Original Article

The role of absorptive silencer in reduction of low-frequency noise produced by a fan

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ABSTRACT

Aims: In this study, the amount of the reduction in absorption silencer sound filled with Iranian absorbing materials and influence of thickness and density of adsorbent material in silence was investigated.

Materials and Methods: We used galvanized channel 0.6 mm with 30 × 30 cm^2 dimension and axial fan. Length of absorptive silencer was 50 cm, and there used the mineral wool absorbent. Absorptive silencer as channel was designed to cross a section of channel and silencers after embedded the absorber be identical together. This study deals with a number of variables that affect performance of absorptive silencer in the channel and their impact on reducing the sound pressure level be examined.

Results: In the frequencies 125 and 250 Hz a reduction of sound pressure level was found. While in frequency 500 Hz minimal reduction is achieved. In this study, an increase in the thickness of the absorbent material of absorption silencer, there was a little change in the volume decreasing but with increasing density from 80 to 100 Kg/m^3 better results were seen to reduce noise levels and it caused to increase NR rate.

Conclusion: According to data from the present study we can used silencer with 5 cm thick and 100 Kg/m^3 density in the reduction of sound pressure level at frequencies lower than 250 Hz in the ventilation system as an effective device.

Key words: Absorptive silencer, density, fan, noise reduction, thickness

INTRODUCTION

Countless numbers of people whether at workplace or in the community are affected by harmful noise and according to development increasing of industry need to review the risk factors of workplace such as the harmful physical agents of workplace more felt. In the conducted studies, about 30 million workers in America are in contact with high noise.[1-4] It is estimated that more than half of the industrial machine sounds with an intensity of 90-100 dB are produced.[5] Noise created diseases include hypertension, hearing loss, mental illness and neurosis disease (irritable, aggression and…).[6] When a person is exposed to noise above a certain level can be causes of permanent hearing loss. Therefore, industries are motivated to find an effective, economical solution to this problem.

Access this article online

Quick Response Code:

Website: www.ijehe.org

DOI: 10.4103/2277-9183.170709

This article may be cited as:
Yousefi HA, Forouharmajd F, Maghsudian L. The role of absorptive silencer in reduction of low-frequency noise produced by a fan. Int J Env Health Eng 2015;4:42.

Ventilation systems in buildings are one of the most important sources of noise, which are spread into the surrounding environment through fans and channels or distributors.[6]

In general, axial and centrifugal fans are used in industry.[7,8] The fans can be divided into two major categories:
(1) Axial,
(2) Centrifugal.[9]

Axial fans are named because the air flow is along the axis of a fan. The most important causes of mechanical noise (non-aerodynamic noise) are lack of balanced fan, bearings, engine noise and structure resonance.[8] Corsini *et al*. have been proposed a formula to calculate the current in the axial fan which is used to reduce noise in the end-plate to reduce noise devices.[10] For aerodynamic efficiency and noise reduction in industrial units, the low-speed axial fan and turbofan engines used.[10]

Silencers are among the devices that used to reduce noise output of air, channels and fans.[11] These devices can be divided into three basic groups: Reactive, absorptive and dispersive.[12]

The simplest form of a reaction silencer is a simple expanded chamber in the direction of a channel that transmitted the sound. In the location for changing channel cross-section, changing impedance caused to reflect sound waves. This reflection along with secondary to destructive interference of incoming sound wave, caused to reduce noise in the channel length, absorptive silencer are devices that used characteristics and features of porous absorbent to absorb sound that passing through the device The simplest form of this kind of silencers, is channel, which covered with absorbent material. Through covering the interior walls of a conduit with sound absorbing material, can create silencer with the desired length. Sound absorptive materials are materials that reduce the acoustic energy of a sound wave as the wave passes through it by the phenomenon of absorption. They are mostly used to soften the acoustic environment of a closed volume by reducing the amplitude of the reflected waves. Application of Sound Absorptive materials are in acoustic engineering such as the control of room acoustics, industrial noise control, studio acoustics and automotive acoustics control the response of artistic performance spaces to steady and transient sound sources, thereby affecting the character of the aural environment, the quality of unreinforced musical sound and the intelligibility of unreinforced speech from other applications are sound absorbent material.[13] Dispersive silencer, in essence, is pressure relief devices, which is located downstream area of current and reduces the percentage of pressure over this range. As a result of this, the noise reduction amounts are too high.

These devices can be built in the form of a shelf that mounted around a control valve or connected back of the valve.[14]

Selamet *et al*. examined noise reduction in silencers filled with filamentous fiber theoretically and experimentally. This study investigates a hybrid silencer type and filled compartments in combination with Helm Holms resonator. They showed that absorbents materials increases transmission loss rate. Moreover, the number of peak reduces with increased thickness of absorbent materials and caused to change frequency of the transmission loss peak.[15]

Wang *et al*. deals with the silencers with/without absorbing materials and showed that the absorption materials reduce the transmission loss at resonance frequencies but in general caused to increased capacity in the valleys of the curve especially. Moreover, the absorbent materials with higher density have ability to absorb noise and sound transmission loss. Wang *et al*. also concluded that in the distributive silencer the density of the filled material reduces the resonant frequency and increased transmission loss.[16]

Seddeq showed better results at frequencies below 500 Hz with the lower density of the adsorbent material and in the higher density showed better performance at frequencies above 2000 Hz.[16]

With the increasing use of machinery and increasing public awareness and concern for controlling noise, tend to silencer properly designed for specific applications is increasing. Since axial fans are used in industry very much and silencers are among ways to voice control in this study, we investigate amount of the reduction in absorption silencer sound filled with Iranian absorbing materials and influence of thickness and density of adsorbent material in silence.

MATERIALS AND METHODS

In this experimental study, we used galvanized channel 0.6 mm with a length of 3 m and 30 × 30 cm^2 dimension and axial fan. Absorptive silencer as channel was designed to cross a section of channel and silencers after embedded the absorber be identical together. The silencer length is 50 cm and In the Silencer also used the mineral wool absorbent and here we investigate functional factors of absorptive silencer in reduction of low-frequency noise of Iranian fans. The fan has been used that predominantly have low-frequency noise.

To determine the sound pressure level in a channel, two microphones are embedded that be accomplished by using Matlab software in the one-third of octave broadband and variable speeds 600-2500 rpm microphones are embedded at a distance of 180 cm and 270 cm of fan (20 cm before and after the silencer) and calibrated with Matlab software [Figure 3]. A program setup of Matlab simulation created. Then two microphones equipped to a calibrator of B&K in 94 dB sound pressure level severity. The graph of Matlab was set to 94 dB on the frequency of 1000 hertz.

For changing fan speed is used a 2kw dimmer and for measurement of fan speed used Tachometer apparatus (model DT-2234B).

For the determination of reduction, the low-frequency noise of fan by absorptive silencer in 20 cm intervals microphones are installed before and after silencer. And the sound pressure level is measured using the software at intervals mentioned. For every fan speed Matlab software is plotted a graph before and after install silencer and resulting data from graph is converted to sound pressure levels four types of absorptive silencer used in channels are silencer with 5 cm thickness and 80 Kg/m^3 density, silencer with 10 cm thickness and 80 Kg/m^3 density, silencer with 5 cm thickness and 100 Kg/m^3 density and silencer with 10 cm thickness and 100 Kg/m^3 density.

The amount of sound pressure level reduction (NR) for different speed 1000-2580 is calculated using the following formula:

$$NR = LP2 - LP1$$

Amount of NR in the 500, 125, 250 Hz frequencies obtained from the graph resulting Matlab software (version 7.12.0.635) and resulted data investigated.[11]

To determine the effect of density of the absorber, it is used the Iranian-absorbing mineral wool (commercial name phono-panel with code 141) with 80 and 100 Kg/m^3 density that amount of NR in these two cases are considered. These absorbers are used in 5 and 10 cm thickness in silencer. Thus, the sound pressure level is measured before and after the silencer and amount of noise reduction with different thicknesses and density are studied.

RESULTS

The sound pressure level in the channel in one-third octave band bandwidth was measured at different speeds [Figure 1], and the results are shown in the Table 1. This study is used Iranian fan 2500 rpm that according to the measurements performed using Tachometer the actual speed tested fan was 2580 rpm.

Reduction in sound pressure levels examined at low frequencies absorbed by absorptive silencer in different fan speeds that in the 125 and 250 Hz reduction in the sound pressure level was seen while in 500 Hz the lowest frequency is achieved.

As can be seen in Figure 2, the maximum reduction of sound pressure levels is in 125 Hz frequency by silencer in 5 cm thickness and 80 Kg/m^3 density. The maximum reduction of sound pressure levels is in 250 Hz frequency by silencer in 5 cm thickness and 100 Kg/m^3 density is achieved.

The maximum sound pressure level reduction 9.41 dB by silencer 5-100 at 181 Hz frequency that is a resonant frequency of the fan 1800 rpm, is obtained [Figures 4 and 5].

The four types of absorptive silencer used in channels, the maximum sound pressure at a frequency below 250 Hz are achieved. Means of reduction of sound pressure level, in different doses from 600 to 2580 dB are presented in the Table 2. The mean reduction in pressure level is presented in Table 2 and decrease of sound pressure level is equivalent to subtracting reduce sound pressure level after installation the silencer and reduced sound pressure level before installing the silencer.

The maximum reduction of sound pressure levels by silencer with 5 cm thickness and 80 Kg/m^3 density in frequency 125, 250, 500 Hz were, respectively, 4.18, 4.8 and 5.02, the maximum reduction of sound pressure levels by silencer with 10 cm thickness and 80 Kg/m^3 density in frequency 125, 250, 500 Hz were, respectively, 3, 3.54 and 2.58 dB and the maximum reduction of sound pressure levels by silencer with 5 cm thickness and 100 Kg/m^3 density in frequency 125, 250, 500 Hz were, respectively, 3.73, 5.72 and 2.5 dB and the maximum reduction of sound pressure levels by silencer with 10 cm thickness and 100 Kg/m^3

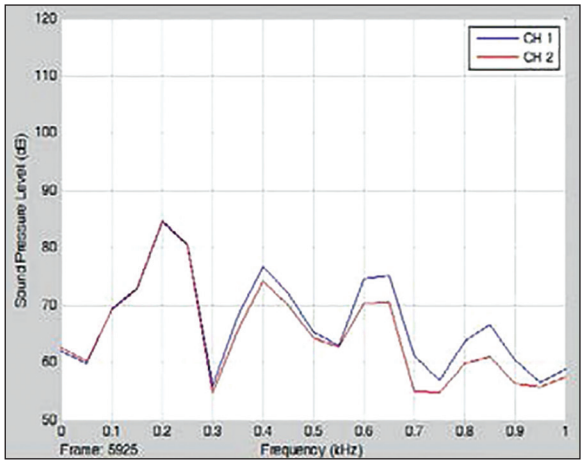

Figure 1: Diagram of sound pressure levels in one-third octave band of bandwidth fan at 2500 rpm

Table 1: Sound pressure level of the fan in dB and frequency distribution of noise in the channel without silencer

RPM Frequency (Hz)	2850	2500	2400	2200	2000	1800	1600	1400	1200	1000	800	600
125	70	71	70	75	68	67	69	68	62	57	53	52
250	75	75	75	70	63	60	57	58	54	55	50	41
500	61	67	63	61	61	57	65	61	57	55	20	19

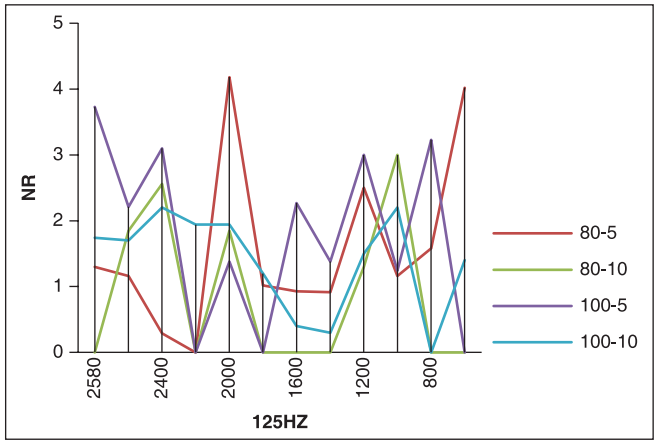

Figure 2: Graphs of comparison changes in sound pressure level reduction based on rpm of fan in 125 Hz frequency according to reduce the sound pressure level in dB

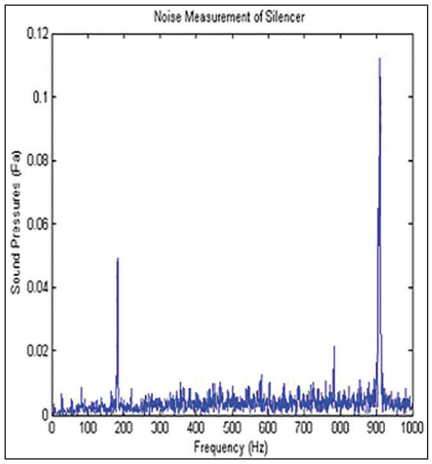

Figure 4: Graph of fan pressure sound at 1800 rpm in 1 point before silencer

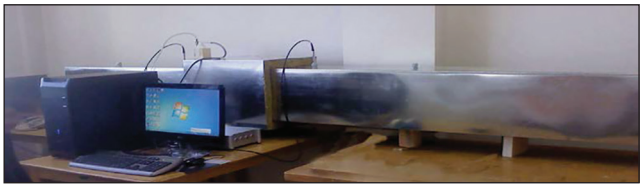

Figure 3: Laboratory Setup for determine sound pressure level and the location of the two microphones in channels

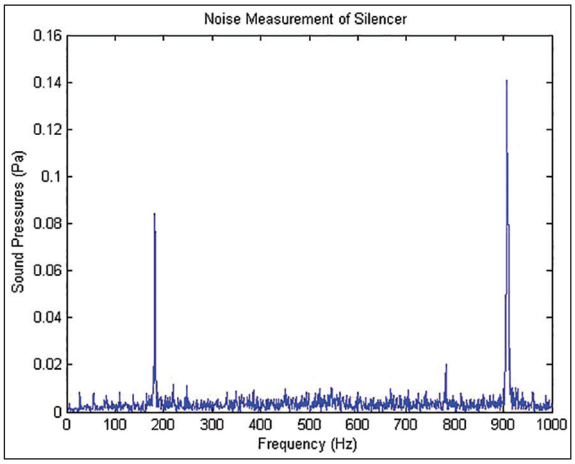

Figure 5: Graph of fan pressure sound at 1800 rpm in 2 point after silencer

Table 2: Means of reduction sound pressure level by used four silencers

Silencer	Frequency (Hz)		125	250	500
	Density (kg/m^3)	Thickness (cm)			
1	80	5	2	1	0.5
2		10	1	1.2	0
3	100	5	2	2	0
4		10	1.5	1.5	0

density in frequency 125, 250, 500 Hz were, respectively, 2.2, 4.02 and 4.68 dBs.

In this study, with increasing thickness of the absorbent material of silencer there was little change in the decrease of noise but with increasing density from 80 to 100 Kg/m^3 better results were seen to reduce sound pressure levels and this caused to increase noise reduction.

DISCUSSION

Our study showed that the maximum 2 dB reduction is in pressure sound at low frequencies of designed absorptive silencer that was design in the channel surface. Selamet *et al*. investigated noise reduction in silencers filled with string fiber theoretically and experimentally, and showed that adsorbents materials increases transmission loss rate and increased thickness of absorbent materials reduces the number of peak and caused to change frequency of the transmission loss peak.[15]

In a study that was done by Na *et al*., they examine the possibility of using micro-fiber fabrics as sound absorbent materials. They showed that fabric density have more effect than fabric thickness or weight on sound absorption.[16]

Furthermore in silencers with higher density, ability of silencer to absorb noise is better that is aligned with the results of the studies of Wang *et al*. Analysis of the results of Wang *et al*. showed that the absorption materials reduce the transmission loss at resonance frequencies but in general caused to increased capacity in the valleys of the curve especially. Moreover, the absorbent materials with higher density have ability to absorb noise and sound transmission loss also concluded that in the distributive silencer the density of the filled material reduces the resonant frequency and increased transmission loss.[17]

In a study conducted by Modarres Razavi *et al*., some of the effective factors on silencer performance are examined using numerical analysis. The results of this study showed

that using sound-absorbing material caused to increased depreciation power and eliminates the resonance frequency and by changing the intensity of the compression level sound-absorbing material, the amount of depreciation power increases to a certain extent proportional to compression of absorbent material.[18]

In the study confirm by Koizumi *et al*. showed that increase the density associated with increases noise absorption coefficient in the mid- and high-frequency.[19]

Seddeq study on fiber material this study showed that the lower density of the adsorbent material showed better results at frequencies below 500 Hz and in the higher density showed better performance at frequencies above 2000 Hz.[13]

For noise control, sound absorbing materials based on material type, dimension and frequency of the noise-controlled selected.[20] Our Result showed that the maximum sound pressure level of fan was in 125, and 250 Hz. In ventilation systems can be used absorptive silencer with the mineral wool absorbent for noise reduction in frequency lower than 250 Hz as an effective instrument and reduced incidence hearing loss.

This study can be done on a variety of active and passive silencer.

In this study, fan has been used that predominantly have low-frequency noise. This study with different in the dominant frequency with consider to its efficiency on those frequency and type of application silencer can be used in various equipment such as exhaust, compressor and that each of the listed equipment is different in the dominant frequency and so it is efficiency on those frequency and type of application silencer is different.

ACKNOWLEDGMENT

This work was supported by Isfahan University of Medical Sciences, Isfahan, Iran.

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Source of Support: Isfahan University of Medical Sciences, **Conflicts of Interest:** None declared.