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THE STUDY OF SOUND ABSORPTION CHARACTERISTIC OF MICRO-PERFORATED PANEL WITH DIFFERENT DIAMETER HOLES

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ABSTRACT
Generally, we are having used micro-perforated panels composed by single diameter holes to reduce noise. In this case, the panel's sound absorbing performance can be predicted precisely. However, in another case, we may use different diameter holes to compose a piece of micro-perforated panel for getting higher sound absorbing performance. Its sound absorption characteristic is different from single aperture panel. It shows from measured results that sound absorption in some frequency is different between the two cases. This paper presents sound absorption performance of the composite construction of micro-perforated panel with different diameter holes, and discuses the sound absorption difference between the two cases. With the composite method, wider sound absorption band can be obtained easily.

1 - INTRODUCTION

A micro-perforated panel is a sheet panel with many small diameter holes on it. Usually the holes, less than one millimeter in diameter, are the same diameter holes distributed over the panel. Micro-perforated panel acoustic resistance increases tremendously when the holes over its surface are reduced to a small size, such as 0.3mm or even much smaller [1], [2]. Research work on micro-perforated panel absorption mechanisms has been carried out for many years and many papers have been published. However, these papers and research focus on the panel with the same diameter holes. This paper discussed the sound absorption of the panel with different diameter holes.

2 - FUNDAMENTAL THEORY

Equivalent circuit of micro-perforated panel absorber composed by single diameter hole can be regarded as following Fig. 1.
Its acoustic impedance is [2]:

$$z = r + j\omega m \tag{1}$$

where

$$r = \frac{0.147}{d^2}\frac{t}{p}k_r,\ k_r = \sqrt{1+\frac{x^2}{32}} + \frac{0.1768xd}{t} \tag{2}$$

$$\omega m = \frac{1.847ft}{p}k_m,\ k_m = 1 + \left(3^2 + \frac{x^2}{2}\right)^{-\frac{1}{2}} + \frac{0.85d}{t} \tag{3}$$

$$x = 10d\sqrt{f} \tag{4}$$

The following figures are sound absorption structure and equivalent circuit of micro-perforated panel with many different diameter holes on it.
The relative acoustic impedance of the panel system:

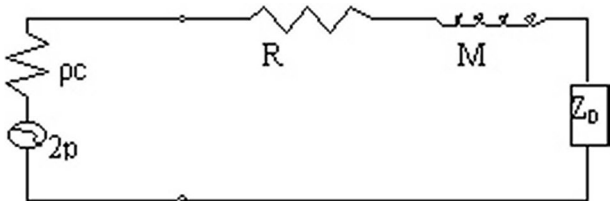

Figure 1: Equivalent circuit of micro-perforated panel absorber.

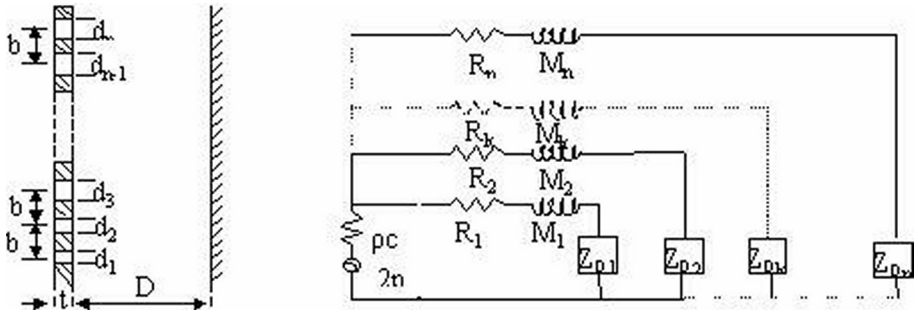

Figure 2: Sound absorption structure and equivalent circuit of micro-perforated panel with many different diameter holes on it.

$$z = \left(\frac{1}{r_1 + j\omega m_1 - jctg\omega d/c} + \frac{1}{r_2 + j\omega m_2 - jctg\omega d/c} + + \frac{1}{r_n + j\omega m_n - jctg\omega d/c} \right)^{-1} \tag{5}$$

The sound resistance and impedance of the panel system can be calculated separately through Eq. (5). Furthermore, the sound absorption coefficient and absorption band of the system can be obtained. However, this calculation will be very complex. For this reason, we simplify this structure to a simple one, i.e. two kind of diameter holes system. Thus, n=2, the sound resistance and impedance are below:

$$r = \frac{\left[r_1 r_2 \left(r_1 + r_2 \right) + r_1 \left(\omega m_2 - ctg\omega d/c \right)^2 + r_2 \left(\omega m_1 - ctg\omega d/c \right)^2 \right]}{\left(r_1 + r_2 \right)^2 + \left(\omega m_1 + \omega m_2 - 2ctg\omega d/c \right)^2} \tag{6}$$

$$x = \frac{\left(\omega m_1 - ctg\ \left(\omega d/c \right) \left(\omega m_2 - ct\omega d/c \right) + \left(\omega m_1 - ctg\omega d/c \right) r_2 + \left(\omega m_2 - ctg\omega d/c \right) r_1 \right.}{\left(r_1 + r_2 \right)^2 + \left(\omega m_1 + \omega m_2 - 2ctg\omega d/c \right)^2} \tag{7}$$

The sound absorption coefficient for normal incidence is:

$$\alpha_N = \frac{4r}{\left(1 + r \right)^2 + x^2} \tag{8}$$

When n=2, we can select double resonant frequencies in order to widen the attenuation peak. If the two resonant frequency's difference is large enough, the absorption bandwidth is usually three octave bands. Although the double resonant system will interfere each other when the two resonant frequency locations are near, the band is wider than a single helmholtz resonant system. Therefore, it is possible that the panel with many different diameter holes has wider absorption band than one with a single diameter holes although the absorption peak may drops slightly.

3 - COMPARISON OF PREDICTED SOUND ABSORPTION CHARACTERISTIC TO MEASURED RESULTS

There is an economic method to process thin micro-perforated metal panel with different diameter holes on a large scale. The panel thickness is 0.3mm. The holes diameter changes from 0.12mm to 0.35mm. The measurement samples were tested in the standing wave tube, which is of ∅100mm in transverse section. Shown in Figs. 3, 4, 5 and 6 are measured octave band sound absorption coefficient for the same tube. Figs. 3, 4, 5 and 6 are comparisons between measured and predicted absorbing coefficient.

In Fig. 3 below, the absorption bandwidth of the panel with different diameter holes is obvious wider than the panel with single diameter holes whatever the hole diameter is the largest 0.35mm or the smallest 0.12mm. In high frequency arrange, the measured result is nearly the same as predicted results of the

panel with the holes of 0.3mm in diameter. However, in low frequency measured result is much higher than predicted of the holes of 0.3 mm in diameter. Figs. 5 and 6 is nearly the same as Fig. 3.
When the cavity back is 150mm in depth, Fig. 4 shows that the measured results both in high frequency and lower frequency are better than predicted guideline of the holes 0.3mm in diameter although the peak of measured results drops slightly.

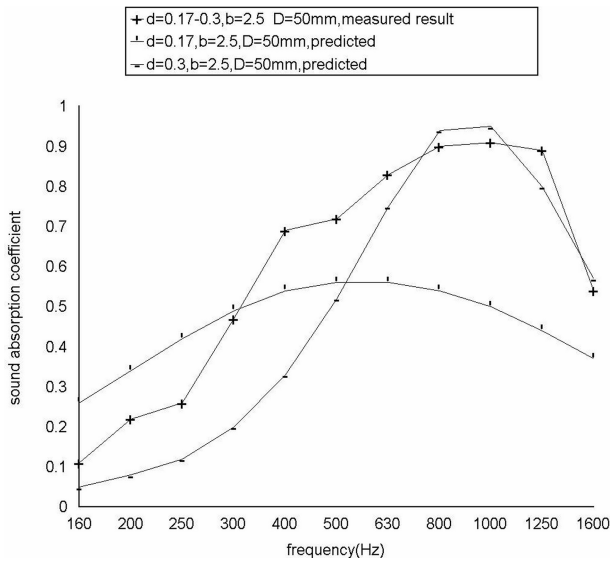

Figure 3: Comparison between predicted and measured sound absorption coefficient.

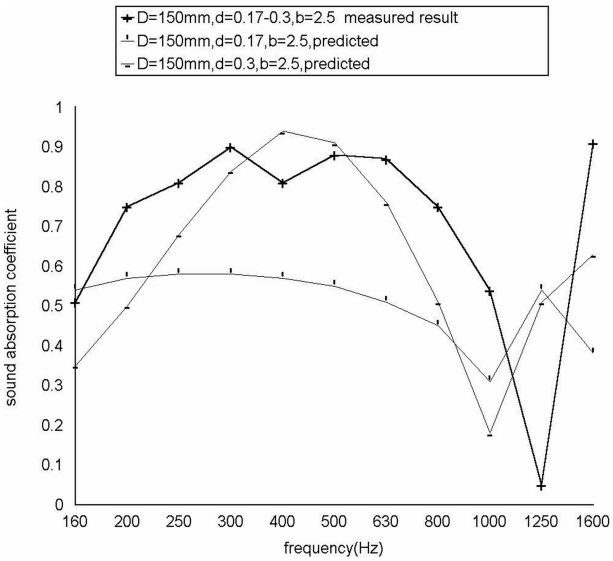

Figure 4: Comparison between predicted and measured sound absorption coefficient.

4 - CONCLUSION

In this paper, equations have been presented for prediction of sound absorption of micro-perforated panel with many different diameter holes. The sound absorption characteristic of the panel with different diameter holes has been discussed. If a selected hole diameter is used for forming micro-perforated panel, we can widen its absorption bandwidth through changing randomly hole diameter in a certain arrange. Generally the diameter of most of the holes should be smaller than the selected diameter.

REFERENCES

1. **D.Y.Maa**, Theory and Design of Micro-perforated Panel Sound Absorbing Constructions, *Scientia Sinica*, Vol. XVIII, pp. 38-50, 1999

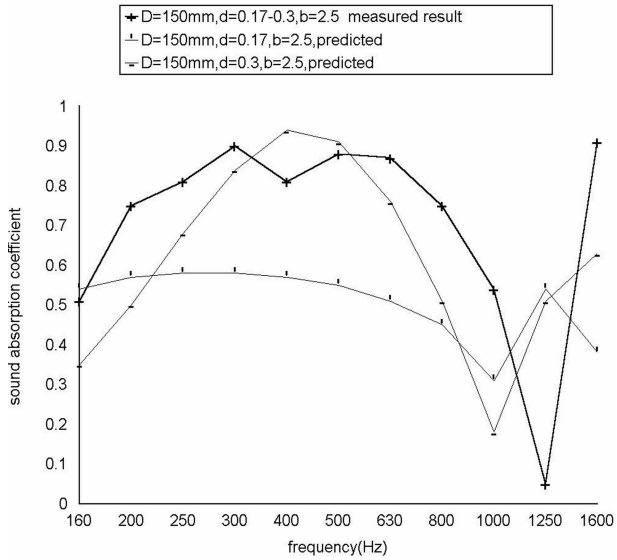

Figure 5: Comparison between predicted and measured sound absorption coefficient.

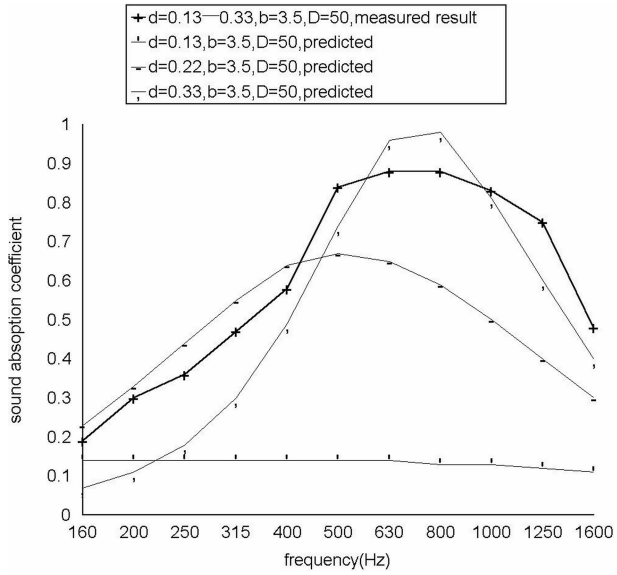

Figure 6: Comparison between predicted and measured sound absorption coefficient.

2. **D.Y.Maa**, General Theory And Design Of Micro-perforated Panel Absorber, *Acta Acoustica*, Vol. 22(5), pp. 365-393, 1997