확산체의 표면적 변화에 따른 흡음 및 확산계수 측정

Measurements of scattering and absorption coefficients of diffusers with variation of surface area

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Key Words : 확산체(Diffuser), 흡음계수(absorption coefficient), 확산계수(scattering coefficient)

ABSTRACT

The absorption power of a surface depends on the surface irregularity which has been known as an important factor in determining scattering coefficient. This study investigates the effect of increase in surface area on the absorption and scattering coefficients of a diffuse surface. The surface irregularity or surface pattern can be compared to the wavelengths and the random-incidence scattering coefficient of surface is measured by ISO 17497-1. The scattering coefficients of increasing the surface area in linear pattern of v-cut groove on rubber plate were measured in 1:10 scale model reverberation chamber. It is found that the scattering and absorption coefficients increase with increasing surface area. At 60% of increased surface area the spacing between the hemisphere diffuser and the v-cut groove acts similar with results of absorption coefficient. The results show that absorption coefficient depends on surface area and the spacing where as scattering coefficient depends on surface area and texture.

1. 서론

The surface irregularity on walls of concert halls is needed to improve the acoustics of spaces [1]. The echo produced at the rear wall can be prevented by using the irregular surface [2]. The specular reflection of the irregular wall surfaces are neither small nor large compared to the wavelength [3]. Providing the irregular surface on the sidewalls, ceiling and rear walls in classical halls enables the audience to hear the sound. Since increasing the area of irregular surface has major effect on diffusion, the relation of increase in surface area and pattern should be a necessary condition.

However, the installation of diffusers in concert halls has not been designed on scientific basis. The coverage densities of diffusers in halls have effect on ACF at later part of the sound [4]. Jeon et al. [5] measured the effect of coverage area using hemisphere diffuser 17.5 mm height and found that the scattering coefficient increases with the increasing coverage density.

In this study, the scattering coefficients on variation of surface area on rubber plate were measured using the ISO method. The purpose of this study is to find the relationship between the surface area and scattering coefficient with absorption power which enables the diffuser design by providing the measured data on the appropriate size and surface area.

2. Measurement procedure

The scattering coefficient measurement is based on ISO 354 - Acoustics-Measurement of Sound absorption in reverberation room. The ISO 17497-1 is an extended measurement condition related to the circular sample using turn table. The test samples to be measured are placed on a turntable and impulse responses are obtained for different sample orientation in reverberation room. The measurements were conducted on 1:10 scale.

The absorption coefficient is conducted using electrical spark source and measurements were carried out according to ISO 354. For scattering coefficient measurement, the turn table made with circular rigid base plate is used for measurement. The structural depth of

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the test specimen is taken as 24 mm which is allowed at maximum of d/16. Two joined tweeter speakers are located in two positions towards the corner of the reverberation chamber with output of MLS signals. Then signals were received from the three positions by 1/8 inch microphone. The signals are recorded with the turn table at stable and rotation manner in with and without specimen condition.

The 420 mm diameter circular and 300 x 400 mm rectangular rubber plate specimen are used for measurement. The v-cut groove is made with depth and width of 21 mm were evaluated. Fig. 1 and table 1 shows specimen details in which the percentage of surface area is increased by increasing number of v-cut groove lines in 1-way and 2-way pattern.

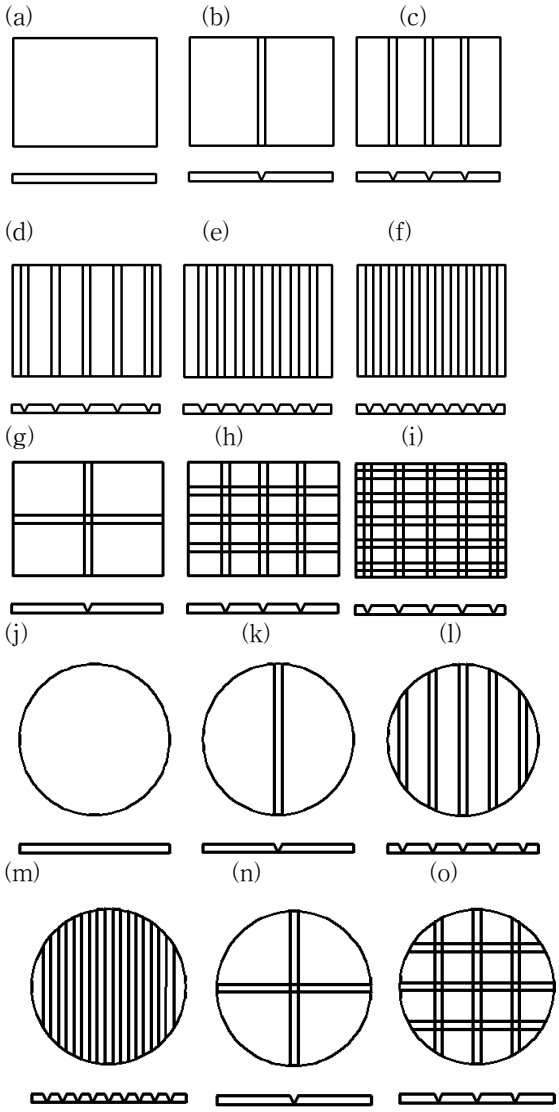

Fig. 1. Features of surface areas increased by number of groove lines on the rubber plate. (a) - (i) shows the rectangular, (j) - (p) shows the circular rubber plate with one way and two way patterns of v-cut groove

Table 1. Increased surface area of specimens

Specimen no.	Type	Number of grooves	Increased surface area (%)
a	Plain	0	0
b	1-way	1	6
c	1-way	3	19
d	1-way	5	32
e	1-way	7	45
f	1-way	9	58
g	2-way	2	14
h	2-way	6	39
i	2-way	10	63
j	Plain	0	0
k	1-way	1	8
l	1-way	5	32
m	1-way	9	60
n	2-way	2	15
o	2-way	6	35
p	2-way	10	54

3. Results

The scattering coefficient and absorption coefficient were measured with increasing surface area. The effect of 1-way and 2-way pattern of v-cut groove is obtained from the measurements. The results are then compared to the hemisphere diffuser with height of 20 mm in order to find the effectiveness of groove.

3.1 Absorption coefficient

The absorption coefficient were measured according to ISO 354 in 1:10 reverberation chamber. The rectangular specimen are used for measuring absorption coefficient by increasing the surface area. The absorption coefficient at 0.5 to 4 kHz ranged from 0.02 to 0.23, which is within the allowable absorption coefficient (0.5) as described in ISO method. From Fig 2 of 1-way

v-cut groove the absorption coefficient increases at range of 1.25 kHz but this tendency changes at higher frequency. However from Fig 2 and 3. the absorption coefficient increases at frequency of 0.63 to 4 kHz. and shows that the increase of surface area has effect on higher frequency than low frequency. Fig 4 shows that For 1-way v-cut groove the absorption coefficient of has more fluctuation which is due to the directional effect of v-cut groove. But for 2-way v-cut groove the reflection from groove occurs in both the planes.

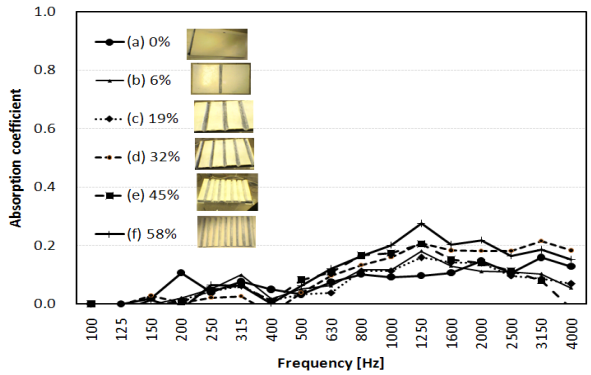

Fig 2. Absorption coefficient of 1-way v-cut groove measured in reverberation chamber

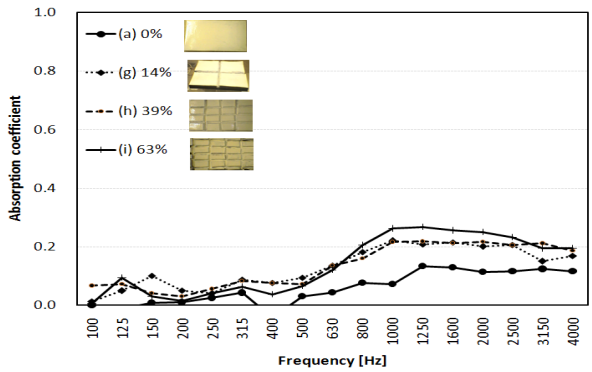

Fig 3. Absorption coefficient of 2-way v-cut groove measured in reverberation chamber.

3.2 Scattering coefficient

Fig. 4 and 5 shows that from 0.4 to 1.2 kHz the scattering coefficient increases with the increase in surface area. The tendency of frequency curve for both the patterns are similar. For 1-way v-cut groove the optimum scattering coefficient were at 1kHz. Similarly for 2-way, the peak occurs at 1kHz for 8 and 32% and at 54% the peak occurs at 1.25 kHz this is due to the wavelength with effect of spacing between the surface. For 1-way pattern the reflection occurs in single plane and the other direction acts as plane surface. Due to this the tendency of frequency curve changes when the surface area is increased

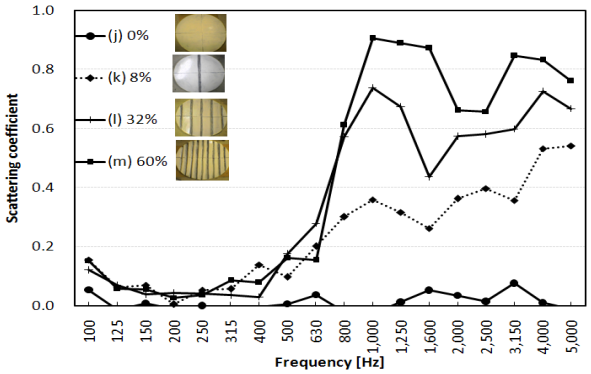

Fig 4. Scattering coefficient of 1-way v-cut groove measured in reverberation chamber

From Fig 4 for 1-way pattern scattering coefficient at low frequency vary with the increase in surface area but in case of 2-way pattern the scattering coefficient at low frequency increases with increasing surface area. This is due to the perpendicular v-cut in two way pattern. These perpendicular v-cut groove surfaces increases the scattering effect at low frequency.

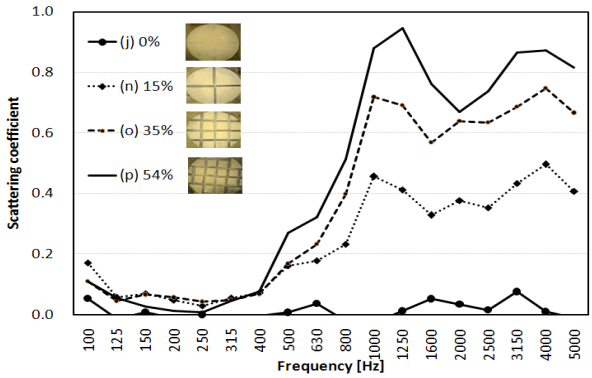

Fig 5. Scattering coefficient of 2-way v-cut groove measured in reverberation chamber

4. Discussion

Fig. 6 shows the comparison of absorption coefficient between the hemisphere diffuser with structural height of 20 mm and v-cut groove. The average absorption coefficient is obtained by averaging 1/3 band values from 0.5 to 5 kHz. The absorption coefficient of hemisphere increases when the spacing between the diffusers decreases. But in case of v-cut the absorption coefficient is affected by deep cut on surface where the reflection is affected by surface itself. In case of hemisphere diffuser at 60% increased surface area the absorption coefficient attains similar to v-cut groove. This is due to the reduced spacing between diffusers and the space between

diffusers.

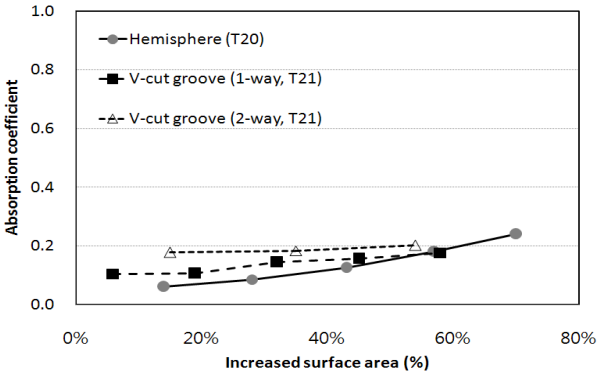

Fig 6. Comparison of absorption coefficient of hemisphere diffuser and v-cut groove diffuser

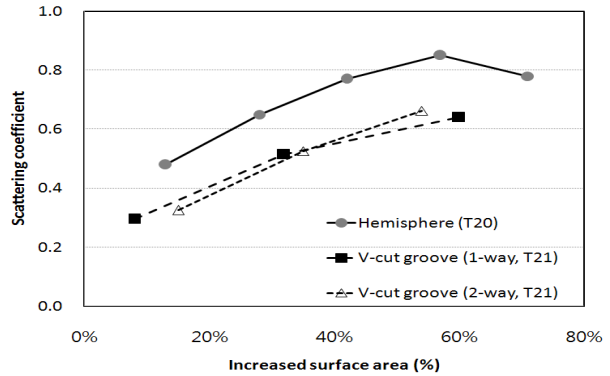

Fig 7. Scattering coefficient as a function of percentage increase of surface area.

The average scattering coefficient is obtained by averaging 1/3-octave band values from 0.5 to 3.15 kHz. As shown in Fig.7 when the percentage of surface is increased from 8 to 60% the scattering coefficient increases up to 0.66. Similarly, for hemisphere diffusers when the surface area is increased the scattering coefficient increases up to optimum of 0.82 at 60%. The variation of scattering coefficient between the above cases is due to the shape of surface. In case of hemisphere diffuser the scattering coefficient is high due to curved surface. But in case of v-cut groove the shape is similar to inverted triangle where the reflection is affected by surface itself. This shows that the scattering coefficient depends on surface area and texture.

5. Conclusions

In this study, the effect of increasing surface area on scattering coefficient and the absorption coefficient were investigated.

The absorption coefficient of 1-way and 2-way pattern shows that the directional characteristics of surface have effect on absorption tendency. In case of 2-way pattern the perpendicular cuts at the junction of grooves increases the scattering effect at low frequencies. The absorption coefficient depends on surface texture, spacing and the surface area. At 60% of increased surface area the spacing between the hemisphere diffuser acts similar to the v-cut groove. In case of scattering coefficient, it depends not only the surface area but also the surface texture. Hence the further measurement by changing the shape of groove is need to be considered.

Since, the surface area is considered to be an important factor in sound diffusion. further the effect of surface area is studied by simulation using computer model. which will make possible to find the relationship between increased surface area and diffusion power.

Acknowledgement

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