Improving the Fire-fighting Design of Silencers

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Abstract. This paper presents fire-fighting design of silencer formed by stepped partitions. Providing the distance between the partitions not exceeding a quarter of the wavelengths and forming the set of ducts with alternating expansions and narrowings create the possibilities for noise reduction and spark arresting. Slit silencer model testing on the stand contained doubled reverberant chambers with removable elements and diaphragm as well as on the stand with internal combustion chamber demonstrates the following: noise reduction is not less than 7.5 dB in a wide frequency range; pressure losses are not more than 120 Pa; sparks don't pass. Correcting the silencer geometry allows forming the devices which acoustic and aerodynamic characteristics are similar to the characteristics of standard plate silencers. Calculating data show the dimensions of single and double silencer, ensuring spark arresting and requirement noise reduction in a gas flue.

1. Introduction
The advantages of silencers without sound-absorbing material include the stability of the characteristics in the aerosol flows and the possibility of dynamic spark arresting [1-4]. However, the prospects of fire-fighting design of silencers are often limited by the appearance of transverse resonant oscillations [5-7]. To ensure the required broadband noise reduction [8-10], it is necessary determining the dimensions of the silencer design [11-14].

Slit silencer construction is formed by means of stepped partitions as the set of ducts which one dimension is much smaller than the other two dimensions [15]. Each duct contains sequence sections of narrowing and expansion. The design is added by turning walls and filter cavities.

Slit silencer is described taking into account not less than one hundred forms of propagating waves [16-18] by the method of electroacoustic analogy. Acoustic calculations are realized using Simulink.

The purpose of the paper is detecting the silencer geometry ensuring the smooth throughout the normalized frequency range noise reduction.

The problems of calculated and experimental bringing out abilities of the slit silencers were solved.

2. Slit ducts geometry

2.1. Slit ducts cross-section
Silencer's slit ducts can be fulfilled vertical or horizontal (figure 1).

The silencer’s slit ducts should have the smallest cross-section dimension no more than a quarter of the wavelengths propagating in the system.
Taking into account the upper normalized frequency [19, 20] and the permissible degree of expansion the distance between the partitions is 4 mm at the sections of narrowing and 160 mm at the section of expansion.

2.2. Model tests
Model tests were carried out to determine [21, 22] the operational abilities of split silencers (figure 2). The requirements of the similarity theory were fulfilled.

Acoustic characteristics of slit silencer were determined by the method of measuring in doubled reverberant chambers with removable elements:

- Mounting the removable elements of the duct connecting two reverberant chambers in one of which loudspeakers were placed.
- Measuring the 1/3-octave sound pressure levels in each reverberant chamber.
- Calculating the noise reduction in silencer model absence.
- Mounting the silencer model in place of the removable element.
- Measuring the 1/3-octave sound pressure levels in each reverberant chamber.
- Calculating the noise reduction in the silencer model presence.
- Calculating the noise reduction ensured by the device.

Aerodynamic characteristics of split silencer were determined by the method of measuring in pressure duct with the diaphragm:

- Setting the fan operation.
- Determining the airflow passed through the diaphragm.
- Measuring the total pressure on the model’s inlet.
- Measuring the total pressure on the model’s outlet.
- Calculating the pressure losses.
Spark arresting ability was tested in the stand with internal-combustion chamber:

- Mounting the silencer model at the stand.
- Initiating the ignition in the chamber.
- Visual fixing the breakthrough sparks.

![Slit Silencer Scheme](image)

**Figure 2.** Slit silencer scheme.

Tests results show the following:

- Noise reduction was no less than 7.5 dB in the frequency range 125-4000 Hz.
- Maximum pressure losses in the slit silencer were 120 Pa.
- Sparks on the silencer’s outlet do not pass.

### 2.3. Slit ducts section length

Based on the calculations of slit silencer variants it was found achieving the smooth broadband characteristic when the change indicator of length for slit ducts is $2^{-0.6}$.

The correction of the design is carried out on the example of the forming the slit silencers which acoustic and aerodynamic performances are close to standard plate silencers.

For plate silencers [23-25]:

- Plates with sound-absorbing material of 200 mm thickness are placed through 200 mm.
- Maximum pressure losses in the split silencer are 120 Pa.
- Device length is 1000 and 2000 mm.

Lengths of narrowing and expansion sections in formed silencers are shown in figures 3, 4.

The largest cross-sectional dimension of the ducts is taken to be 1000 mm.

The acoustic abilities of the slit silencers (figure 5, 6) indicate ensuring the effective noise reduction for a gas flue.
Figure 3. Sections of narrowing and expansion for slit silencer length of 1000 mm

Figure 4. Sections of narrowing and expansion for slit silencer length of 2000 mm

Figure 5. Acoustic characteristics for silencers of 1000 mm.
According to the calculations and experiments the successive placement silencer with vertical partitions and silencer with horizontal partitions increases the noise reduction twice (figure 7).

3. Conclusion
Fire-fighting silencer formed by step partitions is recommended for systems with gas flues. Identified geometry of the slit ducts creates conditions both for smooth broadband noise reduction with acceptable aerodynamic losses and for spark arresting.
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