Study on preparation method of aircraft composite skin considering electromagnetic shielding

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Abstract. As the airborne mission system is increasingly concentrated in a small space, airborne electromagnetic compatibility becomes worse. And the electromagnetic shielding performance of this body mechanism can be improved by blocking its radiation path. Considering the aircraft non-metallic skin properties such as strength, plasticity and resistance to corrosion, by vacuum evaporation, vacuum coating, chemical vapor deposition and dispensing under laboratory conditions and adjusting the material, layer thickness and process parameters, several examples of multiple layers of electromagnetic shielding composite materials are prepared, which has important meaning for engineering practice.

1. Introduction

Airborne radar, communication and other mission systems work in the aircraft's small equipment cabin, easy to produce strong electromagnetic wave and radio frequency interference; Due to the larger transmission power and better reception sensitivity, airborne electromagnetic compatibility becomes more "bad". When the airborne system encounters electromagnetic interference, it will have a huge impact on the navigation and communication system. The practical solution to the electromagnetic compatibility of airborne system is to eliminate the interference, block the way and raise the threshold of the interference. As a sensitive device and interference source, airborne antenna, radio, etc., once designed and formed, it is difficult to realize electromagnetic compatibility by reducing or eliminating interference ability and improving the interference threshold.

Some radiofrequency radiation (emission) signal with high sensitive receiving signal frequency, and even synthetic route at the same time, such as data link signal transmitting frequency fall within the frequency band of GPS system, through its internal antenna front door into the system, if because the chain of data transmitting spectrum stray or harmonic interference, can improve by filtering methods, for the same frequency, at the same time, the same situation, simple filtering and shielding effect is small, can according to relative antenna installation location, by blocking its radiation way, improve the coexistence of radio frequency interference [1-7].

At present, non-metallic aviation composite materials such as fuselage and wing skin on the interference path have been used in a large number of aircraft. On the Boeing 787 aircraft, the amount of composite materials has exceeded 50%, which covers the fuselage structure for the first time.

The wings of the Airbus A350 are made of composite materials and cover an area of 442m², which is more prominent among the same type of aircraft, and its proportion is 14% lower than that of the Boeing 787. Compared with traditional metal materials, composite materials with a smaller specific gravity can greatly reduce the overall weight of the fuselage, reduce fuel consumption and improve
aircraft performance. Under the action of electromagnetic field, the shielding effect of metal structure cannot be formed [8,9].

Feng meng et al pointed out that with the development of electromagnetic shielding technology, shielding materials are no longer limited to the mode composed of metal plates. In recent years, metal-filled polymer and metal-plated electromagnetic shielding composites, as new electromagnetic radiation protection materials, have made great progress in corresponding research [10].Zhang xiaoning et al. analyzed the comprehensive shielding characteristics of double-layer and 3-layer shielding materials, proposed a simple and effective sandwich structure design scheme, prepared two layered electromagnetic shielding materials of metal foil and coating, and carried out corresponding theoretical calculation and sample test [11].

Xu Ming et al. prepared electromagnetic shielding composite by filling thermosetting phenolic resin with gold-plated aluminum glass fiber as conductive filler, and further explored the influence of the material's own structure on its threshold through experiments [12].Li suqin et al. conducted experimental verification on the performance and technological performance of electromagnetic shielding rubber material, and accumulated data for aircraft design material selection [13].

In full consideration aircraft non-metallic skin properties such as strength, plasticity and resistance to corrosion of at the same time, aiming at the shortcomings of the existing technology, the film coating, evaporation, chemical vapor deposition of metal polymer processing, the preparation of electromagnetic shielding composite material, improve the electromagnetic shielding performance of composite materials, reduce the space radiation coupling interference, and the effect of electromagnetic shielding ability and protective strength has carried on the real machine test, solves the existing technology of aircraft skin electromagnetic shielding ability is poor.

2. Technical programme

Aircraft skin is generally surrounded by the aircraft skeleton structure and fixed on the skeleton with adhesives or rivets, forming a dimensional component of aircraft aerodynamic shape. The skin structure composed of the skeleton has a large bearing capacity and stiffness, but the weight is very light, which plays a role in bearing and transmitting aerodynamic loads.

After the skin receives the aerodynamic action, the force will be transferred to the connected fuselage and wing skeleton. The force is complex, and the skin is in direct contact with the outside world. Therefore, the skin material is not only required to have high strength and good plasticity, but also to have a smooth surface and high corrosion resistance.

![Figure 1. block diagram of multilayer metal layer and shielding material](image)

The electromagnetic shielding composite plane skin preparation solution (as shown in figure 1), by vacuum evaporation method in aircraft skin surface coated with a layer of insulating layer, through the method of vacuum coating a layer of chromium plating layer in the surface of insulation, through chemical vapor deposition method in chromium plating on the surface layer of fluoride silicon dioxide layer, through the method of vacuum coating in the surface coated with a layer of copper fluoride silicon dioxide layer, through the dispensing process in the copper layer is formed on the surface of a
shielding layer, and finally through the method of vacuum coating on the shielding layer coated with a layer of alloy protective layer and multilayer metal layer and the electromagnetic shielding materials to cooperate with each other in turn in the aircraft skin surface plating. So that the aircraft skin has a good electromagnetic shielding capability, and multi-layer material Settings, but also greatly improve the aircraft skin protection strength.

3. Preparation scheme
In laboratory conditions, according to the preparation plan and process implementation. The preparation method and process Sn (n=1,2,3,4,5,6) are implemented in sequence, as shown in the preparation scheme and process implementation flow chart of FIG. 2.

Steps S1: Vacuum evaporation method is adopted: with silica or alumina as evaporating material and oxygen as compensating gas, an insulating layer of silica or alumina is plated on the surface of the aircraft skin, and the thickness of the insulating layer is 0.5-1 micron.

The process parameters for forming the insulation layer are evaporation current of 5-10ma, oxygen flow of 200-350sccm and evaporation time of 30-60min.

Step S2: The vacuum coating method is adopted to plate a chromium layer on the aircraft skin insulating layer after S1 treatment, and the thickness of the chromium layer is 0.1-0.5 microns.

The process parameters for forming the chromium layer are as follows: the chromium target material power is 6-12kw, the nitrogen is used as the reaction gas, the nitrogen flow rate is 120-180sccm, and the coating time is 8-15min.

Step S3: By chemical vapor deposition, a layer of fluorosilicon dioxide was plated on the chromium layer treated by S2 at 30-55℃, and the thickness of the fluorosilicon dioxide layer was 0.3-0.8 micron.

The process parameters for forming the fluorosio2 layer are as follows: water and fluorochromotriethoxane are used as reactants, the ratio of water and fluorochromotriethoxane is 1:2-1:4, the reaction chamber pressure is 500-800pa, and the deposition time is 40-70min.
Figure 2. preparation scheme and process implementation flow chart

Step S4: The vacuum coating method is adopted to deposit a copper layer on the fluorosilica layer after S3 treatment, and the thickness of the copper layer is 0.2-0.6 microns.

The technological parameters for forming the copper layer are as follows: the copper target power is 5-10kw, the nitrogen is used as the reaction gas, the nitrogen flow is 100-160sccm, and the coating time is 10-15min.

Step S5: By means of dispensing, a shielding layer is formed on the copper layer treated by S4, the main component of the shielding layer is epoxy resin, and the thickness of the shielding layer is 0.5-1 micron.

The technological parameters for forming the shield layer are: the diameter of the nozzle is 0.2-0.5mm, the dispensing step is 1-2mm, and the diameter of dispensing is 5-15mm.

Step S6: By vacuum coating method, an alloy protective layer is plated on the shielding layer after S5 treatment, and the thickness of the alloy protective layer is 0.2-0.5 micron.
The technological parameters for forming the alloy protective layer are: the power of the alloy material is 8-14kw, the reaction gas is nitrogen, the flow rate of nitrogen is 120-170sccm, and the coating time is 7-12min.

4. Specific implementation and optimization indicators
In accordance with the preparation method and the process Sn (n=1,2,3,4,5,6), specific examples are formed in the specific implementation process through the selection and combination of optimized indicators (as shown in Table 1), including materials, coating thickness and process parameters.

| steps | Basic index of material and layer thickness | Process indicators |
|-------|------------------------------------------|--------------------|
| 1     | Evaporating material, compensating gas, layer thickness | Evaporation current, oxygen flow, evaporation time |
| 2     | The thickness of the coating               | Chromium target power, reaction gas and flow rate, coating time |
| 3     | Temperature, thickness of layer           | Reactants and proportion, chamber pressure, deposition time |
| 4     | The thickness of the coating              | Copper target power, reaction gas and flow rate, coating time |
| 5     | Composition, thickness of layer           | Diameter of glue nozzle, dispensing step, dispensing diameter |
| 6     | thick                                     | Alloy power, reaction gas and flow rate, coating time |

Example 1:
S1: vacuum evaporation method is adopted. Silica is selected as the evaporation material and oxygen is used as the compensation gas.
The insulation thickness is 0.5 microns.
The specific technological parameters for forming the insulation layer are as follows: evaporation current is 6mA, oxygen flow is 250sccm, and evaporation time is 40min.
S2: vacuum coating method is adopted, and the thickness of chromium layer is 0.1m.
The process parameters for forming the chromium layer are as follows: the chromium target power is 8kw, the nitrogen is used as the reaction gas, the nitrogen flow rate is 130sccm, and the coating time is 9min.
S3: chemical vapor deposition method was adopted to form a fluorosilica layer with a thickness of 0.3 microns at a temperature of 35°C.
The specific technological parameters for forming the fluorosio2 layer are as follows: water and fluorochromotriethoxane are used as reactants, the ratio of water and fluorochromotriethoxane is 1:2, the reaction chamber pressure is 600Pa, and the deposition time is 50min.
S4: vacuum coating method is adopted. The thickness of the copper layer is 0.2m.
The specific technological parameters for forming the copper layer are as follows: copper target power is 7kw, nitrogen is used as the reaction gas, nitrogen flow rate is 120sccm, and coating time is 13min.
S5: by dispensing, the main component of the shielding layer is epoxy resin, and the thickness of the shielding layer is 0.5 microns.
The specific technological parameters for forming the shield layer are as follows: the diameter of the nozzle is 0.2mm, the dispensing step is 1mm, and the diameter of dispensing is 8mm.
S6: vacuum coating method is adopted, and the thickness of the alloy protective layer is 0.2m.
The specific technological parameters for forming the alloy protective layer are as follows: the power of the alloy material is 9kw, the reaction gas is nitrogen, the flow rate of nitrogen is 150sccm, and the coating time is 8min.
Example 2:
S1: vacuum evaporation method was adopted. Alumina was selected as the evaporating material. The compensating gas was oxygen.

The specific technological parameters for forming the insulation layer are as follows: evaporation current is 7mA, oxygen flow is 200sccm, and evaporation time is 50min.

S2: the thickness of chromium layer is 0.2 microns by vacuum coating method. The specific technological parameters for forming the chromium layer are as follows: the chromium target material power is 6kw, the nitrogen is used as the reaction gas, the nitrogen flow rate is 140sccm, and the coating time is 10min.

S3: chemical vapor deposition method was adopted. The temperature was 40℃ and the thickness of the fluorosilica layer was 0.4 microns.

The specific technological parameters for forming the fluorosilica layer are as follows: water and fluorochromotriethoxane are used as reactants, the ratio of water and fluorochromotriethoxane is 1:2.5, the reaction chamber pressure is 650Pa, and the deposition time is 45min.

S4: the thickness of the copper coating is 0.3 microns by vacuum coating method. The specific technological parameters for forming the copper layer are as follows: the copper target power is 8kw, nitrogen is used as the reaction gas, nitrogen flow rate is 130sccm, and the coating time is 12min.

S5: by dispensing, the thickness of epoxy resin shielding layer is 0.6 microns. The specific technological parameters for forming the shield layer are: the diameter of the glue nozzle is 0.3mm, the dispensing step is 1.2mm, and the diameter of the dispensing is 10mm.

S6: vacuum coating method is adopted. The thickness of the alloy protective layer is 0.3 microns. The specific technological parameters for forming the alloy protective layer are as follows: the power of the alloy material is 11kw, the reaction gas is nitrogen, the flow rate of nitrogen is 160sccm, and the coating time is 10min.

5. Conclusion

According to the strength, plasticity and corrosion resistance of aircraft non-metallic skin, the multilayer electromagnetic shielding composite material is prepared by vacuum evaporation, vacuum coating, chemical vapor deposition and dispensing under laboratory conditions. Considering the indicators such as material, layer thickness and process parameters, four specific implementations are proposed, which can improve the ability of electromagnetic shielding and protection strength of the aircraft skin.

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