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Research Progress of Electromagnetic Shielding Materials

Changan He *, Qingguo Wang, Zhaoming Qu

School of Army Engineering University, Shijiazhuang, China

*Corresponding author e-mail: brailletesla@163.com

Abstract. This paper introduces the research progress and development status of bisexual electromagnetic shielding materials and discusses the bisexual electromagnetic shielding materials from the aspects of mechanism, material classification, application and development of bisexual electromagnetic shielding materials, and the existing problems.

1. Introduction

With the rapid development of electronic and information technology, electromagnetic waves as an important carrier of information dissemination, has infiltrated all aspects of life, electrical and electronic equipment has become increasingly widely used in the national economy and family life in various fields however, electromagnetic interference caused by electromagnetic waves (EMI) will not only interfere with electrical equipment, but also a serious threat to human health, electromagnetic pollution has been recognized as the following air pollution, water pollution, noise pollution after the fourth largest pollution [1].

For the purification of urban electromagnetic environment, to prevent electromagnetic radiation hazards, to protect people's physical and mental health, electromagnetic radiation hazards prevention and control has become a very urgent and important task, and electromagnetic shielding materials in various fields of application and development is particularly important. The use of electromagnetic shielding materials can effectively shield the interference of electromagnetic waves and reduce the harm of electromagnetic pollution, so the study and development of electromagnetic shielding materials will be social life and national defense construction has great practical significance.

2. Electromagnetic shielding mechanism

Electromagnetic shielding refers to the use of shielding materials to block or attenuate the shielding area and the outside world of electromagnetic energy transmission. The shielding performance of the shielding material is determined by the shielding efficiency SE, which is closely related to the charge, current and polarization of the surface of the shield structure and the inside of the shield. When electromagnetic waves reach the surface of the shield material [2], there are usually three different mechanisms for attenuation:

(1) The attenuation (R) of the electromagnetic wave caused by the impedance change on the incident surface;

(2) The attenuation (A) of the electromagnetic wave that is not reflected and enters the shield by the material;

(3) Reflection attenuation (B).

$$SE = R + A + B$$

The shielding effectiveness of the electromagnetic wave through the shielding material can be calculated as follows:

$SE = 20\lg(E_0/E_1) = 20\lg(H_0/H_1)$

In the formula, E0, E1, respectively, there is no shield when the electric field strength H0, H1, respectively, there is no shield when the magnetic field strength.

In general, the shielding effect produced by the surface reflection attenuation R requires that the shield has carriers that are free to move in the magnetic field. Therefore, the shielding mechanism-based materials usually have good electrical conductivity, such as silver, copper, gold and so on. And to absorb the attenuation of A-based shielding materials need to have a large number of electric dipole or magnetic dipole, generally have the appropriate dielectric constant, high permeability and high electromagnetic loss of the material, commonly used are perm alloy and other high permeability alloy. When A> 10dB, or the thickness of the reflective layer is much larger than the thickness of the electromagnetic wave penetration, the multiple reflection attenuation B can be ignored.

3. Electromagnetic shielding material classification

3.1. Metal electromagnetic shielding materials

The main advantage of metal for electromagnetic shielding is its high conductivity, in addition, part of the magnetic metal material also has a high permeability. In general, its high and low frequency electromagnetic fields and electrostatic field has a very good shielding effect; but the metal's density, easy to corrosion [3], easy processing and other shortcomings obvious, the application of limitations.

3.2. Ferromagnetic material

Ferromagnetic material for low frequency (less than 100kHz) magnetic field shielding, the principle of its role is the use of high permeability magnetic materials can guide the magnetic field convergence and through the high penetration of materials and in the vicinity of the magnetic flux density to achieve the purpose of magnetic shielding. Commonly used ferromagnetic materials are pure iron, silicon steel, permalloy (iron-nickel alloy), iron and cobalt alloy.

3.3. Excellent metal conductor

Excellent metal conductor under the action of high frequency magnetic field, the internal free electron movement to produce the opposite direction of the eddy current magnetic field and the original magnetic field offset and weaken the interference of high frequency magnetic field [4], so as to achieve shielding effect. In order to avoid the limitations of the application of traditional metal sheet, the general use of metal good conductor in the plastic and other insulators on the surface of a layer of conductive layer, The preparation method comprises the following steps: electroless gold plating, vacuum gold plating, sputtering gold plating, metal melting and metal foil, and the like.

3.4. Amorphous electromagnetic shielding materials

Amorphous alloy with high strength, high hardness, high ductility and other mechanical properties, corrosion resistance, high permeability and other advantages; for electromagnetic shielding materials, the main molding methods are electroplating, hot extrusion, plasma spraying [5].

4. Application and Development of Electromagnetic Shielding Material

According to the current research progress of electromagnetic shielding materials, its application can be divided into the following types:

4.1. Electromagnetic shielding coating

China began to research shield electromagnetic radiation conductive coating from the 20th century, the late 80s, in the field of electromagnetic shielding coatings more backward, The research on the microwave stealth materials with more than 1GHz is carried out. The research on electromagnetic

shielding coatings with frequency [6] in the range of 10k Hz ~ 1 GHz has just started. The research units are few, the research varieties are single, commonly used shielding coatings are made by the composite method of blending coating, mainly by the film-forming material (binder), thinner, additives and conductive filler Through the spraying, brushing, dip coating and roller coating and other methods coated on the substrate surface to form a layer of curing film, resulting in conductive shielding effect.

4.2. Electromagnetic shielding fabric

Conductive fabric is in the general surface of the metal coated with metal, or anti-electromagnetic shielding fibers into the textile or in the fabric surface coated with conductive coating, so that it has a good shielding effectiveness, while yet the original flexibility of textiles and other characteristics.

The development direction of the electroless metallization of the surface of the textile is to replace the original fabric pretreatment process by using plasma and laser technology to eliminate the harmful environment and develop the composite plating to further improve the shielding performance of the existing electromagnetic shielding fabric and hope to give It has anti-ultraviolet radiation, antibacterial deodorant or some other additional features.

There are three main types of anti-electromagnetic radiation fiber:

(1) Conductive type of absorbing fiber, that is, by virtue of low-resistance conductive material on the electromagnetic radiation reflection in the conductor to produce the opposite of the original electromagnetic radiation and magnetic polarization, the formation of a shield

(2) Composite anti-electromagnetic radiation fiber, by adding other compounds or elements to the fiber so that the fiber has a radiation-resistant performance;

(3) Resistance to electromagnetic radiation type fiber, the fiber itself on the basis of the fiber, Radiation resistance [7].

4.3. Electromagnetic shielding plastic

Electromagnetic shielding plastic can be divided into surface conductive type shielded plastic and filled with shielded plastic.

Surface conductive shielding plastic is the use of metal foil, metal melt and non-electrolytic plating and other methods in the plastic surface to obtain a very thin metal layer, so as to achieve the purpose of shielding. It has good electrical conductivity, good shielding effect, but its thin metal composite layer or coating in the use and processing process easy to peel, poor performance, so useless.

Filled composite shielded plastic is made of conductive filler and synthetic resin by mixing and granulation, and the use of injection molding [8], extrusion or compression molding and other methods. Compared to the latter, the latter has a forming characteristics, which can reduce costs, improve product reliability, use more. In general, the performance of shielded plastics depends on the conductivity of the conductive filler and the degree of overlap between them. Fill-type composite shield packing is generally metal powder, metal fiber, carbon black, carbon fiber, conductive glass fiber and some polymer fiber (PAN fiber, polyaniline fiber, etc.) and so on. Carbon black cost is low, good dispersion, but in the plastic matrix filled with the general mass fraction of 20% to 40% in order to have a certain effect, so that the high filling volume will inevitably affect the mechanical properties of the material.

Carbon fiber with a small proportion, small diameter, large diameter ratio, with high strength, high modulus, good chemical stability and other advantages, easy to form a conductive network, but also has a strengthening material function. If the direct use, because of its poor conductivity, high content and make the effect is not good, usually in its surface coated with a layer of metal film, so you can get a better shielding effect. The commonly used metal conductive fibers are copper fibers, nickel fibers, iron fibers or stainless steel fibers. With the micro-vibration cutting technology made of brass fiber low price, less filling, you can achieve better shielding effectiveness. Iron fiber filled with plastic is a new development of a variety, its comprehensive performance is good, good molding process. Stainless steel fiber wear, corrosion resistance, oxidation resistance and good conductivity, bending

strength, but the price is more expensive. As the metal fiber is generally more difficult to process, so commonly used surface metal coated carbon fiber instead of pure metal fiber.

5. problems

Most of the electromagnetic shielding materials developed by the single-component high-conductivity electromagnetic shielding filler or high permeability electromagnetic shielding filler evenly dispersed in the polymer matrix compound processing, and thus the following problems [9].

5.1. Shield mechanism is single

If the use of conductive coating to shield electromagnetic waves, the main rely on reflective electromagnetic waves to achieve shielding. With the modern military weapons and equipment in the electronic, electrical equipment, miniaturization, integration and intelligence, this shielding mode is likely to cause secondary interference of electromagnetic waves, which lead to more serious consequences. Conductive material shielding mechanism for most of the electromagnetic [10] wave is reflected back by the material, so reflected back to the space of electromagnetic waves once again become the source of electromagnetic interference, and conductive magnetic composite electromagnetic shielding material in the reflection by the loss of electromagnetic waves at the same time, will also be quite Part of the electromagnetic wave through the absorption of the loss.

5.2. Shielding band narrow and the low frequency

Improve the electromagnetic shielding effectiveness and broaden the frequency range is the most important research content of electromagnetic shielding materials4. China's weapons and equipment, such as fighters, armored tanks [11], long-range rocket launchers, submarines, ships, the future of aircraft carriers and other high-performance broadband electromagnetic shielding materials increasingly urgent needs, the band from the original 30MHz ~ 1.5GHz widened to 14kHz ~ 18GHz or even wider [12], Especially 100kHz below the shielding effectiveness of 35dB or more shielding material.

5.3. The problem of electromagnetic shielding filler

Commonly used metal shielding agent generally requires the mass fraction of 20% to 40% of the amount of material in order to make the material with excellent shielding performance, but the mechanical properties of the material will have a certain impact. In addition, China's military equipment used in the majority of electromagnetic shielding materials need to import, restricting China's electronic products [13], anti-information leakage and anti-electronic interference ability to improve, will bring security risks to our country.

6. Conclusion

From the research status and development trend of electromagnetic shielding materials, its future development direction is a new type of shielding material with low cost, no pollution, light and durable, shielding frequency bandwidth and comprehensive performance [14].

(1) Shielding materials of amorphization and nano-use, the use of its excellent conductive, magnetic properties, improve the composite electromagnetic shielding effect.

(2) The development of aqueous coatings and improve the dispersion of conductive filler in the polymer matrix [15].

(3) The study of functional and structural combination of intelligent shielding materials, so that shielding materials can shield electromagnetic waves, but also as a load-bearing structural materials.

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