Silencers for exhaust gas stacks of a power station

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Introduction

9 MW oil burning engines are not only producing energy but also waste gas and noise. The waste gas stacks are equipped with high attenuation silencers. In order to fulfil the acoustic requirements in the low frequency range a combination of reactive and porous silencers are installed. The gas temperature is about 280°C and the required attenuation is more than 40 dB in all octave bands including the 31 Hz band. The paper presents the principle of the solution and the acoustic results measured under operation.

Diesel engines as noise sources

Large diesel engines for the production of electrical energy (Figure 1) operate with heavy oil-residues obtained from the petroleum industry. The power station is placed next to a Fjord, where a residential area is located at the opposite bank at 1 km distance. The measured sound power level in the exhaust stack is presented in Figure 2. Strong tonal components are present especially at the motor outlet frequency at 40 Hz. An immission level of 35 dB(A) has to be met in a residential area. In order to exclude any annoyance there, the required insertion loss of the exhaust stack silencer as shown in Figure 3 was evaluated and agreed by the acoustic consultant of the customer. Because of spatial and static reasons the silencer had to be integrated into a chimney with a maximal height of 31 m and 2 m outer diameter.

Silencers in the exhaust gas stack

The commonly used silencers with mineral wool as absorbent material behind a perforated metal sheet comprise good performance at frequencies above 500 Hz for a less polluted medium. Since long special designs of Helmholtz- and/or quarter-wavelength-resonators are employed for the attenuation of low frequencies and polluted media which are able to avoid the disadvantages of mineral wool silencers. Unfortunately, they could not be applied in this case due to the restricted space. Therefore, the customer has chosen the "Cleanable Reactive Silencer" and the "Angular Stack Silencer" to reduce the low frequency noise [1]. These resonance type silencers have been developed in 1996 and successfully applied in other industrial sectors, but for the first time in this kind of application. They were combined with conventional mineral wool silencers for high frequencies and their surface is protected against the fluid by an additional layer of stainless steel wool behind a perforated metal sheet. The principle layout of the sound attenuating chimney is shown in Figure 4.

The following sections focus on theses new silencer types and the obtained measurement results.

Figure 1: View of a 9 MW Diesel engine.

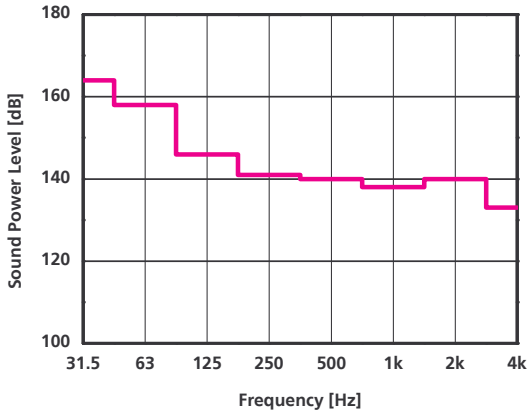

Figure 2: Sound power level L_w of the 9 MW engine measured in the exhaust gas system.

Cleanable Reactive Silencer CRS

The exhaust gas enters the CRS of 7.6 m length with a flow speed of 28 m/s. The silencer consists of three chambers with different volumes and lengths which act essentially as quarter-wavelength resonators providing a broad attenuation at low frequencies. The chambers of the silencer are acoustically coupled to the stack by ring-shaped perforated metal sheets but without flow through the chambers. Hence, the silencer does not cause additional pressure losses, which is an advantage appreciated not only by operators of power plants. The silencer reduces noise at low frequencies by 10 to 30 dB (in the 31 Hz to 250 Hz octave bands), where the limiting attenuation of the stack structure is reached at 31 Hz. The three chambers of the CRS are acoustically tuned for peak attenuation at the 40 Hz third-octave band matching the engine outlet frequency.

Angular Stack Silencer ASS

The CRS is followed by an ASS of 9 m length according to Figure 4. The latter consists of panel resonators which are fitted into the stack forming a polygonal

shape in cross section. The resonators are tuned to the frequency range from 31 Hz to 2 kHz by varying the panel thickness and dimensions. The main focus of the silencer design is again at low frequencies where a noise reduction of 25 dB at 40 Hz is obtained. In order to arrive at this result it was necessary to insert a 200 mm thick splitter with Panel Resonators [2] on both sides dividing the cross sectional area into two parts as shown in Figure 5.

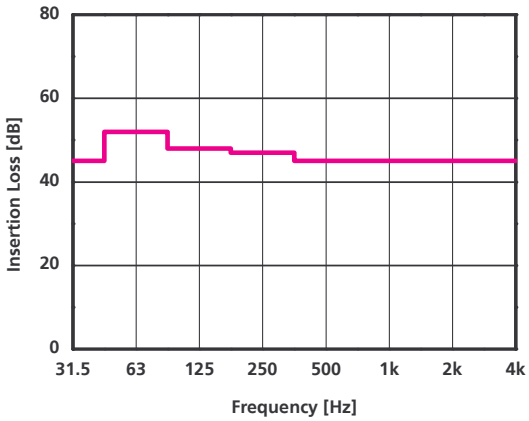

Figure 3: Required insertion loss.

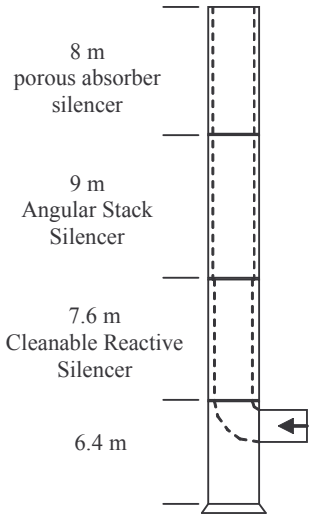

Figure 4: Sketch of the chimney with internal silencers.

Combined Silencer

The last piece of the chimney is equipped with a tubular porous absorber of 8 m length for noise reduction in the mid and high frequency range, again with a central splitter. As mentioned above, the attenuation at low frequencies for each silencer approaches the limit attenuation. This means that the high attenuation rates are only obtained when the structure borne sound flanking transmission between each silencer piece is eliminated. For that reason, the silencers were separated from each other by steel spring elements. Figure 6 shows the spring elements at the end of the CRS. The in situ measured sound power levels at the end of the stack and the guaranteed values are shown in Figure 7. Even if the porous absorber, whose mineral wool is separated by a 10 mm thick stainless steel wool layer from the perforated metal sheet, becomes gradually polluted, the allowed emission levels are still met.

Figure 5: Inner view of the ASS.

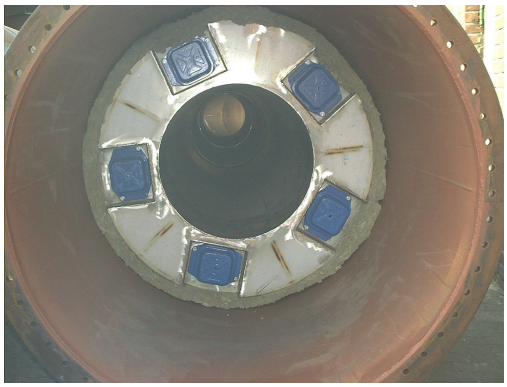

Figure 6: View to the spring elements (blue) at the CRS.

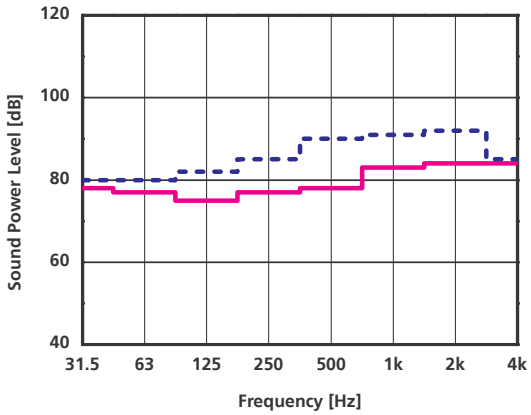

Figure 7: A-weighted sound power levels L_w measured (full line) and required (dashed line).

Summary

Remaining low frequency components, which often cause annoyance to residents nearby an industrial plant, can be reduced efficiently with the described low frequency silencers. They offer additional advantages due to the compact design by requiring less space and causing only small additional pressure loss. In the present case the pressure loss was just about 250 Pa. The first unit is operating since summer 2003 and two more units are already delivered.

References:

[1] Fuchs, H.V.; Eckoldt, D.; Hemsing, J.: Alternative sound absorbers for industrial use. VGB PowerTech 79 (1999), 58-60

[2] Hanisch, R. et al.: Panel Resonator and Slot Absorber silencers for low and mid frequencies. In: CFA/DAGA 04, p. 329