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Tunable Sonic Crystals Assisted Sound Absorber with a Single and Multi Local Defect

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Abstract

In this paper, we emphasize on the experimental study of absorption properties of tunable sonic crystal assisted sound absorber regarding replacement of sonic crystal unit with an artificial single and multi local defect element. Nine pieces of Helmholtz resonators was constructed in a three row to form square 3x3 resonators unit sound absorber model. The influence of a single and multiple Helmholtz resonator manipulation on its sound absorption coefficient was investigated. The experimental results show that the artificial defect manipulation gives the promising possibility for researchers to develop tunable sonic crystals assisted sound absorber. The sound absorber shows a higher sound absorption performance on several different frequency bands associated with the local defect placement position in the sonic crystal structure.

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Keywords: sonic crystals; local defect; sound absorber; tunable.

1. Introduction

The quest and demand for high performance and broadband frequency range sound absorber has been increased in this decade. Various approaches and models have been implemented i.e. perforated panels [1,2], resonators and cavities [3-5], membranes [6-8] and the using of natural and synthetic fibrous or porous materials [9]. Most of the proposed approaches have the good performance only in the certain short frequency range. It is very rare yet to find achievements featuring broadband or even full spectrum performance.

Recently researchers attention has strongly attracted to the development of acoustic metamaterials. This new material has unique features such as local resonant and negative refraction. It gives the new way for creating noise control technology. Phononic and sonic crystals assisted sound absorber and barrier then showing a rapid development progress [10-12]. The idea has been adopted widely and tunable sound absorber was developed in various ways [13-15]. The main goal is the better functional sound absorber featuring high performance in a broadband frequency range. To do this purpose, researchers proposed many different approaches.

One of the mentioned approaches is by manipulating the defect in the sonic crystals structure. Most of the previous works focused on the crystals lattice by placing and or replace the local scatterer in a certain position to create point defect [16-20]. The local scatterer could be a split ring, spherical, or cylindrical Helmholtz resonator. Hence the influence of Helmholtz local resonant defect on the acoustic propagation being analyzed as the function of scatterer geometrical size. In this paper, the sound absorption was investigated subject to the shape and position of the defect on local scatterer in the sonic crystal structure. All the local scatterer is a single degree of freedom cylindrical Helmholtz resonators with the same geometrical size. Investigation of local Helmholtz resonant defect on sonic crystal assisted sound absorber consisting same geometrical size scatterer giving significant advantages to researchers. The tuning process would be easier since it depends only on the number, orientation and

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the position of the local defect. It more simple compared to the same purposes by using multi geometrical size local scatterer where the local defects may have different resonant frequencies.

2. The object of the study

The sonic crystal model was made from cylindrical PVC with 12 mm and 60 mm in diameter and height respectively. Nine pieces of scatterer attached to a pair of laser machining 2 mm thickness acrylic frames at the both ends. A cubical sonic crystal model with 3 × 3 elements constructed where the slit between the scatterer is 1 mm. The result depicted in Figure (1d) and (1e). For comparison analysis purposes there are two different model with the same geometrical size was investigated. The first model is called as reference model type which is consists of nine pieces of cylindrical Helmholtz resonator with a 2 mm diameter hole on the mid of the tube. The second or tested model constructed by scatterer with the artificial defect. To create this artificial defect a pair of 1 cm long horizontal cuts were made on the body of the cylindrical PVC. The area between the two small cuts was gently pressed to make a concave shaped defect. The first type as illustrated in Figure (1b) has the defect on the bottom, while the second type on the mid of the tube as shown in Figure (1c). So the defect position on the second type is similar to the hole in the reference model.

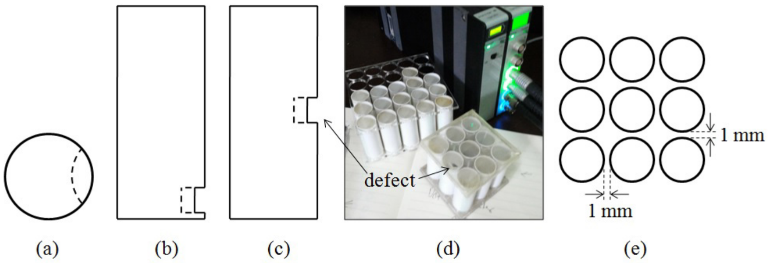

Fig 1. The tested sonic crystal element model, (a). top view, (b) and (c). side view, (d) and (e). the nine elements cubical structure

3. Methods

The main objective of the works is to develop a new model of sonic crystals assisted sound absorber with an easier tuning approach. Defect manipulation on the single size scatterer element was considered to evaluate its influence on the sound absorption performance. Since the artificial defect differs from it's of the reference model, spectra measurement become important to understand how the sound pressure inside scatterer cavity changes according to the shape of the local defect and how it influencing the sound absorption. To do this purposes, there are two steps of laboratory investigation was conducted as follows.

Intracavity spectra were measured by using a pair of quarter-inch B&K 4187 microphones and 2670 pre-amplifier. A random noise was generated from the generator of B&K Pulse type 3160 LAN-Xi model and being amplified before it is radiated by a loudspeaker positioned at the one end of B&K impedance tube 4206. A dedicated holder was made for placing the sonic crystal model at opposite end of the impedance tube. The first microphone is used for capturing the sound pressure signal of the reference scatterer while the second microphone for the test scatterer signal. The FFT analysis has been using for calculating the spectra of the both captured signals.

The second laboratory investigation procedure is the sound absorption measurement. It was conducted by using transfer function based two microphone impedance tube refer to the standard method after ASTM E-1050 / ISO 1534-2 [21]. Since the works are focused on the sound absorption at the low frequency range so the large tube of B&K 4206 is chosen. The sound absorption coefficient was measured for various variation of the test and reference model, including the number of the defects, its position and the orientation to acoustic incident waves as well.

A laboratory scale prototype of the proposed tunable sonic crystal assisted sound absorber was built and its performance also investigated at the end of the study. It is a cavity backed sound absorber where the sonic crystal with proposed local defect inserted as the inclusion inside the cavity of the prototype. A commercial 12 mm thickness felt produced by the local manufacturer was cut and fitted as the top layer of the sound absorber.