Research on Design and Application of Absorbing Material Based On Electromagnetic Compatibility of Handheld Device

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Abstract. The paper analyzes the characteristics of the absorbing materials through detailed data, and then studies the manufacturing theory of electromagnetic compatibility about absorbing materials. In the course of the experiment, the writer solved the problem that the reflectivity measurement could not be accurately predicted. The experiment was carried out and finally found that the absorbing material reflectivity modeling simulation experiment with finite integral method is the great method. In the next test process, the writer used the above theory to test the handheld device. Finally, the results show that the finite integral method is worked, and then the absorbing material reflection simulation operation is performed. The method can accurately obtain the range of the test frequency. The writer tested the electromagnetic compatibility of the handheld device and found that the effect of the absorbing material using the method was very obvious, the material could have a good application market.

1. Introduction

Absorbing materials are widely used in electronic equipment and other fields. For general experiments, such as in electromagnetic compatibility darkrooms, transverse electromagnetic wave transmission rooms and other test sites and equipment, the absorbing materials are generally placed on metal surfaces or as terminal devices, which can reduce electromagnetic waves reflection [1]. The most important characteristic of the absorbing material is that it has absorbing properties. The reflectivity is an important indicator of the absorbing properties of the absorbing material. The size depends on the geometry and electromagnetic parameters of the absorbing material. However, the electromagnetic compatibility problems that can cause electronic, electrical equipment or systems to malfunction, performance degradation, and even damage. How to effectively solve the electromagnetic compatibility problem of electronic products, and obtain market opportunities, that become a problem that every electronic product design engineer must take seriously. In this paper, the finite integral method [2] is used to model the electromagnetic compatibility absorbing materials. In the experiment of calculating the reflectivity of the absorbing materials, the simulation results are compared with the measured data, and the finite element integration method can be accurately modeled. The ground reflects the absorbing properties of the absorbing material, helping the electromagnetic compatibility dark room and the conduction chamber to optimize the design. The paper applies the method to the
experiment of handheld devices, and finds that the absorbing material after using this method has better performance, and the electromagnetic compatibility effect of the absorbing material in handling the handheld device is more obvious.

2. Absorbing material

The so-called absorbing material refers to a material that can absorb and convert most of the electromagnetic waves projected onto its surface into other forms of energy (mainly thermal energy) with almost no reflection [3]. At first, it was used in military warfare. Later, with the development of technology, the electromagnetic compatibility problem in the civilian field has become more and more serious. The application and research of absorbing materials have far exceeded the scope of military applications, and are more widely used in microwave darkrooms and electromagnetic shielding, reduce optics reflection, avoid interference from communication equipment, building anti-radiation, eliminate TV ghosting and many other aspects [4].

2.1. The working principle of absorbing materials

Absorbing materials are generally made into two basic types of flat shapes and special shapes. The main performance character of the flat-plate absorbing body is the reflectance $\rho$ when electromagnetic waves are perpendicularly incident from the space to the surface of the material (incident angle $\theta_i = 0$), through experimental analysis, it can be concluded that the smaller the value of this experimental result, the higher the absorbing performance of the material. We can think the incident angle $\theta_i \neq 0$ is called oblique incident, the reflection and refraction will occur when obliquely incident. At this time, the theoretical calculation of the reflectivity is complicated, and the incident angle, the electrical parameters of the two media, and the polarization direction of the wave, and other factors are related. This paper simplifies the reflectivity to satisfy the cosine law, i.e. $\rho(\alpha) = \rho \cos \alpha$, where $\alpha$ is the incident angle and $\rho$ is the perpendicularly incidence reflectivity.

It is known from physics that, except for vacuum, no medium is absolutely transparent to the propagation of electromagnetic radiation waves (including sound waves) in various frequency bands. When waves are radiated from one medium to another, different degrees of reflection, refraction and even scattering will occur. The energy of a part of the wave is absorbed and converted into the internal energy of the medium. The definition of the reflectance is the ratio of the reflected wave power $P_r$ to the incident wave power $P_i$: $\rho = P_r/P_i$, apparently $\rho < 1$.

![Fig. 1 Schematic diagram of the absorbing function of the pointed absorbing body](image)
In order to improve the absorbing performance of the anechoic chamber, a cone (positive quadrangular pyramid or a positive cone, etc.) or a cusp-shaped absorbing body is generally used, and a large number of cones or cusps are regularly arranged to form an integral paste on the wall forming an absorbing body. The main reason for adopting these shapes is that they enable the radiation waves to form multiple reflections and transmission-reflections between the sharp geometrical voids, reducing the reflected energy and achieving high efficiency absorption.

2.2. Absorbing material classification

(1) According to the loss mechanism, it can be divided into a dielectric type absorbing material and a magnetic absorbing material. The main characteristic of dielectric absorbing materials is that they have a high dielectric constant and a dielectric loss angle, and absorb electromagnetic waves by electron polarization or interface attenuation of the medium. The magnetic absorbing material loss mechanism is mainly ferromagnetic absorption, has a large magnetic loss angle, and absorbs electromagnetic waves by eddy current loss, hysteresis loss, and residual loss attenuation.

(2) According to the molding process and bearing capacity, it can be divided into coating type and structural type. The coated absorbing material is a coating with electromagnetic wave absorbing function, and the process is simple, convenient to use, and is highly valued for easy adjustment, and almost all of the stealth weapons use coated absorbing materials. The structural absorbing material has the dual functions of bearing and absorbing, and its structure forms are honeycomb, pyramidal and corrugated.

(3) According to the absorption principle, it can be divided into absorption type and interference type. The absorption type absorbing material itself absorbs the loss of radar waves. The basic types are absorbers with complex magnetic permeability and complex permittivity, impedance gradient "broadband" absorbers and thin layer absorbers for attenuating surface currents; The interference wave of the two columns of the surface of the absorbing layer and the bottom layer are equal in amplitude and opposite in phase, such as a 1/4 wavelength "resonant" absorber. The disadvantage of this type of material is that the absorption band is narrow.

3. Simulation of electromagnetic compatibility absorbing material reflectivity based on finite element analysis

The finite integral method was first proposed by Weiland [5], and the current development is relatively perfect, which can be used to solve a variety of electromagnetic field problems. The basic idea of the finite integration method is to first divide a finite computational region into many small grid elements, and then discretize Maxwell's equations on each mesh surface to obtain a fully discretized Maxwell's lattice equation. Finally, the dielectric equations associated with the material properties are substituted into the fully discretized Maxwellian lattice equations, and all electrical and magnetic quantities are solved numerically. After obtaining the field strength value of the port, the calculation is performed by the basic definition of the reflectivity. In the meshing, the orthogonal hexahedral mesh is used in this paper, and the time domain solver is used to solve the numerical solution. The stability of the equation needs to be considered in the solution process. The stability conditions are as follows:

$$\Delta t \leq \frac{\sqrt{\epsilon \mu}}{\sqrt{\left(\frac{1}{\Delta x}\right)^2 + \left(\frac{1}{\Delta y}\right)^2 + \left(\frac{1}{\Delta z}\right)^2}}$$

(1)

Where $\Delta t$ is the time step; $\Delta x$, $\Delta y$, $\Delta z$ are the grid steps in three directions; $\epsilon$ and $\mu$ are the dielectric constant and permeability of the material.

Figure 2 shows the simulation modeling process of this paper. At first, a rectangular coaxial test device model is established, and the correctness of the model is verified by calculating its no-load
reflection coefficient. The absorbing material is then loaded in the test device and the electromagnetic parameters of the absorbing material are given. Finally, the reflection coefficient of the port is calculated by the finite integral method. The reflection coefficient obtained by simulation modeling is compared with the experimental test results to verify the correctness of the proposed simulation model.

**Fig. 2 absorbing material reflection coefficient simulation flow chart**

When modeling, the cross-section lengths of the inner and outer conductors of the rectangular coaxial test device are set to 5cm and 5mm respectively. In order to verify the influence of the height of the test device on the simulation results, the height of the test device is set to 1.5-2 times of the cross-sectional area during the simulation. The simulation results show that the influence of the height of the test device on the reflection coefficient is only reflected in the ripple oscillation degree, and does not change the position of the extreme point of the reflection coefficient. The electromagnetic parameters of the pyramidal foam absorbing material are not uniform due to the processing technology. For the convenience of modeling, the geometric model of the pyramidal bubble absorbing material is simplified to the same model with the same electromagnetic parameters, and the electromagnetic parameters are tested and calculated by the air coaxial fixture using the transmission reflection method. Figure 3. The surface of the tested absorbing material is treated to a suitable shape. Figure 4 is the measured complex permittivity curve and the fitted curve. The fit model coincides with the test data over the entire frequency band.
4. Experimental analysis of electromagnetic compatibility of absorbing materials for handheld devices

When the handheld device is working, it will continuously emit electromagnetic waves, and the maximum power can reach 2w, which has a great impact on the surrounding environment. When dealing with stray radiation in handheld devices, common measures include filtering, shielding, etc., and in some special cases, the application of absorbing materials is also a good solution. The following is a typical case to illustrate the application of absorbing materials in solving the problem of stray radiation in handheld devices [6]. In this case, the handheld device cannot meet the requirements of the above specifications in terms of coupled spurious radiation performance. The main problem is that the second harmonic reflected in each frequency band of the handheld device exceeds the limit value. The test data is shown in Table 1:

|                       | GSM850 | GSM900 | DCS1800 | PCS1900 |
|-----------------------|--------|--------|---------|---------|
| Second harmonic       | -11.88 | -15.67 | -15.33  | -6.24   |
| Third harmonic        | -21.56 | -25.42 | -31.8   | -33.58  |
From the above raw data, the handheld device exceeds the requirements of the 3GPP specifications at the second and third harmonic points of each frequency band, and the maximum exceeds 23.53 dBm. Therefore, you need to find out further reasons. Therefore, the design and test of radiation absorption of the absorbing material, in the experiment using the spectral test method, as shown in Figure 5, respectively, for GSM850, GSM900, DCS1800, PCS1900, can be seen at 1148cm⁻¹, 1302cm⁻¹, 1484cm⁻¹, 1567cm⁻¹, the bending vibration of the GSM850 stretching vibration absorption peak is at the lowest point, so it also has excellent experimental performance, and is an absorption peak of vibration at 1148 cm⁻¹.

![Fig. 5 Absorbing material effect test curve](image)

It has been found that the handheld terminal is designed to be a handheld device. Considering the size and space constraints, a transparent absorbing material is used in front of the display screen, and the handheld terminal liquid crystal display is a touch screen. Wave materials should also consider the use of flexible materials, so after comprehensive consideration, we chose to use a small amount of space on the PCB in the handheld terminal products, so the absorbing material is used for electromagnetic shielding. Figure 4 shows the absorbing material on the motherboard of a product. Pay special attention when using absorbing materials, that is, you need good grounding. There should be no gap between the absorbing material and the ground. If there is a gap, a slot antenna will be formed, and electromagnetic waves will leak out from the gap. The absorbing material will be it doesn't work. In addition, and the design of the absorbing material should be maintained in an appropriate position. The cost of manufacturing and assembly of absorbing materials is relatively high, and the appearance of absorbing materials is an economical choice. The RF module of the handheld terminal product uses a customized mold box. On the one hand, the RF module adopts a modular design, and becomes a module independently of other baseband circuits to facilitate debugging; on the other hand, the RF module adopts a customized mold box form. The electromagnetic shielding is good and the electromagnetic interference is reduced. The test was re-run and the results were greatly improved, as shown in Table 2.
Fig. 6 The principle of testing absorbing materials

|                        | GSM850 | GSM900 | DCS1800 | PCS1900 |
|------------------------|--------|--------|---------|---------|
| Second harmonic        | -11.88 | -15.67 | -15.33  | -6.24   |
| Third harmonic         | -21.56 | -25.42 | -31.8   | -33.58  |
| Second harmonic improvement | -5.6  | -10.25 | -7.83   | -3.18   |
| Third harmonic improvement | -11.25 | -12.54 | -17.25  | -4.35   |

It can be seen from Table 2 that after using the absorbing material, it actually absorbs electromagnetic waves and reduces reflection, thereby improving the coupling secondary and third harmonic radiation performance.

4.1. The role and prospect of absorbing materials

According to this experiment, the absorbing mechanism of different loss type absorbing materials is optimized, and the structural design of the material is optimized, and the structural design and a series of absorption bands are adopted. To study the new absorbing mechanism and develop absorbing materials in multi-band and selective frequency bands, that is, absorbing materials that can absorb meters, centimeter waves, millimeter waves, infrared and laser bands are the future research directions. The combination of absorbing materials and structural materials can develop the absorbing materials of portable handheld devices and the mechanical structural properties and electromagnetic properties under various effects.

5. Conclusion

In recent years, with the increasing demand for electromagnetic compatibility design of civilian products, the application of absorbing materials has far exceeded the original military field, and has continued to develop in the direction of civilian use. At the same time, products suitable for applications such as electromagnetic compatibility design of consumer products such as handheld devices are constantly being developed. As can be seen from the above examples, the absorbing material is very effective in solving the electromagnetic compatibility design problem of the handheld device product. With the miniaturization, multi-functionalization, digital development and increasing working frequency of electronic products, absorbing materials, especially ferrite absorbing materials with non-conductive properties, will be available in the electromagnetic compatibility design of these products that plays a bigger and bigger role.
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