Preparation and Properties of an Anti-Friction and Anti-Corrosive Radar Absorbing Material with Periodic Intermediate Coating

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Abstract. In this paper, an anti-friction and anti-corrosive radar absorbing material with periodic structure intermediate coating is studied. The preparation process is introduced and its electrical and mechanical properties are studied. The radar reflection loss of the material is less than -10 dB in the X-band and a tensile strength of 16 MPa, and the material has the characteristics of abrasion resistance and anticorrosion. The radar absorbing materials solve the problem of the existence of extended damage in the middle layer due to the continuity of the fiber cloth in the existing coating technology.

1. Introduction
Radar detection has the advantages of high detection accuracy and high precision. The development of new radars increases a growing threat to weapon equipment. Therefore, countries are striving to develop radar stealth technology [1]. Radar stealth technology includes shape stealth technology and radar absorbing materials stealth technology [2-3], and material stealth technology develops increasingly rapidly [4-5]. At present, coated absorbing materials with simple process, convenient use and strong ship adaptability have been widely used.

In this paper, an anti-friction and anti-corrosive radar absorbing material with periodic structure intermediate coating is studied. The preparation process is introduced and its electrical and mechanical properties are studied. As a result, the radar reflection loss of the material is less than -10 dB in the X-band and a tensile strength of 16 MPa, and the material has the characteristics of abrasion resistance and anticorrosion.

2. Preparation of Radar Absorbing Materials

2.1. Selection of the Material
The material consists of a primer, an absorbing layer, intermediate coating and a top coating which are closely arranged from inside to outside. The primer has a thickness of 40-60 μm and is composed of an epoxy primer and an epoxy primer curing agent having a mass ratio of (6-8):1. The thickness of the absorbing layer is 1.5-2.0 mm, and is composed of an epoxy resin (one or two of E-44, E-20, 830), a low molecular polyamide curing agent (polyamide resin 650 or polyamide resin 651). A magnetic absorbent consisting of ferrite or carbonyl iron powder,. a dispersing agent, a toughening agent, an antifoaming agent and a leveling agent. The intermediate coating has a thickness of 0.2-0.3 mm and has a periodic opening unit. The shape of the opening unit is square, diamond or rectangular, the side length of the opening unit is 20 mm-50 mm, and the spacing distance of the opening unit is not more than 2 mm. The intermediate coating is composed of an inner layer, an intermediate layer and an outer
layer, and the inner layer and the outer layer are all a mixture of an epoxy resin, a polyamide resin curing agent, a toughening agent and a filler, and the intermediate layer is made of an impregnated epoxy resin, a glass fiber cloth of a mixture of a polyamide resin curing agent, a toughening agent and a filler. The top coating has a thickness of 0.20-0.40 mm and is composed of an abrasion resistant coating and an anticorrosive coating having a mass ratio of 1:1.

2.2. Preparation of the Material
The preparation method of the above materials comprises the following steps:

Step one: preparation of primer.
The primer and the matching primer curing agent are uniformly mixed according to the mass ratio (6-8):1, and then sprayed or brushed on the metal substrate after roughening treatment and cleaning treatment, and the thickness is 40-60 μm. Curing at room temperature for 24 h or 60 °C for more than 3 h, and the coating was obtained.

Step two: Preparation of absorption layer.
The epoxy resin, low molecular weight polyamide curing agent, dispersant, toughening agent, defoaming agent and leveling agent are stirred and mixed uniformly according to the proportion. The magnetic absorbent is added to mix and mix evenly. After 10-20 minutes of pre-curing at room temperature and pressure, uniform spraying or brushing was applied to the polished and cleaned bottom coatings for several times. After reaching the predetermined thickness, the absorbent layer was obtained after curing at room temperature for more than 24 hours.

Step three: Preparation of intermediate coating.
The epoxy resin, curing agent, toughening agent and filling agent were added into the solvent according to the proportion. After fully mixing and mixing, the mixture was prepared by pre-curing at room temperature and pressure for 10-20 minutes. A portion of the mixture to infiltrate the fiberglass cloth, and a portion of the mixture thinly and evenly sprayed or brushed on the polished and cleaned absorption layer, and the inner layer is obtained. Before the inner layer is cured, the fully infiltrated glass fiber cloth is coated on the inner layer surface, and the coating process is as tight as possible to ensure that there is no air bubble on the surface of the application, and the intermediate layer is obtained. Before the intermediate layer is cured, spraying or brushing a layer of the mixture on the surface of the intermediate layer, and removing the bubbles generated during the coating process to keep the glass fiber cloth flat, and spraying or brushing the mixture until the desired thickness is reached. The the outer layer is obtained. Curing at room temperature for 72h or more at 60°C for more than 8h, after curing the array is cut into a periodic structure according to a predetermined size by machining, and ensures that the fiber cloth between each cycle is completely cut during the processing process.

Step 4: preparation of top coating
The fluoroolefin-vinyl ether copolymer resin and the fluoroolefin-vinyl ether copolymer resin curing agent are thoroughly stirred and uniformly mixed according to the ratio to obtain an abrasion resistant coating. The solvent-based polyurethane rain-resistant resin and the solvent-based polyurethane resin curing agent are thoroughly stirred and uniformly mixed according to the ratio to obtain an anticorrosive coating. Mix the anti-corrosion coating and the anti-wear coating according to the ratio, add 3-5% of the total mass of the anti-corrosion coating and the anti-wear coating to the polyurethane solvent, stir well and mix evenly until the bubbles are eliminated. If necessary, add 0.1% defoamer, BYK-W980, then apply or spray on the middle coating after grinding and cleaning until the desired thickness is reached. If the organic processing demand is required, it is necessary to continue to increase the thickness of the top coating by 0.40mm or more, and reserve enough size for machining. Finally, curing at room temperature for more than 7 days, obtaining an absorbing coating with a periodic structure coating.

3. Properties of the Material
According to the absorbing coating with periodic structure coating proposed in this paper and its preparation method, two kinds of absorbing materials were fabricated according to different ratio schemes, and electrical performance test and material mechanics test were carried out.
3.1. Electrical Performance Test
The electrical performance of the material was tested. The results are shown in Fig. 1. As can be seen from Fig. 1, the radar reflectivity loss of the material at the 8-12 GHz band can be less than -10 dB throughout the X-band.

![Figure 1. Radar reflectivity loss](image)

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- The text should be set to single line spacing.
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3.2. Mechanical Performance Test
The coatings of Examples 1-2 were respectively subjected to rubbing resistance test, and 2,000 times of relative sliding friction tests with the metal surface were measured, and the coating wear thicknesses were 0.065 mm, 0.09 mm, and 0.06 mm, respectively. The coatings of example 1, example 2 and comparative to example 1 were tested for tensile strength according to GB/T 5210-2006. The results are shown in Table 1. As can be seen from Table 1, the material with periodic structure was better than the material with not a periodic structure.

| Sample | Destructive strength Non-periodic structure | Destructive strength Example 1 with periodic structure | Destructive strength Example 2 with periodic structure | The diameter of test column |
|--------|-------------------------------------------|-----------------------------------------------------|-----------------------------------------------------|-----------------------------|
| 1      | 14.5573                                   | 15.5423                                             | 16.5423                                             | 20                          |
| 2      | 14.1716                                   | 15.1261                                             | 17.1261                                             | 20                          |
| 3      | 13.8107                                   | 16.2096                                             | 16.2096                                             | 20                          |
| 4      | 14.1824                                   | 16.5693                                             | 15.5693                                             | 20                          |
| 5      | 14.5012                                   | 16.7467                                             | 15.3467                                             | 20                          |
| 6      | 13.9627                                   | 15.4702                                             | 15.7702                                             | 20                          |

The absorbing coating of Example 2 was tested for peel strength in accordance with GB/T 2790-1995, and the results are shown in Table 2.
Table 2. Peel strength test

| Sample | Geometric shape | Width (mm) | Speed (mm/min) | Average peel (N/m) | Maximum peel (N/m) |
|--------|-----------------|------------|----------------|--------------------|--------------------|
| 1      | 180 degree      | 25         | 100            | 4140.35            | 7647.01            |
| 2      | 180 degree      | 25         | 100            | 4426.28            | 6692.58            |
| 3      | 180 degree      | 25         | 100            | 3216.49            | 6157.77            |
| 4      | 180 degree      | 25         | 100            | 3805.72            | 5761.84            |
| 5      | 180 degree      | 25         | 100            | 5332.02            | 7029.96            |
| Average|                 |            |                | 4184.17            | 6657.83            |

Based on the above test description, the material has excellent corrosion resistance, wear resistance and impact resistance, and the environmental test results are consistent with the absorbing coating without periodic structure. The strength can reach above 16 MPa, which is higher than the mechanical strength of the material without periodic structure. The damage area is maintained within the structural unit of the periodic structure and does not result in a larger area expansion due to the fiber cloth.

4. Conclusion

The radar absorbing materials with periodic structure intermediate coatings studied in this paper have excellent electrical properties and ideal properties, and solve the problem of the existence of extended damage in the middle layer due to the continuity of the fiber cloth in the existing coating technology. The layers of the coating combine to provide excellent corrosion resistance, abrasion resistance and impact resistance.

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