Compact silencer for heating systems

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Introduction

Burner noise of boilers is mainly due to the flow produced by the fan and to the flame burning oil or gas. An altogether broadband sound spectrum is produced, which exhibits the highest levels within the low-frequency range (Figure 1). Additionally, characteristic resonances and tonal components occur. Special silencers are required if the immission values according to [1-4] have to be met at these low frequencies. A compact silencer, as combination of active and porous components, is introduced. Its design and working principle is presented together with the level reduction achieved in the low and mid frequency range based on measured data.

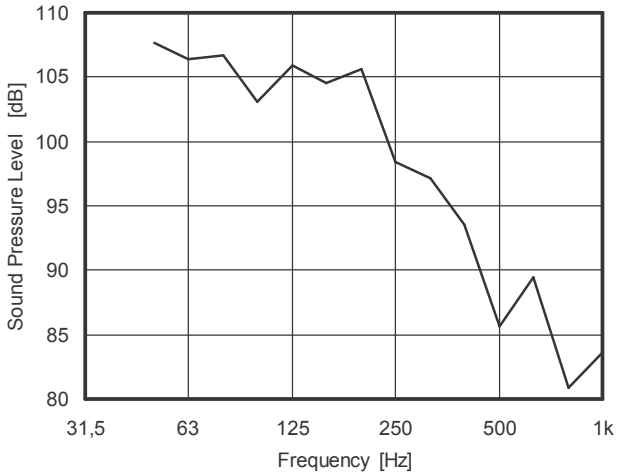

Figure 1: Sound pressure level in the connecting pipe between boiler and chimney of a heating system (100 to 500 kW)

Active Branch Resonator ABR

With its small construction volume the ABR [5] as shown in Figure 2 represents an effective and practicable solution [6] for the attenuation of low-frequency burner noise in the exhaust line.

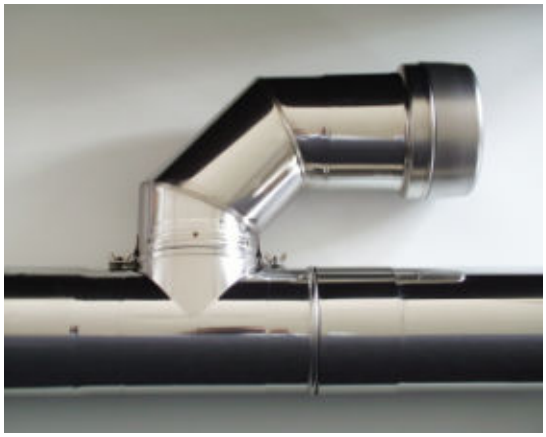

Figure 2: Active Branch Resonator (photo: Kutzner+Weber)

The basis is formed by the so-called branch resonator, a pipe with rigid termination, acting as λ/4-resonator. The length of the cavity determines the resonance frequency, defining the range of maximum attenuation. By coupling of an active electroacoustic component at the end of the branch as shown in Figure 3, the λ/4-resonator effect is shifted towards lower frequencies and increased over a broader frequency range.

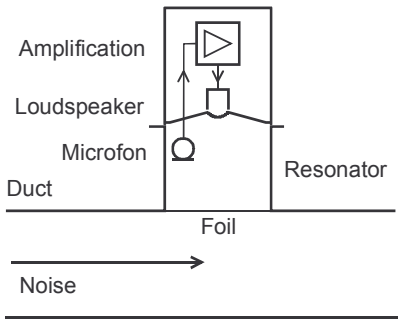

Figure 3: Schematic of an Active Branch Resonator

The rigid termination is replaced by the active component with smaller impedance due to the mass-spring system consisting of the mass of the loudspeaker diaphragm and the air volume installed behind it in the cabinet. The coupling of the branch resonator with this mass-spring system leads to a shift of the resonance to lower frequencies. The diaphragm movement is enhanced by activation of the electroacoustic component. The sound pressure level which is determined close to the loudspeaker by a microphone is amplified, inverted and fed back to the loudspeaker. The branch terminating impedance of this active mass-spring system is thereby substantially reduced. Thus, the absorption rises in a broad band at low frequencies. The mechanical and geometrical parameters of this complex resonator silencer as well as electroacoustic tuning determine the frequency range and the absorption.

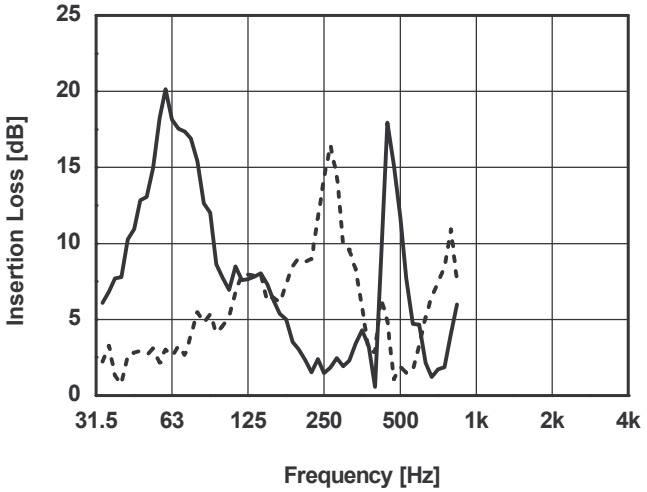

Figure 4: Insertion loss of an ABR.
—— switched on (active), - - - switched off (passive)

The measured insertion loss of an ABR, attached to a duct, in passive and activated condition is exemplarily shown in Figure 4. In "active" operation, a clear broadband rise of the attenuation is noticeable at low frequencies. For the protection of loudspeaker and microphone a heat and condensate-resistant foil is attached at the branch separating the active component from the exhaust gas flow. This preventive measure hardly affects the attenuation in the low-frequency range.

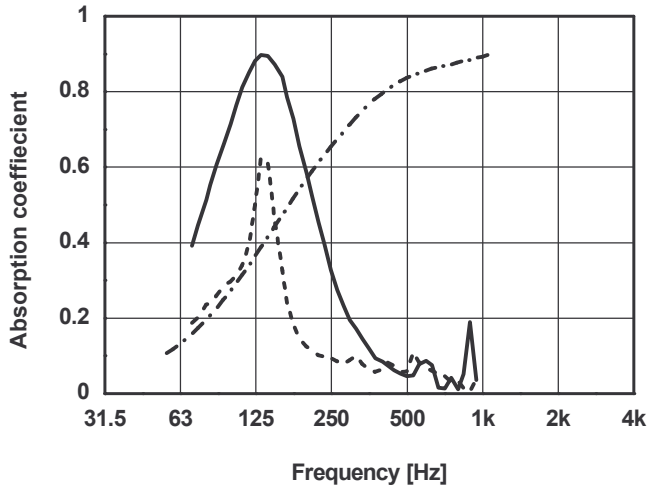

Figure 5: Absorption coefficient α_0 of an ABR compared to a 10 cm thick porous absorber. - - - ABR switched off (passive); ——ABR switched on (active); - · - porous absorber.

Aktiv+ Silencer

In Figure 5, the measured absorption coefficient of an ABR is compared with that of an optimally adapted porous absorber. This suggests the connection of both parts to a compact combination silencer. Such a silencer, consisting of an active branch resonator for the attenuation of low-frequency noise combined with a conventional passive tubular silencer for middle and high frequencies, is presented in Figure 6. This silencer combination was developed by the IBP in cooperation with Kutzner+Weber [7].

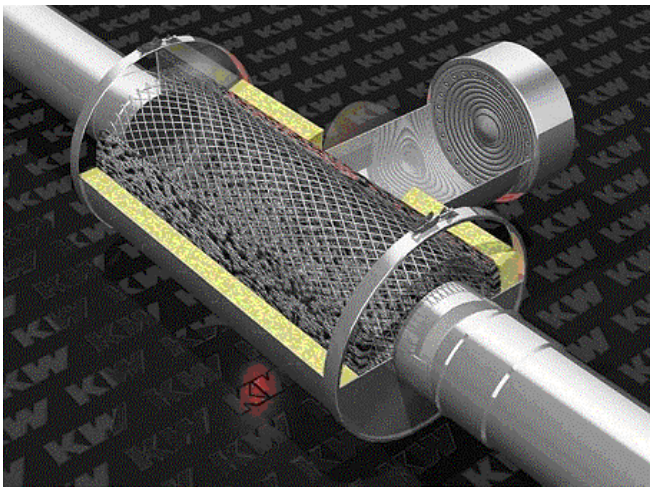

Figure 6: Aktiv+ Silencer consisting of an ABR with integrated passive silencer [7] (illustration: Kutzner+Weber).

A characteristic insertion loss is shown in Figure 7. The attenuation of the active branch resonator is clearly pronounced at low frequencies and the effect of the passive tubular silencer is found at mid and high frequencies.

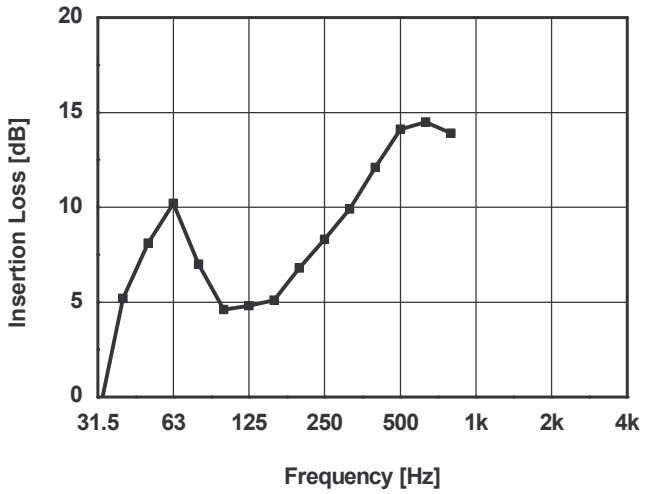

Figure 7: Example of the insertion loss of an Aktiv+ Silencer determined in the silencer test stand of the IBP.

Summary

The necessary installation volume could be strongly reduced by the integral approach of connecting active, reactive and passive silencer components with a broadband attenuation. The range of application can be adapted by the resonator chamber, the mass-spring system as well as electroacoustic tuning. Thus, the silencer combination Aktiv+ is an effective, space-saving alternative to conventional noise control of burner noise in the exhaust pipe of heating systems [8] and a successful representative of the ALFA-series developed at IBP [9].

References

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