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Study on the weight reduction of the OSR film paste technology for satellite

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Abstract. This paper studied the weight reduction implementation of the OSR sheet bonding process for satellites. This research realized the weight reduction of the OSR sheet by changing the types of conductive fillers and the thickness of the adhesive layer. And the change of bonding performance of OSR sheet after weight reduction was verified by experiments. This paper provided a reference for the weight reduction design and manufacture of subsequent thermal control projects of the satellite.

Keywords: OSR sheet; Bonding process; Weight reduction

1. Introduction

The thermal control coating is an important part of the spacecraft thermal control system. Its function is to use the coating to change the surface thermophysical properties of the spacecraft [1]~[2], so as to effectively control the temperature of the satellite and make the temperature of the internal instruments and equipment within the allowable range. Within the range, ensure the normal operation of the satellite. Optical Solar Reflector (OSR) is a widely used thermal control coating with low absorption-radiation ratio [2]~[5].

With the rapid development of my country's aerospace field, especially large-scale remote sensing optical satellites and communication satellites in recent years, the size of the spacecraft has become larger and larger, the structure layout has become more and more complex, and the functions and number of instruments and equipment have continued to increase. At present, the weight of the OSR heat dissipation surface is about 1.5 kg/m2, for satellites with high heat consumption, when the OSR heat dissipation area is large, the weight cost to meet the grounding requirements is very high, so the research on weight reduction of OSR sheet paste is imperative.

2. Weight reduction strategy

At present, the commonly used OSR sheet for satellites is mainly used RTV series silicone rubber to add Ag powder to meet the electrical conductivity requirements of the adhesive. The OSR sheet with a thickness of 0.15 mm is glued to the outer surface of the honeycomb sandwich panel. The thickness of the adhesive layer is generally controlled at 0.2 mm, press-cured at room temperature to complete the paste of the OSR sheet. This article mainly discusses the adhesives used in the OSR sheet bonding process.

Under the premise of not affecting the bonding performance of the OSR sheet, that is, without changing the adhesive system. One method is the use of new lightweight conductive fillers is a more effective way to reduce weight. At present, Beijing Satellite Manufacturing Plant has adopted a new type of conductive material (hereinafter referred to as conductive powder). The density of the conductive powder is only 0.25 g/cm3, while the density of the Ag powder is 7.6 g/cm3. Under the condition that the adhesive reaches the same resistance value, the weight of the conductive powder is also much lower than that of the Ag powder, which shows the weight reduction of the replacement material, and we can find that the effect is obvious. Another method is that the thickness of the adhesive layer is halved, that is, the thickness of the adhesive layer can be reduced

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from 0.2 mm to 0.1 mm, and the amount of adhesive and conductive fillers can be halved, which can also play a role in weight reduction.

Taking a satellite heat radiator structural board as an example, the area of the OSR sheet on one side of the product is about 3 m2, one side uses conductive powder, and the thickness of the adhesive layer is 0.2 mm; the other side uses silver powder, and the thickness of the adhesive layer is 0.1 mm; For the same type and quantity of OSR sheets, the weight reduction of the two process schemes is compared, and the specific results are shown in Table 1. From the data in Table 1, it can be seen that the weight of the OSR heat dissipation surface is reduced to 1/3 of the original weight by replacing the conductive filler with light conductive powder, and the weight reduction effect is particularly significant. The weight is reduced to 1/2 of the original, and the weight loss effect is also very impressive.

Table 1.Weight reduction of the heat radiator structural plate before and after adopting different schemes

Conductive filler	Bondline thickness	OSR heat dissipation surface weight(g/m2)	Weight reduction(g/m2)
Ag powder	0.2 mm	1500	/
Conductive powder	0.2 mm	521	979
Ag powder	0.1 mm	798	702

In summary, the weight reduction effect of the OSR heat dissipation surface can be achieved by replacing the conductive filler and reducing the thickness of the adhesive layer. However, the effect of replacing the conductive filler and reducing the thickness of the adhesive layer on the performance indicators of the OSR sheet needs further experiments. analysis.

3. Experiment results

3.1 Preparation of test items and test pieces

According to the operating environment and requirements of the OSR film, the performance testing items and index requirements of the OSR film are shown in Table 2.

Table 2.OSR sheet performance testing and index requirements

Test items	Indicator requirements
Visual inspection	The conductive coating on the surface of the OSR sheet should have no obvious scratches; The OSR sheet is allowed to crack, but the crack must be clear and single, no radial and network cracks are allowed, and each OSR sheet is allowed to have one crack.
Paste strength	The OSR sheet should pass the pull strap test without being pulled up
Ground resistance	The resistance between the surface of each OSR sheet and the paste is not more than 200 kW
Surface radiation performance	The solar absorption ratio $\alpha S \leq 0.13$ of the OSR sheet, and the hemispherical emissivity $\varepsilon H \geq 0.77$
Thermal vacuum performance	After the thermal vacuum test, it is confirmed that the OSR sheet on the specimen has no radial and mesh cracks, and the OSR sheet should not fall off under the action of gravity when the specimen is inverted (the experimental conditions are the same as the whole star)
Mechanical properties	After the vibration test of the specified magnitude, the appearance and adhesive strength of the OSR sheet meet the requirements of items 1 and 2 (the experimental conditions are the same as the whole star)

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According to the different adhesive conditions in Table 1 and the test items in Table 2, thermal vacuum test pieces and mechanical property test test pieces need to be prepared respectively, and 3 kinds of each test piece are prepared, as shown in Table 3.

Table 3.Preparation types of test pieces

Test items	Bondline thickness (mm)	Conductive filler	Specimen number
Thermal vacuum performance sample	0.2	conductive powder	1-1
	0.1	Ag powder	1-2
	0.2	Ag powder	1-3
Mechanical Properties Specimen	0.2	conductive powder	2-1
	0.1	Ag powder	2-2
	0.2	Ag powder	2-3

The preparation of thermal vacuum test piece: paste 3 × 3 pieces of OSR sheets of 40 mm × 40 mm in total on an aluminum plate of 150 mm × 150 mm × 1 mm. The dimensions of the test piece are shown in Figure 1.

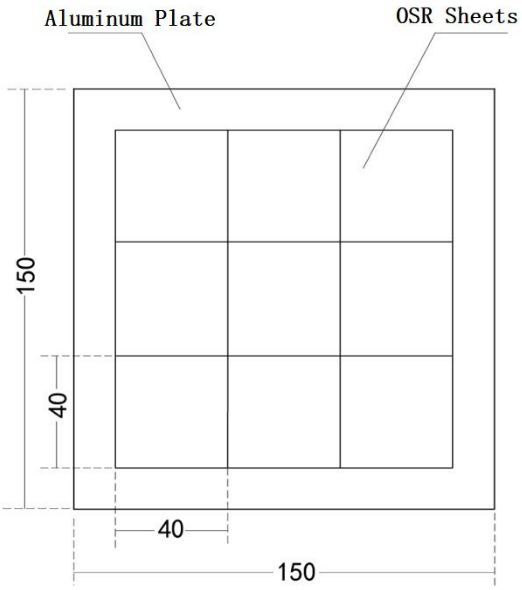

Fig. 1 Schematic diagram of thermal vacuum test piece (mm)

The preparation of mechanical properties test pieces: paste 5×10 pieces of OSR sheets of 40 mm × 40 mm on an aluminum honeycomb sandwich board of 500 mm × 300 mm × 25.6 mm. The dimensions of the test pieces are shown in Figure 2.

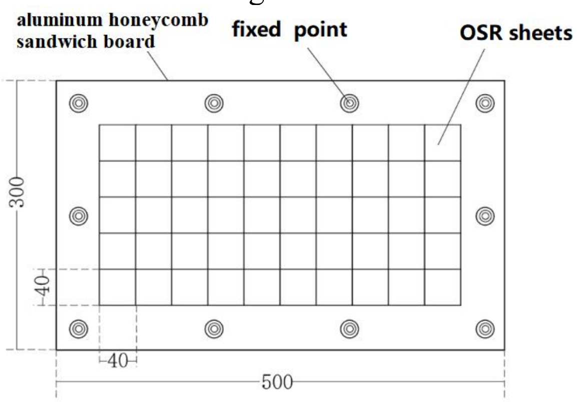

Fig. 2 Schematic diagram of mechanical properties test piece (mm)

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3.2 Results

Before and after the thermal vacuum and mechanical properties of the test pieces were respectively tested, the appearance, bonding strength, grounding resistance and irradiation performance of the pasted OSR sheets were tested respectively. The specific test data are shown in Table 4.

Table 4.OSR sheet performance detection before and after the test

Test	Specimen number	Exterior	Paste strength	Ground resistance	Irradiation performance
Before thermal vacuum performance	1-1	No scratches and cracks	The OSR pieces on the specimen were tested in both horizontal and vertical directions, and all the OSR pieces were not pulled up.	The grounding resistance of the OSR chip meets the requirement of not more than 200 KΩ	αs=0.09 εh=0.81
	1-2				αs=0.11 εh=0.80
	1-3				αs=0.10 εh=0.80
After thermal vacuum performance	1-1	There is 1 OSR sheet on the edge with a single crack	The OSR pieces on the specimen were tested in both horizontal and vertical directions, and all the OSR pieces were not pulled up.	The grounding resistance of the OSR chip meets the requirement of not more than 200 KΩ	αs=0.10 εh=0.80
	1-2	No scratches and cracks			αs=0.11 εh=0.79
	1-3	No scratches and cracks			αs=0.10 εh=0.81
Before mechanical test	2-1	No scratches and cracks	The OSR pieces on the specimen were tested in both horizontal and vertical directions, and all the OSR pieces were not pulled up.	The grounding resistance of the OSR chip meets the requirement of not more than 200 KΩ	αs=0.10 εh=0.78
	2-2				αs=0.11 εh=0.78
	2-3				αs=0.10 εh=0.79
After mechanical test	2-1	There are 2 OSR sheets on the edge and there is a gap of φ1	The OSR pieces on the specimen were tested in both horizontal and vertical directions, and all the OSR pieces were not pulled up.	The grounding resistance of the OSR chip meets the requirement of not more than 200 KΩ	αs=0.10 εh=0.79
	2-2	There is 1 OSR sheet on the edge with a single crack			αs=0.11 εh=0.79
	2-3	There is 1 OSR sheet on the edge with a single crack			αs=0.09 εh=0.79

From the experimental results, the implementation of the two process schemes of replacing the conductive filler and reducing the thickness of the adhesive layer can meet the inspection requirements for the appearance, bonding strength, grounding resistance, surface radiation performance, thermal vacuum performance and mechanical properties of the OSR sheet. However, due to the limited number of test pieces and types of tests, further verifications are required in the future based on the use environment and requirements of different satellites.

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4. Conclusion

1) For the paste of the satellite product OSR sheet, the weight reduction can be achieved by replacing the conductive filler and reducing the thickness of the adhesive layer. Among these two methods, the conductive filler is replaced from Ag powder to conductive powder, and the weight reduction effect is more obvious.

2) The comparison test results before and after the improvement of the existing scheme show that the OSR sheet made by replacing the conductive filler and reducing the thickness of the adhesive layer has no obvious effect on its appearance, bonding strength, grounding resistance, surface radiation performance, thermal vacuum performance and mechanical properties.

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