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A Study on Output Enhancement through Speaker Type Improvement

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Abstract:

The Sound Fire Extinguisher was developed to fire extinguishing by concentrating sound energy into flames. The Sound Fire Extinguisher requires high power, miniaturization and weight lightening to be used in the real field. In general, an excessive weight increase is inevitable in order to increase output. In this study, the permanent-magnet type was improved to the electro-magnet type for the general dynamic speaker to minimize the weight increase and improve the output. As a result of the experiment in Chapter 4, the 1.5kg permanent-magnet type speaker outputs 150W, whereas the permanent-magnet is replaced with electro-magnet, and the electro-magnet type speaker weighing 2kg outputs 500W. This resulted in a speaker system's output enhancement of 233% despite a 33% weight increase. As the output is increased by applying electro-magnet to the general speaker, further research is required to improve the durability of the speaker itself.

Keyword: Sound Fire Extinguisher, High power, Weight lightening, Permanent-magnet type speaker, Electro-magnet type speaker

1. INTRODUCTION

The Sound Fire Extinguisher is a device that fire extinguishing by concentrating low frequency sounds below 100 Hz to the flame. The Sound Fire Extinguisher requires a loud speaker to be used to control the flame. On the other hand, in order to use the Sound Fire Extinguisher in a real environment, mobility must be secured. In the case of fixed devices, it takes up less installation place. Therefore, it is necessary to miniaturize and weighten the Sound Fire Extinguisher to be practical in the fire fight field [1-5].

In general, for the most commonly used dynamic speakers, the speaker output is proportional to the strength of magnetism in the speaker and the electric current flowing through the voice coil. The strength of the electric current flowing through the voice coil is determined by a power amplifier that amplifies the signal from the outside. The magnetism inside the loudspeaker is determined by the permanent magnet, so its size is fixed. In order to increase the output of the speaker, the magnetism in the speaker must be increased, which increases the weight and volume of the permanent-magnet. In particular, as the output increases relatively less than the weight of the permanent-magnet, there is a problem that the weight is excessively increased as the output increases [6-7].

This study aims to achieve high power, miniaturization and weight lightening of the speaker by improving the speaker type and enhancing the output while minimizing the increase of the speaker weight. Chapter 2 describes the permanent-magnet type speaker and the electro-magnet type speaker, and Chapter 3 describes the speaker type improvement method applied to increase the speaker output. Chapter 4 describes experiments and results, and Chapter 5 concludes.

2. PERMANENT-MAGNET TYPE SPEAKER & ELECTRO-MAGNET TYPE SPEAKER

2.1 Driving principle of the speaker

A speaker is a device that reproduces sound and converts electrical signals amplified by a power amplifier into acoustic energy. The speaker outputs acoustic energy by vibrating the diaphragm. The speaker is classified into a dynamic speaker, an electrostatic speaker, and a piezoelectric speaker according to the driving method of vibrating the diaphragm. The most commonly used type of speaker is the dynamic speaker. The dynamic speaker vibrates the diaphragm by moving coil transducers that move voice coils in the magnetic field. The direction of the force applied to the voice coil is according to Flaming's left hand law. Figure 1 illustrates the flaming left hand rule [6–7].

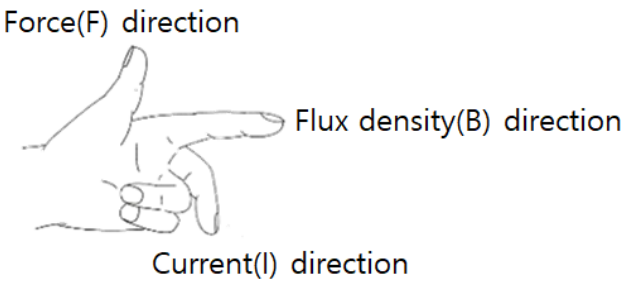

Fig 1. Fleming's left hand rule [7]

2.2 permanent-magnet type speaker

In the dynamic speaker, magnetism is supplied to the voice coil using a magnet. Depending on how magnetism is supplied to the voice coil, it can be divided into permanent-magnet type speaker and electro-magnet type speaker. Generally, permanent-magnet type speaker is mainly used and power consumption is low because it uses natural magnetism. Figure 2 shows the structure of a permanent-magnet type speaker. The magnitude of the force applied to the voice coil in the dynamic speaker is shown in Equation (1) and is proportional to the magnetic flux density (B), the electric current magnitude (I), and the length of the coil (L) [6-7].

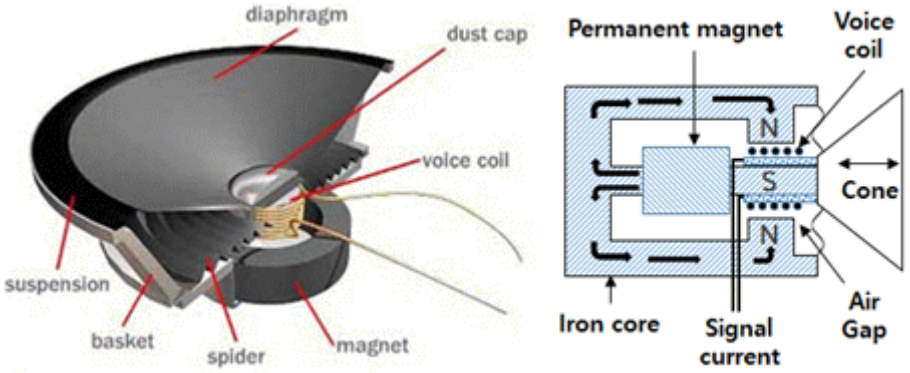

Fig 2. Structure of permanent-magnet type speaker [http://www.audiocircuit.com/][7]

$$F[N] = B[T] \cdot I[A] \cdot L[m] \qquad (1)$$

Since the permanent-magnet type speaker has a fixed magnetic flux density (B) and a coil length (L), the magnitude of the force is determined by the magnitude (I) of the electric current. In order to increase the output further from the permanent-magnet type speaker, the magnetic flux density should be increased by increasing the size of the permanent-magnet. In a dynamic speaker, leakage of the magnetic field from the permanent-magnet occurs. If the magnetic field is forced to flow, the leakage flux to the outside of the magnet increases, resulting in a large loss. In order to increase the output of the speaker, the increase rate of permanent-magnet weight is higher than the increase of the output. For example, if 500g of permanent-magnet is used to produce 100W of power, 3500g of permanent-magnet of 7 times heavier will be used to output 300W of 3 times larger [7].

2.3 electro-magnet type speaker

To produce very loud sound in places such as large venues, the speaker is larger and weighted due to the increase in permanent-magnet weight. In this case, an electro-magnet type speaker is used that forms magnetism through power supply. Electro-magnet type speakers can be weight-lightened by using field coils instead of permanent-magnets. However, power consumption is greater than permanent-magnet type speaker as it generates magnetism by supplying power. Therefore, it is easily used in concert halls that require very high output, and is a somewhat unnecessary method in everyday life. Figure 3 shows the structure of an electro-magnet type speaker [8].

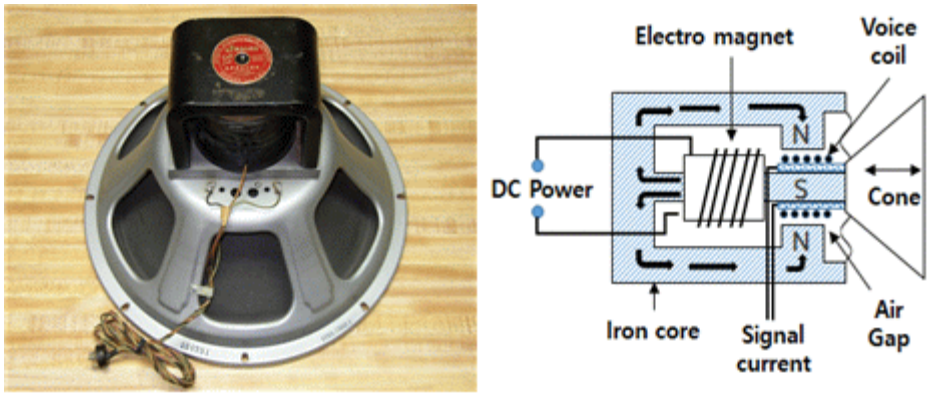

Fig 3. Structure of electro-magnet type speaker [https://www.diyaudio.com/][8]

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3. OUTPUT ENHANCEMENT METHOD ACCORDING TO SPEAKER TYPE IMPROVEMENT

The Sound Fire Extinguisher requires high power, miniaturization and weight lightening for use in real environments [9–10]. In the existing small and medium dynamic speakers, heavy permanent-magnets are used to increase the output at low manufacturing cost. In this study, the speaker type was improved to realize high power while minimizing the weight increase.

Applied method is to remove permanent-magnet from permanent-magnet type speaker and increase magnetism by manufacturing electro-magnet. The magnitude of the magnetism flowing through the voice coil is determined by the magnitude of the electric current flowing through the field coil. The magnitude of the force applied to the voice coil is influenced by the magnitude of the electric current flowing through the field coil in addition to the electric current flowing through the voice coil. Therefore, it is possible to enhance the speaker output by increasing the electric current flowing through the field coil without increasing the weight.

4. EXPERIMENT AND RESULT

For the speaker's output enhancement method according to the speaker type improvement described in Chapter 3, we experimented to check the degree of weight lightening and high power. The experimental method was compared to the output of 1.5kg permanent-magnet type speaker and the improved speaker described in Chapter 3. The sound used for measurement was sinusoidal wave of 60 ㎐ pure tone, and the same size signal was supplied through power AMP. The speaker uses a 1.5kg speaker, removes the permanent-magnet from the same speaker, and manufactures a speaker wound with a separate coil. Figure 4 shows the measurement of the output using a typical permanent-magnet type speaker. Figure 5 shows the measurement of the speaker output by removing the permanent-magnet from the speaker of Figure 4 and making an electro-magnet.

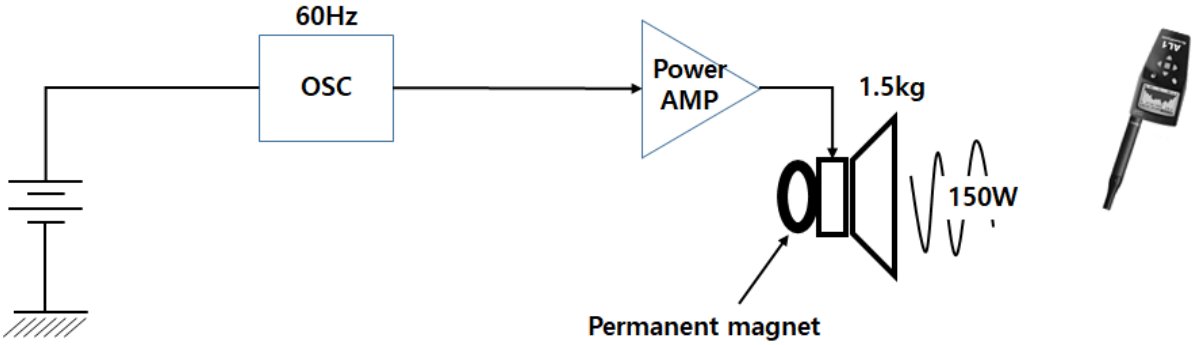

Fig 4. Output measurement using general permanent-magnet type speaker

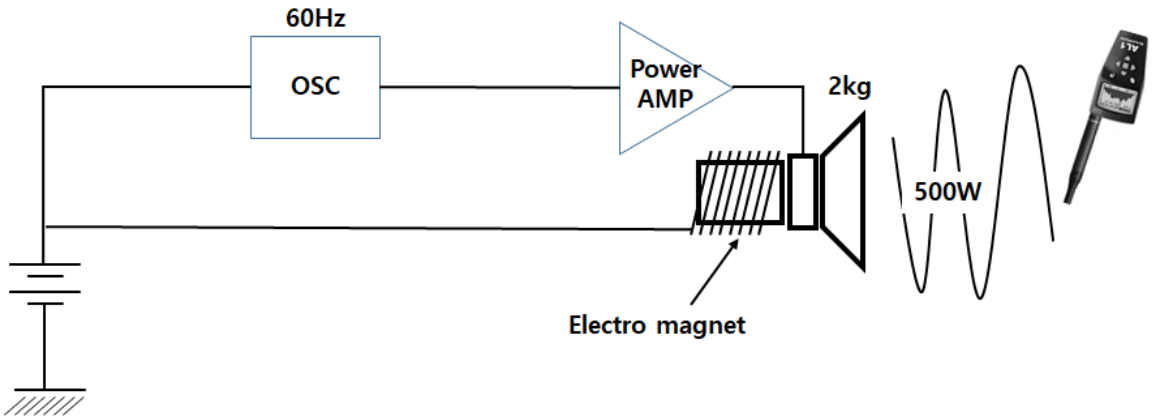

Fig 5. Output measurement using an improved electro-magnet type speaker

In Figure 4, the speaker weighs 1.5kg and outputs up to 150W. In the case of the improved electro-magnet type speaker in Fig. 5, the coil was wound a little thick to stably supply the large electric current to the field coil, and the weight was 2 kg, which was somewhat heavier than the existing speaker. However, the weight is increased by 33%, but the maximum output is 500W, which is increased by 233%.

5. CONCLUSION

Since the Sound Fire Extinguisher suppresses the flame by supplying sound energy below 100 Hz to the flame, the speaker must output a very loud sound. High power, miniaturization and weight lightening are important for the Sound Fire Extinguisher to be used in a fire fighting environment.

A typical speaker needs to increase the size of the permanent-magnet to increase its output. However, the larger the permanent-magnet, the greater the leakage flux and the greater the loss of magnetism. As a result, the permanent-magnet weight increases much more than the increase in output. In other words, there is a problem in that the weight of the speaker is increased too much even if the output of the speaker is slightly increased. For example, if a speaker using 500g permanent-magnet outputs 100W, a 3500g permanent-magnet is required to output 300W. In this case, it can be said to increase the weight of 3000g for the increase of 200W.

In this study, instead of increasing the weight of the permanent-magnet to enhance the output of the speaker, we applied the electro-magnet type speaker method, which is mainly used for large speakers, to the Sound Fire Extinguisher speaker to make the speaker high power, miniaturization, and weight lightening. Application method was to remove permanent-magnet from general speaker and manufacture electro-magnet to achieve high power with little weight increase. For the improved electro-magnet type speaker described in Chapter 3, we tried to verify how much the output is compared with the increase rate of weight. As a result of the experiment of Chapter 4, the general permanent-magnet type speaker outputs 150W at 1.5kg and the improved electro-magnet type speaker outputs 500W at 2kg. This is an increase of 350W output despite the weight increase of 500g. This results in an output enhancement of more than 10 times the weight increase compared to the permanent-magnet type with an increase of 3000 grams and an increase of 200 watts. Compared with the existing permanent-magnet, the speaker coil consumes much power because the field coil needs to generate 333% magnetism. However, the power consumption of electro-magnet replaces the weight of permanent-magnet, and it is natural that power consumption increases with increasing output.

By improving the general speaker type to enhance the output, the speaker can be easily damaged. In order for the improved electro-magnet type speaker to produce consistently high output, further research is needed to improve speaker durability.

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