ACOUSTIC PERFORMANCE OF SPIRAL-TYPED RESONATOR

Xiaonan Wang, Lechun Ying, and Yude Zhou

Shanghai Acedamy of Environmental Sciences, Shanghai, China

Shanghai Engineering Research Center of Urban Environmental Noise Control, Shanghai, China

email: wangxn@saes.sh.cn

Xu Wang

Institute of Acoustics, Tongji University, Shanghai, China

We designed a spiral-typed resonator in this paper, which is inspired by the gastropod shells and features gradually changing channel width. It can be regarded as having a cavity connecting with a neck with gradual changing cross section area. Numerical simulation was conducted to study its mechanism and parametric study is also carried out. Due to the space curling, the equivalent neck length is increased, and therefore, compared to the traditional resonators, such a proposed spiral-typed resonator provides a lower resonant frequency and broader attenuation band. In addition, since its curling-space nature, such a spiral-typed resonator possesses rather higher efficiency in space utilization than the traditional bulky resonators. Such a spiral resonator may have the potential to be widely used on noise control engineering.

Keywords: spiral-typed resonator, curling space, noise control

1. Introduction

Abatement of low frequency noise has always been a challenging topic. Most traditional method such as porous lining suffer from serious drawback. Meanwhile, the Helmholtz resonator (HR) is widely used as an effective way to reduce noise around the resonance frequency, but bulky volume is needed for the HR for a low frequency noise control. To this point, a lot of work has been conducted to improve the sound attenuation performance of a HR. Lining a HR with porous material can tune its resonance frequency to lower frequency [1]. Selamet and Lee[2] extended the HR neck into the cavity and found that the resonance frequency could be shifted to lower frequency. A spiral neck was designed for a HR, aiming at increasing the effective length of the neck[3,4], and it is validated that the structure could achieve high sound reduction within a small space at low frequencies.

This study proposes a spiral-typed resonator, which is inspired by the gastropod shells and features gradually changing channel width. It can be regarded as having a cavity connecting with a neck with gradual changing cross section area. Numerical study is conducted to study its mechanism and performance, and comparison is also made to validate its higher efficiency in space utilization.
2. **Numerical study on spiral-typed resonator**

A spiral-typed resonator flushed mounted along a duct is illustrated in Fig.1. As shown, the resonator can be regarded as a cavity in connect with a spiralling tube. The spiral geometry can be expressed in a parametric form as \( r(\theta) = a \cdot c^{\cos(\theta)} (\theta_1 < \theta < \theta_2) \). Here \( a, b \) and \( c \) are constants and the angular span ranges from \( \theta_1 \) to \( \theta_2 \). The height of the duct is denoted as \( S_d \) and the width and height of the resonator are denoted as \( R_w \) and \( R_h \), respectively.

![Figure 1 Configuration of a spiral-typed resonator flush mounted along a duct](image)

Finite element method (FEM) is used to conduct the numerical study by using Comsol Multiphysics, and the parameters are set as below: \( a=0.03, b=0.1, c=3; S_d=0.2, \theta_1=0 \) and \( \theta_2=4.2\pi \). Thus the height and width of the spiral can be calculated based on the tangentiality for the curves, and \( R_w=0.2 \) and \( R_h=0.17 \), respectively.

![Figure 2 Transmission loss of the spiral-typed resonator](image)

It is shown that the first TL peak occurs around frequency of 253 Hz. In principle, a spiral-typed resonator can be regarded as a spherical cavity attached with a neck of gradually varying area of cross section, which indicates that the coiling up space created by the spiral can be stretched into a straight tube, shown in Fig.3.
Therefore, comparing the spiral-typed resonator with the configuration shown in Fig. 3, if the same first resonance frequency occur for the two configuration, the height of the structure $R_h$ can be shortened for about 50\% by comparing with $l$. It is indicated that the spiral-typed resonator has higher efficiency in space utilization.

3. Conclusion

In this paper, a spiral-typed resonator is numerically studied. This structure is inspired by the gastropod shells, aiming at higher efficiency space utilization and lower frequency noise control. It is shown that the structure can be principally treated as a cavity in connect with a spiralling tube. Numerical study is carried on to show that the first resonant peak occurs at relative low frequency range and by comparison with a HR of approximately same cavity volume with a neck of gradually varying area, the height of the resonator is greatly reduced. Such a spiral resonator may have the potential to be widely used on noise control engineering.

REFERENCES