TRANSMISSION LOSS OF HELMHOLTZ WITH AN MICROPERFORATED PANEL INSERTION

Gai Xiaoling, Li Xianhui, Xing Tuo, Zhang Bin, Hu Wencheng, Cai Zenong, Wang Fang and Qin Qin

Beijing Municipal Institute of Labor Protection, Beijing 100054, China
Beijing Key Laboratory of Environment Noise and Vibration, Beijing 100054, China
email: gxldynmg@163.com

In air duct noise control, Helmholtz resonators are considered as narrow band attenuators. In this paper, a microperforated panel (MPP) is introduced to improve the sound insulation performance of Helmholtz resonator. The Helmholtz with an MPP insertion is modeled using the finite element method. Numerical simulation shows that the transmission loss valleys are leveled up. By making hole on the inserted MPP, ventilation cooling function is realized. The result shows that the peak value of transmission loss is reduced slightly, but the overall sound insulation effect is still satisfying after making appropriate hole. A kind of broadband sound insulation structure can be implemented.

Keywords: sound insulation, microperforated panel, resonance, transmission loss

1. Introduction

Helmholtz resonators, which consist of a cavity communicating with the main duct through a neck, have been widely used to effectively attenuate the narrow-band low-frequency noise. The classic lumped approach approximates this resonator as an equivalent spring (cavity) and mass (neck) system, and yields the expressions for the resonator frequency and the transmission loss [1-5]. Easy to tune, durable and affordable, silencing devices based on the Helmholtz resonator principle are very popular in air duct noise control applications [6]. Silencers have been designed following this idea for, exhaust stacks [7], ICE turbo compressor [8], compressor exhaust [9， 10], HVAC ducts [11] and aerospace applications [12， 13]. They are found in building ventilation systems [14].

In air duct noise control, Helmholtz resonators (HR) are considered as narrow band attenuators. To improve the sound attenuation performance, Helmholtz resonators with a variety of modifications have been examined. Selamet and Lee [15] studied the effect of length, shape, and

Perforation of the neck extension on the resonance frequency and transmission loss of concentric circular Helmholtz resonators with extended neck. Selamet et al. [16] developed a closed-form, 2D analytical solution to investigate the effect of density and thickness of the fibrous material in the cavity on the resonance frequency and transmission loss of circular Helmholtz resonators lined with absorbent. Tang [17] experimentally and theoretically investigated the Helmholtz resonators with tapered necks with the cross-sectional area increasing towards cavity. Griffin et al. [18] developed an analytical model for a single, coupled resonator system mounted on a one-dimensional duct. The proposed mechanically-coupled resonators produced a particular transmission loss response, provided a wider bandwidth of attenuation, and adapted the transmission loss characteristics of a structure to attenuate disturbances of varying frequency. Wan and Soedel [19] derived an expression for the resonance frequencies of 2-DOF Helmholtz resonator using a lumped analysis. They obtained the resonance frequencies and compared them to the computational results and measurements. De

Bedout et al. [20] proposed a tunable Helmholtz resonator with a feedback system to achieve an optimal tuning of time-varying tonal noise.

In this paper, the acoustic properties of the Helmholtz with a microperforated panel (MPP) insertion structure are investigated. Wide sound attenuators can be realized by Helmholtz resonators. Structure of this paper will be arranged as follows: In Section 2, sample constructions will be introduced. In Section 3, the transmission loss for Helmholtz with an MPP insertion structure will be studied. Finally, the conclusions will be given in Section 4.

2. Sample construction

The Helmholtz with an MPP insertion structure is constructed by using a Helmholtz resonators and MPP. The schematic of the Helmholtz with an MPP insertion structure is showed in Fig. 1. The diameter and length of Helmholtz resonators' cavity are 100mm and 120mm. MPP is located in the middle of the cavity. The diameter and length of Helmholtz resonators' neck are 10mm and 30mm. Thickness, aperture and porosity for the MPP are 1 mm, 0.4mm and 1% respectively.

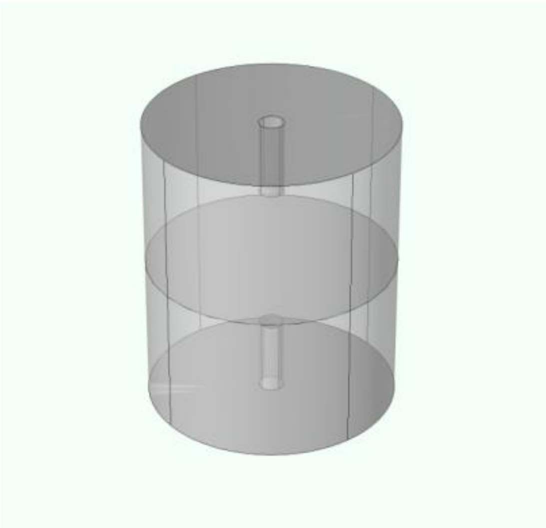

Figure.1: Helmholtz with an MPP insertion structure

3. Transmission loss analysis

Finite element analysis is used to calculate the transmission loss of the Helmholtz with an MPP insertion structure using COMSOL software. The 3D model is used for geometric modelling. In the simulations, Pressure acoustics modules are used to create a calculation program. The initial pressure magnitude normal incident on the structure is set at 1 Pa. The Helmholtz with an MPP insertion structure is modelled with free-triangular mesh elements. The number of degrees of freedom was 26118. Fig. 2 shows that the transmission losses of single Helmholtz resonators. Calculation results shows that there are two transmission loss valleys at 1435Hz and 2860Hz below 4000Hz. Based on the single Helmholtz resonators, MPP is introduced to Helmholtz resonator cavity. Fig. 3 shows that the transmission losses of Helmholtz resonators with an MPP insertion structure. The result shows that the transmission loss valley disappeared at 1435Hz. After adding MPP insertion structure, the transmission losses of Helmholtz resonators is more than 15dB in the frequency range of 50-4000Hz except the narrow gap at around 2860Hz. The maximum transmission loss reached 70dB.

Consider the need for ventilation and heat dissipation, the hole is made in MPP. The schematic of the Helmholtz and an MPP with hole insertion structure is showed in Fig. 4. The diameter of hole is 30mm. Fig. 5 shows the transmission loss of the transmission loss of Helmholtz and an MPP with hole insertion structure. The result shows that the peak value of transmission loss is reduced slightly. But the overall sound insulation effect is still good after making hole on MPP.

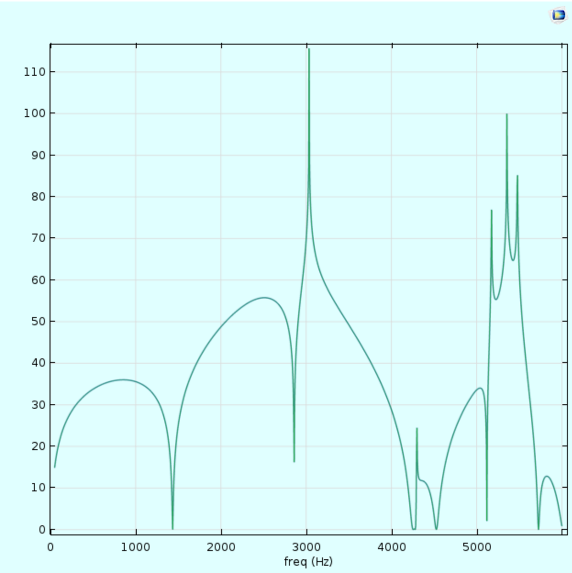

Figure.2: Transmission losses of Helmholtz resonators

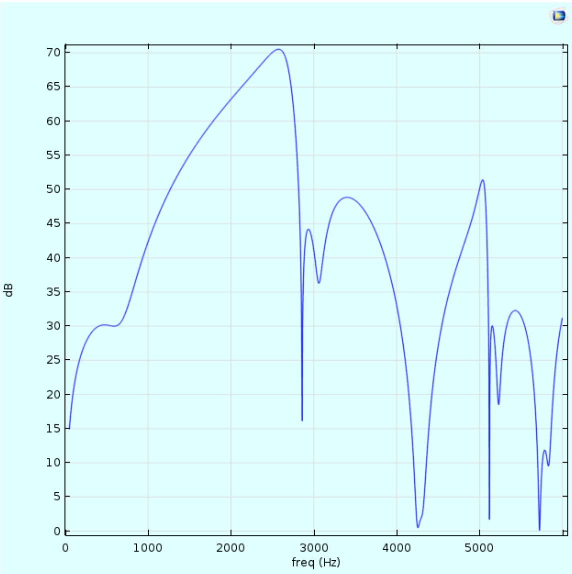

Figure.3: Transmission losses of Helmholtz resonators with an MPP insertion structure

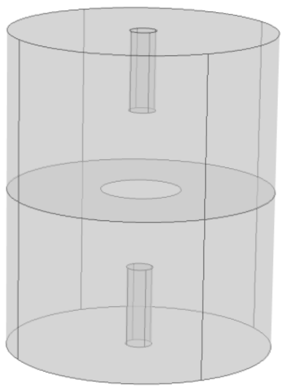

Figure.4: The Helmholtz and an MPP with hole insertion structure

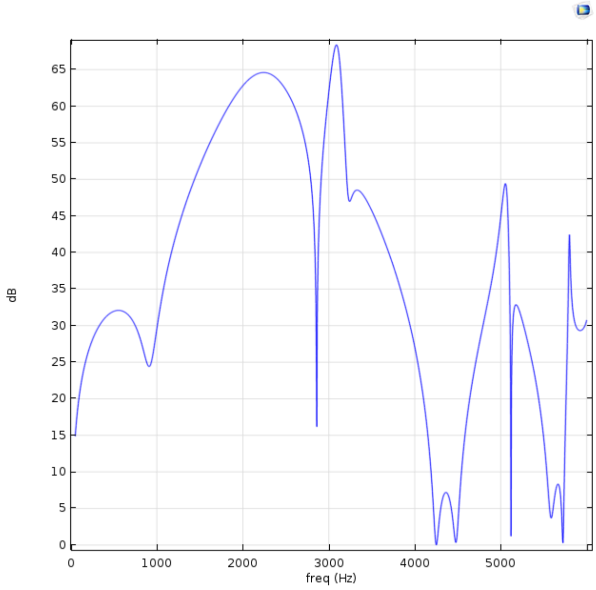

Figure.5: Transmission losses of Helmholtz resonators with an MPP insertion structure

4. Conclusions

The present work focuses on the Helmholtz with an MPP insertion structure. Its transmission loss is obtained by the finite element analysis. The results show that transmission loss valley disappeared at the specified frequency after adding MPP insertion. Considering the need for ventilation and heat dissipation, the hole is made on MPP. The result shows that the peak value of transmission loss is reduced slightly, but the overall sound insulation effect is still satisfying.

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