Noise reduction from air intakes of compressors and blower fans

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ABSTRACT

The noise radiated by from air intakes of compressors and blower fans is a source of noise for the territory of the enterprise and the surrounding area. The using of acoustic barriers (screens) and dissipative silencers for reducing noise from air intake of compressor and blower fans were analyzed. The effect of the distance from the acoustic screen to the air intake on the reduction of noise and changing the aerodynamic drag were investigating. It is detected the region of using acoustic barriers to reduce noise from air intake of compressors and from air intake of blower fans. The baffle silencers should be used when the noise reduction more 10 dBA. The baffle silencers have a high acoustic efficiency, but create additional aerodynamic drag. It stressed that the air intake design plays an important role in the aerodynamic drag of the air path. The case of reconstruction was shown, when the air channel with improved aerodynamic air intake and the silencer has less aerodynamic drag then the air channel without silencer before reconstruction. This is achieved by the implementation of the air intake structure. The results of acoustic measurements of the baffle silencer are shown.

Keywords: Silencers, Barrier I-INCE Classification of Subjects Number(s): 34.1

1. INTRODUCTION

The noise radiated by from air intakes of compressors and blower fans is a source of noise for the territory of the enterprise and the surrounding area (1—3).

This is typical for thermal power stations (TPS), steel mills, and many other cases.

Blower fans at these enterprises have the following characteristics: flow rates are in range of 200000 — 580000 m³/h; the developed pressures are 3000 — 9800 Pa.

Excess sanitary norms can be up to 15-20 dBA at a distance of 500 meters from the TPS.

There are dissipative silencers and barriers (screens) used to reduce noise from air intakes of compressors and blower fans.

In developing noise reduction must take into account the change of climatic factors during the year. The required reduction of the silencer throughout the year can be changed up to 5-8 dB for the same point (4).

It is important to use a new method for determining the lengths of multi-stage baffle silencers, with different thicknesses of baffles installed in the gas path of heat power stations (HPS) based on the minimum discounted costs (5—9).

The package of measures to reduce noise from the air intakes compressors and blower fans considered. The using of acoustic barriers and dissipative silencers for reducing noise from air intake of compressor and blower fans were analyzed. The advantages and disadvantages from the using of acoustic barriers and dissipative silencers to reduce air intake noise are shown.

2. ABSORPTION SILENCERS FOR AIR INTAKES

Design of absorption (dissipative) silencers for air intakes of compressors and blower fans are well
known by references (10-11). As usually baffle silencers are used for noise reduction from air intakes of compressors and blower fans. The acoustic calculation of the baffle silencers is well-developed (10-11). Noise reduction of silencers could be for thermal power station of high capacity are about 10 — 25 dBA (1—3). The decreasing of tonal noise is very important for the blower fans silencers (1,3).

The advantage of baffle silencers are relative simplicity of production and technology maturity of installation. Noise reduction is carried out in the wide range of frequencies and makes up to 25 dB at moderate aerodynamic resistance. The extreme value of the noise reduction by the baffle silencer established in a metal channel makes about 50 dB, and in the channel with brick or concrete walls - about 76 dB.

Installations of multi-stage baffle silencers associated with increased aerodynamic drag (3,12—14), which determines the additional costs for its own needs. This is especially important for larger channels where the transportation of large volumes of gases takes place. It is an important task to reduce aerodynamic drag.

The baffle silencers have a high acoustic efficiency, but create additional aerodynamic drag. The air intake design plays an important role in the aerodynamic drag of the air path.

The experience of noise reduction by installation of the baffle silencer (figure 1a) which has allowed to reduce at the same time aerodynamic resistance is shown. At reconstruction the round air intake was replacement on square air intake with a silencer. The air intake before reconstruction is shown in figure1b.; after reconstruction – in figure 1c. The silencer was mounted in a channel with sizes of 2000x2000 mm. The inlet has the developed air intake.

Acoustic efficiency of the baffle silencer was defined by measurements in a control point before installation of the silencer and makes near 10 dBA.

Calculations of aerodynamic resistance of the air intake before and after installation of the silencer are given below.

Aerodynamic resistance after installation of silencer $H_s$, Pa, is on a formula by reference (12):

$$H_s = H_c + H,$$  \hspace{1cm} (1)

where $H$ — aerodynamic resistance of the baffle silencer, Pa; $H_c$ — aerodynamic resistance of converging, Pa.

Aerodynamic drag of the multi-stage baffle silencer $H$, Pa, is calculated by the known formula (12):

$$H = \sum_{i=1}^{n} \left( \xi_{s,i} + \xi_{f,i} \frac{l_i}{D_i} \right) \frac{v^2 \rho}{2},$$  \hspace{1cm} (2)

where $\xi_{s,i}$, $\xi_{f,i}$ — coefficient of local resistance and coefficient of friction the $i$-th stage of the silencer; $l_i$ — the length of the $i$-th section of the silencer, m; $D_i$ — hydraulic diameter of the silencer, m; $v$ — flow rate at the section between the baffles of the silencer, m/s; $\rho$ — density of the fluid in the duct, kg/m$^3$; $n$ — the number of stages.

The hydraulic diameter of the cell’s silencer is equal $D_c = 4S/\Pi \approx 2t$, where $S$ — cell’s area of the silencer, m$^2$; $\Pi$ — cell perimeter of the silencer, m; $t$ — the distance between the middle baffle of the silencer, m.

Aerodynamic resistance of converging $H_c$, Pa, is on a formula:

$$H_c = \zeta \cdot \rho \cdot w^2/2,$$  \hspace{1cm} (3)

where $\zeta$ — stream inlet resistance coefficient to duct; $w$ — flow velocity, m/s.

Aerodynamic resistance before silencer installation $H_{bef}$, Pa, is on a formula:

$$H_{bef} = H_0 + H_{en0},$$  \hspace{1cm} (4)

Where aerodynamic resistance of inlet $H_{en0}$, Pa, is:

$$H_{en0} = \zeta \cdot \rho \cdot w_1^2/2,$$  \hspace{1cm} (5)
where $\zeta$ – stream inlet resistance coefficient to duct; $w_l$ – stream velocity before silencer installation, m/s.

Aerodynamic resistance of the straight channel $H_0$, Pa, is:

$$ H_0 = (\zeta_3 \cdot l/D_1) \cdot \rho \cdot w_l^2 / 2 $$  \hspace{1cm} (6)

where $\zeta_3$ – frictional coefficient; $w_l$ – stream velocity before silencer installation, m/s; $D_1$ – hydraulic diameter on inlet before silencer installation, m.

The change of aerodynamic resistance after silencer installation $\Delta H$, Pa, is:

$$ \Delta H = H_{bef} - H_s $$  \hspace{1cm} (7)

Flow rate is 217000 m$^3$/h.

The air channel with improved aerodynamic air intake and the silencer has less aerodynamic drag than the air channel without silencer before reconstruction. Aerodynamic resistance of a new air intake with the silencer installation has decreased by 179 Pa. This is significantly improved conditions operation of the blower fan. This is achieved by the development of the air intake.

### 3. BARRIER (SCREEN) FOR AIR INTAKES

Acoustic barriers (screens) could be used for noise reduction from air intakes compressors and the blower fans. The advantages of acoustic barriers (screens) are simplicity of a design and rather small capital expenditures.

In this case noise level decrease happens:

1. due to reflection of part of sound energy back to the channel $\Delta L_1$;
2. absorption of sound energy $\Delta L_2$;
3. change of directivity index.

The value of sound power level $\Delta L_1$, dB, due to reflection of part of sound energy back to the channel could be calculated:

$$ \Delta L_1 = 10 \log \left( \frac{(1 + m_{rel})^3 / ((1 + m_{rel})^3 - 1)}{(1 + m_{rel})^3 / ((1 + m_{rel})^3 - 1)} \right) $$  \hspace{1cm} (8)

where $m_{rel} = 4t/D_h$ - relative distance; $t$ - distance between the screen and the air intake, m; $D_h$ - hydraulic diameter of air intake, m. The formula is fair when $D_h >> \lambda$.

It must be kept in mind that at low frequencies ($0.5 \lambda > t$) sound waves bend around the screen and it practically doesn't influence on radiation. Screen diameter is always more than an air intake diameter.

Distance $t$ between the screen and the air intake influence to acoustic efficiency and aerodynamic resistance at the same time.

There are some recommendations for selection the distance $t$ between the screen and the air intake (12):

- at $t/D_h > 1$ aerodynamic resistance of screen can be neglected;
- at $t/D_h < 0.8$ aerodynamic resistance of screen sharply increases because of stream velocity increase.

It’s mean that when $t/D_h > 0.8$ the value $\Delta L_1$ is close to zero.

Absorption of sound energy $\Delta L_2$, dB, is reached due to facing by sound-absorbing material. Reduction of screen sound power at $t=0.5$ m makes about 10 dB.

The baffle silencers should be used when the value of sound power level reduction is more 8-9 dBA.

The screen change of directivity index in the directions close to axis of air intake.

Figure 2 shows model of acoustic barrier (screen) (a) and place of acoustic barrier (screen) installation (b). The height of screen is 4200 mm and the length of screen — 7060 mm.

The screen is located at a distance of 700 mm from the compressor air intake.

Sound intensity reduction in the directions close to axis of a compressor air intake due the screen
makes up to 25-30 dB.
This means that changes of directivity index play the main role in reducing the sound pressure level at the screen at the control point in the directions close to axis of a compressor air intake.

4. CONCLUSIONS

1. Baffle silencers and barriers (screens) are effective for noise reduction from air intakes of compressors and blower fans.
2. The aerodynamic resistance could be important at the choice of a silencer and barrier (screen) design for compressors and blower fans air intakes.
3. It is necessary to use all opportunities to reduce aerodynamic drag by silencers and by barriers (screens). This can be achieved by special designs as well as the observance of certain recommendations.

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Figure 1 – Model of baffle silencer (a); 1 – sound absorbing material, 2 – perforated metal sheets, 3 – round fairings, 4 – plates of silencer; Air intake of blower fan before installation of silencer (b); Place of silencer installation (c)
Figure 2— Model of acoustic barrier (screen) (a); 1 – sound absorbing panel; Place of acoustic barrier (screen) installation (b)