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Experimental study on sound absorption performance of microperforated panel with membrane cell

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ABSTRACT

Microperforated panel (MPP) absorbers have been widely used in noise reduction and are regarded as a promising alternative to the traditional porous materials. However, the absorption bandwidth of a single-layer MPP is insufficient to compete with the porous materials. In order to improve the sound absorption ability of the single-layer MPP, a composite MPP sound absorber with membrane cells (MPPM) is introduced. Sound absorption properties of the MPPM are studied by the impedance tube experiment. Results show that the membranes have a significant influence on the sound impedance. The sound absorption performance of MPPM gradually increases with the increase of the membrane area. The single-layer MPP with some small area membrane cells may have the same effect and single large area membranes. By adjusting the size of the membrane cells, one can implement a sound absorber with a wider absorption bandwidth and higher absorption peaks than the single-layer MPP.

1. Introduction

In recent years, noise control has received much attention for improving living environments. A microperforated panel (MPP) absorber has become widely known as the most attractive alternative for the next generation sound absorbing material [1]. The MPP is first proposed by Maa, who has established its theoretical basis and design principle [2–4]. The MPP absorber is a thin panel or membrane less than 1 mm thick with perforation of less than 1% perforation ratio with air-back cavity and a rigid backing [5]. The fundamental absorbing mechanism of the MPP absorber, which is typically backed by an air cavity and a rigid wall, is Helmholtz-resonance absorption [6]. This type of absorption is mainly due to frictional loss in the air flow of the apertures [6]. With the rapid development of processing technologies and computational methods, micro-perforated panel sound absorption theory has also been further development [7–9]. But usually the single-leaf MPP sound absorbing structure is generally only one resonance absorption peak and the sound absorption bandwidth is usually limited to about two octaves [2–4]. In order to heighten the absorption property of MPP, Maa has proposed a double-leaf MPP backed by a rigid-back wall with an air-cavity [10]. Recently, Asdrubali and Pispola have studied this type of absorber for its application to noise barriers [11]. This absorber is intended to produce two resonators so that a broader absorption frequency range can be obtained. The acoustical properties of a structure composed of two parallel MPP with an air-cavity between them and no rigid backing is studied numerically by Sakagami [12]. Meanwhile, Sakagami et al. also studied the sound absorption characteristics of a single microperforated panel absorber backed by a porous absorbent layer and a double-leaf structure with MPP and permeable membrane [13,14]. More recently, A theoretical study is made to examine the effect of a permeable membrane in side the air-cavity by Sakagami et al. [15]. Qian et al. have investigated the acoustical properties of MPP with ultra-micro perforations based on MEMS technology [16]. Results show that better absorption capability can be given with MPP by using an ultra-micro perforation [16]. Liu and Herrin have study the sound attenuation performance of MPP with adjoining air cavity [17]. The resulting sound pressure fields indicated that partitioning the adjoining air cavity increase the overall sound attenuation due to the MPP by approximately 4d B [17]. Wang and Huang have investigated the acoustic properties of parallel arrangement of multiple MPP absorbers with different cavity depths [18]. Compared with single MPP absorber, the absorber array requires lower acoustic resistance for good absorption, and the resonance frequencies shift due to inter-resonator interactions [18]. Tao et al. have studied the sound absorption of a finite micro-perforated panel backed by a shunted loudspeaker [19]. The results show that the composite absorber is more effective than the traditional MPP absorbers especially at the low frequency when there is a length constraint thanks to the resonance

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Fig. 1. The structure of MPP.

absorption provided by the shunted loudspeaker [19]. Although lots of researches have been done on heighten the absorption property of MPP, it appears that no relevant reports have been given for the MPP with membrane cell. The main purpose of this paper will focus on the acoustic performance studies of MPP absorbers with membrane cell. Structure of this paper will be arranged as follows: In Section 2, sample of the MPP with membrane cell (MPPM) will be shown. In Section 3, the sound absorption performance of MPPM will be studied. Finally, the conclusions will be given in Section 4.

2. Sample construction

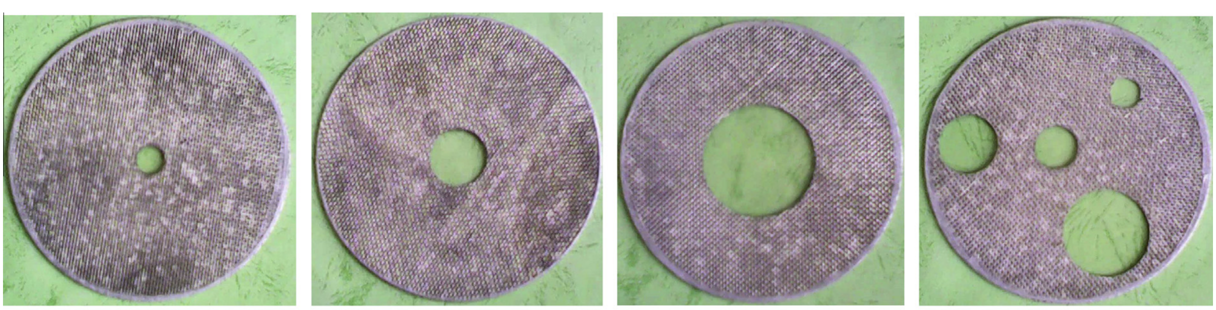
MPP absorbers with membrane cell are constructed by a MPP and a structure of membrane cell. MPP used is aluminum panel 100 mm in diameter of SoundMicro made by CKM Building material CORP. Thickness and perforation ratio for the MPP are 1 mm and 1.33%, respectively. MPP has 400,000 holes per square meter. Fig. 1 shows the structure of MPP. Fig. 2 shows the structure of MPPM. The membrane is biaxially oriented polypropylene whose surface density is 46 g/m^2, thickness is 0.05 mm and tension is 130 MPa. The structure of membrane cell is attached to MPP by acrylic glue. Diameters of membrane of previous three pictures are 10 mm, 20 mm and 40 mm, respectively. The forth pictures have four holes whose diameters are 10 mm, 15 mm, 20 mm and 30 mm, respectively.

3. Impedance tube experiments

Two-microphone impedance tube (type 4206) of Bruel Kjaer is applied to measure the normal incident absorption coefficient according to the standard procedure detailed in ISO (10534-2). The frequency range of measures is from 100 to 1600 Hz. Fig. 3 is the test system of impedance tube.

3.1. Effect of membrane cell on single-leaf MPP

Fig. 4 shows the normal incidence sound absorption coefficient of the single-leaf MPP and MPP with holes. The deeps of backing cavity are 50 mm in impedance tube experiments. P1, P2 and P3



(a) (b) (c) (d)

Fig. 2. The structure of MPPM.

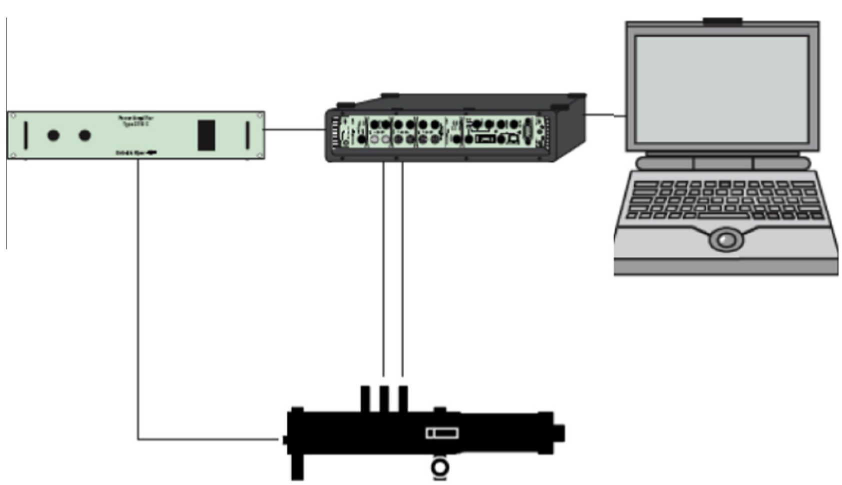


Fig. 3. The test system of impedance.