer offers the advantage of a completely closed design. As a result, fibre discharge, soiling or germ formation tendency are minimized to render possible applications in hygienic demanding environments, such as hospitals. First successful applications are described in [13, 14].

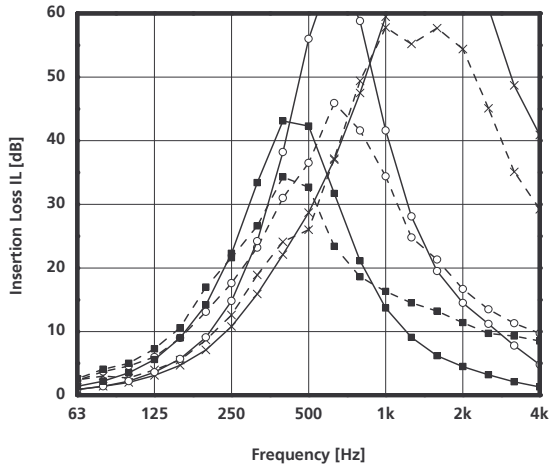

Figure 5: Calculated (—) and measured (– –) insertion loss of Slot Absorbers with *b/a* = 20/90 mm (O), 10/105 mm (■), no cover (x); splitter width 100 mm, air passage width 100 mm and splitter length 1500 mm.

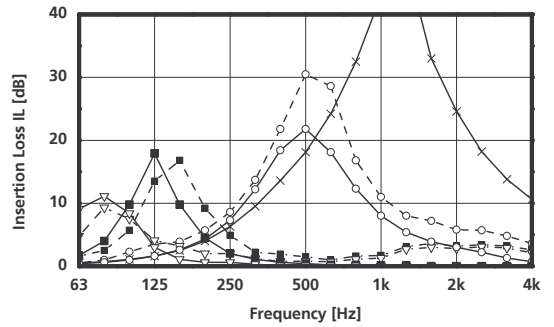

Figure 6: Calculated (—) and measured (– –) insertion loss of Panel Resonators with thickness t = 0.025 mm (O), 0.4 mm (■), 1 mm (▽), no panel (x); splitter thickness 100 mm, air passage width 200 mm and splitter length 1500 mm.

Summary

The novel silencers introduced here close the gap at the middle and low frequencies and are causing only small pressure losses. Their theoretical high effectiveness was confirmed in practical investigations. The reduction of pressure loss is caused by their slimmer design compared to porous silencers with equal performance at mid frequencies. Additionally, both silencer types are characterised by a special robustness to the surrounding medium. The investigations were supported by Deutsche Bundesstiftung Umwelt (DBU) [9].

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