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A Study on the Specificity of Metamaterials Using Polygonal Changes in Acoustic Environment

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Abstract *- Characteristics of metamaterials are mainly used to obtain desired acoustic characteristics by artificially changing spacings or thicknesses. In particular, in the field of acoustics, in consideration of the characteristics of the equalizer using metamaterials, it is possible to make acoustic changes in consideration of various characteristics by emphasizing or shifting specific frequencies. Since these characteristics can be applied in various ways without changing the characteristics of the existing room, it is possible to create free acoustic spaces in an auditorium or open space that cannot give spatial changes. Because the acoustic characteristics use the characteristics of the frequency amount, the fact that the existing electro-acoustic can be used is very beneficial. This study introduces an acoustic metamaterial that can be changed with various characteristics by designing these metamaterials.*

Keywords - *Metamaterials, sound pressure, frequency response, structures.*

I. INTRODUCTION

In today's industrial structure pursuing green energies, acoustic changes are given by changing artificial structures for structures. In various industrial societies, to give acoustic changes without using electricity is applied by changing sound pressure changes by adding or subtracting acoustic frequencies. These studies have been studied by measuring the changes in frequencies appearing in natural phenomena and have found that these characteristics appear in structures specific to them. Structures appearing in these structures are called metamaterials, and by using these features, they are being studied using features that emphasize or reduce the sound pressure of frequency components required. In particular, the sound pressure can be changed, and desired frequency components can be changed by changing the structures. In order to obtain structures with high-quality sound characteristics, it is necessary to understand the physical characteristics to make structures. Since these metamaterials are made based on the characteristics of the structure, they can be used in various places and devices.

Metamaterials made by taking advantage of these characteristics change the characteristics of frequency components appearing in sound pressure changes, so they are being researched and conducted in various places without using electrical energy. High-quality sounds are required in any space, and most use an equalizer in consideration of the electrical characteristics to enhance the characteristics. Since there are many spatially diverse structures these days, various metamaterials are needed. Therefore, it is an important research task to develop structures and metamaterials that apply well the characteristics of spaces. In particular, it should be studied with a material that is well suited to the characteristics of the structures, considering the acoustic properties well. Up to now, structural characteristics have been evaluated by the simulation to evaluate the characteristics created by sound passing through, and the emphasis has been placed on emphasizing or reducing the characteristics of the desired frequency with the structure. The existing method emphasizes the characteristics of sound pressure by applying electrical characteristics rather than considering the characteristics of surrounding structures. It is important to convey the characteristics of structures well in space because they are made by measuring with an equalizer that constitutes flattening in the measurement. However, since most of the variables that cause sound distortion appear in the walls, these characteristics should be carefully considered.

In this study, an equalizer for spatial flattening is made in consideration of electrical characteristics, but a method to eliminate distortion in structures is proposed. Chapter 2 describes the characteristics of the equalizer used by applying the existing method, Chapter 3 describes the composition and characteristics of metamaterials considering the characteristics of structures, and Chapter 4 concludes this thesis.

II. STRUCTURAL SPECIFICITY OF METAMATERIALS

In general, acoustic characteristics can change the characteristics of the sound by reflection or dispersion. Acoustic reflections can be offset or emphasized directly by adjusting the angle. Acoustic dispersion appears to be separated in several directions according to the frequency of the sound, and this effect appears as an acoustic effect by dispersing the energies of each frequency. Acoustic characteristics change a lot depending on the surrounding medium, and the characteristics appear by the surface facing the structure. Acoustic characteristics appear in various structures by making and utilizing those that exhibit artificial acoustic effects using these characteristics. In general, depending on reflection and angle, structures exhibit the characteristics of openness and closedness. The openness is characterized by maintaining the speed and clarity of sound for a long time because it transmits the sound without being disturbed by the surroundings. The occlusion of sound does not interfere with the surrounding environment, but the amount of reflected sound greatly affects the direct waves. It allows you to focus on the reduction or enhancement of energies. If these characteristics are used well, various changes of metamaterials can be made.

In general, metamaterials have been studied for a long time. These materials, which are changed by acoustic effects to structural changes, do not appear in nature but have characteristics that appear well in structural changes. In many cases, it appears in various ways depending on the characteristics of acoustic energy. Since these cases can be created by observing environmental structures that are well represented by the surrounding features, research considering only environmental structures is very limited. In order to overcome these cases, it is necessary to constantly consider both the constraints of the structure and the constraints of the environment. Structures should only consider straight lines and widths, and constant acoustic pressure should be used to prevent energy diversification. These sound pressures must be composed of what we know, and the conditions must be that the structures are computationally comprehensible. For this reason, it is easy to apply to calculations, predictable, and diversification can make a difference.

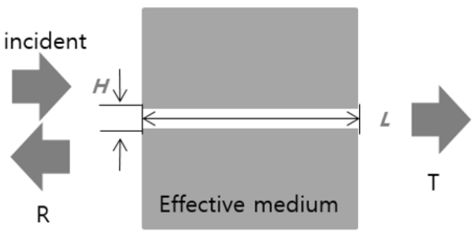
The calculation of the reflection and dispersion of structures is very important, and in this way, various changing characteristics can be calculated. Since complex and curved structures are made from simple structures, an engineering approach is possible, and changes can be predicted. These days, the characteristics of these structures make it possible to analyze the frequency in the offset or emphasis of the sound pressure. Because it is very difficult to interpret the characteristics of structures in terms of frequency, if they are used in the calculation in consideration of the frequency characteristics of the sound, it is possible to apply details that have not been considered before. The study of metamaterials must be made in consideration of all these spatial constraints and frequency characteristics, except in this special exceptional case, a numerical approach is possible.

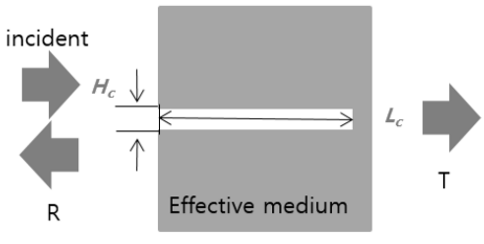
III. CHARACTERISTICS OF EXISTING METAMATERIALS

Existing metamaterials are designed to be open or closed. This is a characteristic of general structures. This feature was used by changing the structure according to the high and low acoustic pressures, which are displayed by uniformly arranging feature manipulations like Legos. In particular, in the space of a certain size, acoustic energies combine to cause resonance, and the walls of the structures act as resistances and appear to be canceled or reinforced. The more walls of a structure, the more acoustic reflection or extinction occurs, and these have various characteristics. Existing metamaterials design these characteristics through a numerical approach and have a sound pressure effect. Here, when the structures of structures are polygonal or curved, they appear complicated in the calculation. For this reason, in order to effectively calculate this effect, the structure is simplified to implement a smooth surface from simplicity. Having a resonance characteristic indicates that acoustic energy is collected or dispersed in a structure, and various characteristics can be made depending on the angle. It is possible to take advantage of the fact that the effect of these characteristics having the specificity of the structures is arranged and used, and the effect becomes larger or smaller by arranging them in various ways. The effect of a general polyhedron is that the characteristics are determined according to the size of the face or the size of the area. Metamaterials have been artificially diversified using these characteristics. However, it becomes difficult to distinguish only the acoustic reduction and increase of the feature structures in consideration of frequency components. In order to compensate for such shortcomings, in this study, it is considered appropriate to arrange and use structures by dividing them into energy characteristic structure and frequency characteristic structure.

IV. CHARACTERISTICS OF PROPOSED METAMATERIALS

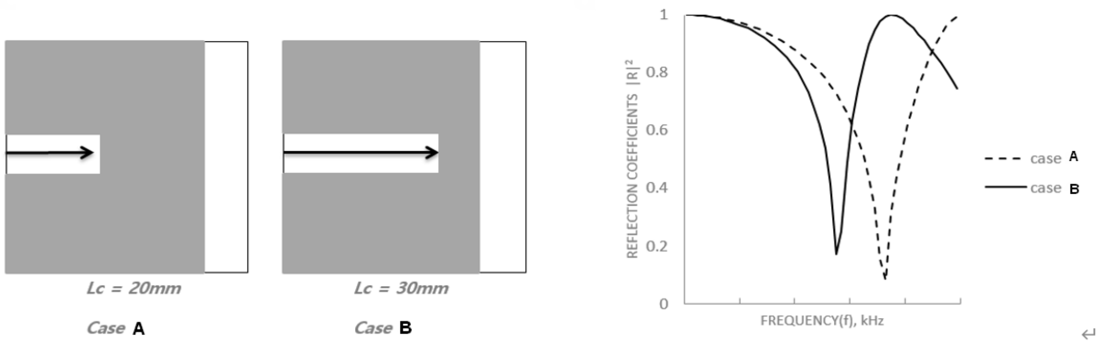
The proposed method uses the characteristics that appear by variously changing the structures of the metal material. Looking at the characteristics of the frequency characteristics and reflection coefficient according to the change of the structure, the longer the length, the more emphasized the low-frequency characteristics of the frequency, and the shorter the length, the higher the frequency. The more each cavity is, the more it affects the frequency, and the smaller it is, the less the influence. These characteristics can vary depending on the spatial dominance and temporal exposure of the sound signal. In particular, when making a sound equalizer, it should be studied considering the extinction of the sound and the characteristics of the cavity. Therefore, this study can be constructed in various ways using various cavities and modules.





(a) the effective medium of the open cavity structure (b) the effective medium of the closed cavity structure

Figure 3. Structural characteristics of two cavities along length L



(a) two different effective structures with closed cavities and varying length L
(b) Reflection coefficients inside the wavelength cavity for the two different effective mediums

Figure 4. Characteristics of the reflection coefficient of two cavities along length L

As shown in Figure 4, it can be seen that the reflection coefficient varies according to the length of the cavity. It can be seen that the shorter the cavity length, the higher the frequency, and the longer the cavity length, the lower the frequency. By using these features, the characteristics of the cavity can be varied to decrease or increase the desired frequencies. In order to emphasize the frequency characteristics, the effect can be increased as more cavities are applied rather than small cavities. The method used in this study applied these characteristics in various ways.

For the measurement of the proposed method, three methods were operated and evaluated. First, the LPF was used to filter out a specific part of the input sound. Although it is important to analyze the frequencies of the entire band, it was applied focusing on the available bands. The input sound signal is divided into three types. A sound pressure analysis was performed to change the sound volume. Second, frequency analysis was performed to compensate for the frequency component. Finally, energy was measured for the conservation of energy. Since these measured measurement elements are very important for making each metamaterial, it was manufactured based on its size and width. Structures that make use of acoustic characteristics emphasize their characteristics by connecting several dozen simple structures. The characteristics of one structure appear small, but when many identical structures are gathered, they have large energy. This study emphasized diversity more by arranging these characteristics as energy, frequency, and sound pressure structures.

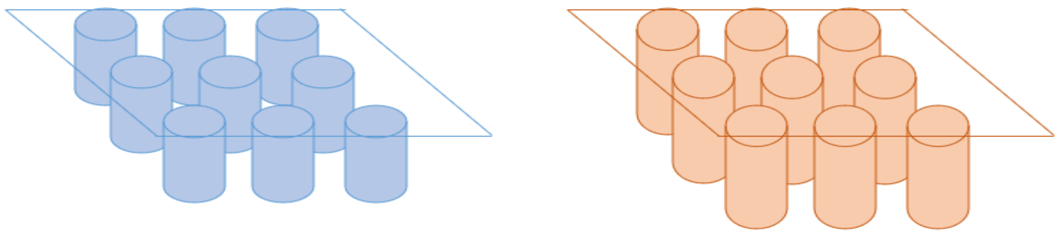


Figure 5. Composition of the proposed two metal materials

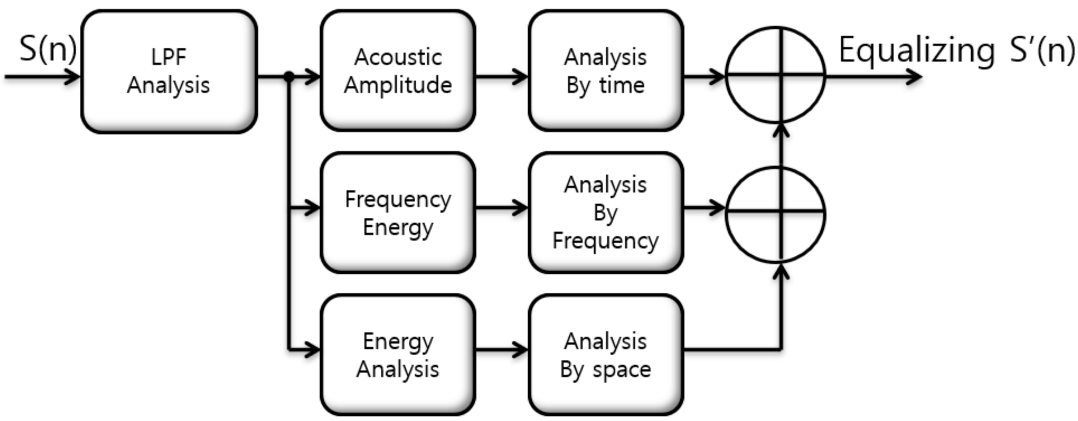


Figure 6 Block diagram of the proposed method

V. CONCLUSION

Metamaterials considering spatial characteristics have been used in various ways. This structure is used by well applying the characteristics of the sense of space and sound pressure felt in the space. However, since this structure does not solve the loss or distortion of the structure, it can produce distorted sound in the space in some cases. Structural features used in the existing method minimize sound distortion by using a hole on the short side or using a complex structure to emphasize frequencies that are increased or decreased in space, but it is insufficient to apply to various structures.

In this study, metamaterials were studied in order to minimize the distortion of these various structures and to utilize the characteristics of the desired frequency. Since the characteristics of the desired frequency can be emphasized or reduced by studying various problems in the existing structure, it can be applied to stable structures in various ways, so the specificity of sound quality can be well applied. Since the metamaterial used in this study uses the characteristics of the structure well, better results can be obtained if it can be used as a three-dimensional material in consideration of structural diversity in the future. Therefore, the sound effect using the metamaterial proposed in this study has the advantage of maintaining sound absorption or sound emphasis characteristics better than general materials and changing the frequency response of the space to suit the listener's needs without distortion of the original sound. In this study, it was introduced whether it has the characteristics of metamaterials using the characteristics of polygons. In the future, we will study metamaterials to make the features appearing in these polygonal features into a simple configuration. This material is characterized by making structural complexity simple, but it will make it possible to apply it in a variety of places.

ACKNOWLEDGEMENT

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