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EXPERIMENTAL TESTING AND CORRELATION STATISTICAL ANALYSIS OF ACOUSTIC PROPERTIES OF MANGANESE-ZINC FERRITE

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Abstract

In this paper, we investigate in depth the relationship between the acoustic response intensity of manganese-zinc ferrite and the strength of the applied external magnetic field. Experimental results demonstrate that the Mn-Zn ferrite exhibits a magneto-acoustic resonance phenomenon within a magnetic field frequency range extending 500 Hz on either side of the peak resonant frequency. Furthermore, the acoustic intensity is found to increase linearly with the strength of the applied magnetic field.

Keywords: ferrite, manganese-zinc ferrite, acoustic properties, magneto-acoustic effect, statistical analysis.

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1. Introduction

Manganese-zinc ferrite (in short Mn-Zn ferrite) is one of the most common soft magnetic ferrites. It is a ferromagnetic complex oxide composed of various metals, including manganese, zinc, and iron [1]. It is characterized by its softest magnetic properties and its ease of magnetization and demagnetization [2].

Mn-Zn ferrite exhibits excellent performance characteristics. It is capable of undergoing magneto striction when subjected to an alternating magnetic field and also possesses high permeability, high resistivity, and low magnetic losses at high frequencies. These specific properties are current research hotspots in material science.

In this paper, we primarily focus on experimental studies and related analysis concerning the acoustic properties of Mn-Zn ferrite materials. The main objective is to investigate the influence of the applied magnetic field intensity on the sound pressure level of the soft magnetic ferrite's emission, thereby opening new avenues for the practical application of the magneto-strictive acoustic phenomenon.

2. Experimental Testing and Correlation Statistical Analysis

2.1. Experimental Principle

The magnetic field strength and frequency were altered by adjusting the output voltage and current of the signal generator, as well as the number of turns in the energized solenoid. For an infinitely long current carrying copper coil, the magnetic field magnitude inside it, as derived from Biot-Savart Law, is given by

$$B = B_0 \sin(\omega t + \varphi) = \mu_0 n l_0 \sin(\omega t + \varphi). \tag{1}$$

where B is the magnetic flux density inside the copper coil, B_0 the initial magnetic flux density, ω the angular frequency of the current variation, φ the initial phase of the current variation, μ_0 the permeability of free space, n the turn density of the coil, l_0 the amplitude of the alternating current in the copper coil and t is the time.

According to Equation (1), an alternating magnetic field is generated in the copper coil energized by alternating current, and the magnetic field frequency is identical to the current frequency. Furthermore, the magnetic flux density inside the copper coil can be altered by changing the turn density of the coil and the output voltage/current.

In order to obtain the sound pressure level of the Mn-Zn ferrite under varying coil turn densities and output voltages, the controlling variables method was employed. This approach was used to construct a correlation analysis model (1) relating the acoustic response intensity of the Mn-Zn ferrite to the magnetic field intensity. Based on the experimental data, the respective correlation analyses between the Mn-Zn ferrite's sound pressure level and the coil turn density, and between the SPL and the output voltage, were performed. The results of this analysis are summarized in Table 1, with their corresponding visual representations provided in Figure 1 and Figure 2.

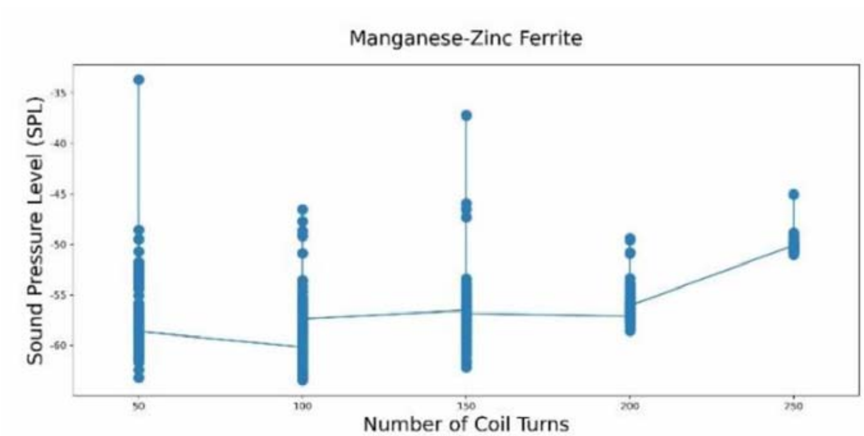

Figure 1. Relationship between number of coil turns and sound pressure level of Mn-Zn ferrite.

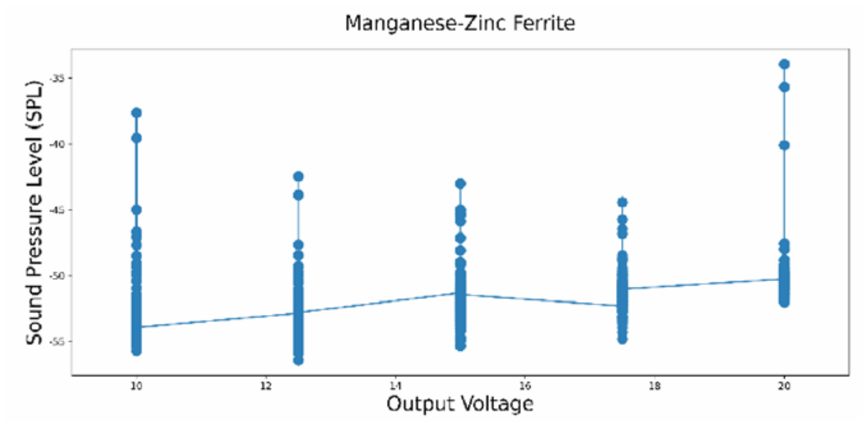

Figure 2. Relationship between output voltage and sound pressure level of Mn-Zn ferrite.

Figure 1 indicates that as the number of turns of the coil surrounding the Mn-Zn ferrite increases during the experiment, its Sound Pressure Level rises gradually, which is consistent with the subsequent correlation analysis results. Similarly, Figure 2 indicates that as the output voltage increases during the experiment, the sound pressure level of the Mn-Zn ferrite progressively increases.

Further statistical analysis based on the data in Table 1 reveals the following. First, a moderate positive correlation exists between the number of coil turns and the sound pressure level of the Mn-Zn ferrite. The Pearson correlation coefficient (r) between the number of coil turns and the sound pressure level is 0.4741. Since the corresponding p-value is significantly less than 0.05, this result is statistically significant and demonstrates high reliability. Second, the correlation coefficient between the output voltage and the sound pressure level of the Mn-Zn ferrite is 0.4758. As the corresponding p-value is also far below 0.05, this correlation is statistically significant, indicating a moderate positive relationship between the two variables

Table 1. Correlation Analysis Results between Mn-Zn Ferrite SPL and Magnetic Field Intensity

Variable Pairs	**Correlation Coefficient** r	***p*-value**
Coil Turn Number and Sound Pressure Level	0.4741	5.322*10-66
Output Voltage and Sound Pressure Level	0.4758	5.655*10-45

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