Application of lightweight magnesium alloy in satellite antenna products

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Abstract: Combined with the actual work, the new metal matrix composite has the characteristics of lightweight, low thermal expansion (CTE), ultra-high thermal conductivity, high specific strength, specific stiffness, good damping, etc. which is the key to realize the requirements of miniaturization, lightweight, long life and high reliability of aerospace products. This paper introduces the selection analysis and practical application of magnesium alloy in satellite antenna products. Antenna products based on magnesium alloy will be more and more widely used in aerospace field.

1. Introduction

In order to realize the industrialization of electronic packaging materials on a large scale, new lightweight metal matrix composites (MMCs) are developed. To meet the development needs of semiconductor chip integration along Moore's law, which leads to a sharp increase in chip calorific value, a decline in the service life, and the "thin and tiny" of electronic packaging, especially in aerospace, microwave integrated circuits, power modules, military RF system chips and other packaging, has become an important trend in the application and development of aerospace electronic product packaging materials. At the same time, it is one of the important development for the lightweight of aerospace electronic products.

The new lightweight metal matrix composites can be roughly divided into the following five types [1-6]:

1. PMC (polymer matrix composites): polymer matrix composites;
2. MMC (metal matrix composites): including various kinds of diamond powder reinforced metal matrix composites, etc. SiC powder reinforced aluminum (Al/SiC) is the most widely used packaging material for electronic products. Al/SiC microwave packaging and PCB heat sink as solid or flow are widely used in a variety of spacecraft systems;
3. CCC (carbon/carbon composites): ceramic matrix composites have good strength and hardness, and are not as brittle as single crystal carbon materials. Some of them have high thermal conductivity. This kind of material is still limited in the field of heat treatment;
4. CMC (ceramic matrix composites): ceramic matrix composites. Diamond powder reinforced silicon carbide radiator is now used in IBM notebook computer;
5. MCM (monolithic carbon materials): single crystal carbon materials, including CVD diamond film, high performance Oriented pyrolytic graphite is a potential electronic packaging material;
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2.1. Pure magnesium and its application
The density of pure magnesium is 1.74g/cm³ at 20°C, which is 2/3 times of that of aluminum. It is the lightest metal in structural materials. The melting point is 650 °C, which is equivalent to that of aluminum. The boiling point is 1090 °C, the vapor pressure is very high, and it is 1.04kpa at 727 °C, which is easy to burn when melting. In developed countries, 49.8% of magnesium output is used in aluminum alloying, 17% in preparation of die casting magnesium alloy, 14.8% in desulfurization of iron and steel metallurgical process, 5.6% in nodularizing agent of nodular cast iron, 6.3% in electronics and chemical industry, 1.8% in manufacturing wrought magnesium alloy, 1.3% in reducing metal, 0.6% in ordinary casting and 2% in other applications. The development of new magnesium alloys has great potential.

2.2. Advantages of magnesium alloys used as structural materials
High integrated, low-quality, multi-functional, high-speed information generation, transmission and imaging equipment requires that new materials must have good damping, heat dissipation and anti electromagnetic interference performance in physical properties; high specific stiffness and specific strength in mechanical properties; beauty and touch in vision and feeling; energy saving and renewable in ecology. Compared with other alloys, the biggest advantage of magnesium alloy is its light weight, its density is about 64% of that of aluminum alloy, and the elastic modulus of 23% mg of steel is lower than that of al. When it is used as stressed parts, it is necessary to use stiffeners or increase the section thickness of parts properly. However, the weight of the parts can be reduced by about 20%. Magnesium alloy is characterized by good machinability, and its cutting speed is much higher than other metals. Another outstanding feature is that it does not need grinding and polishing. Other properties of magnesium alloy include damping, dimensional stability, impact and compression resistance, as well as high thermal conductivity, non-toxic, non-magnetic, not easy to break and so on. However, the space to reduce the engine mass through structural optimization design is very small. The lightest magnesium alloy in structural materials has friendly biocompatibility [8], the highest specific strength and stiffness, excellent process performance, good corrosion resistance, good thermal conductivity, vibration reduction and electromagnetic shielding. It is considered to be the most promising material for the preparation of shell and frame of electrical products, transportation tools and aerospace vehicle parts. China is rich in magnesium resources, and the price is equivalent to that of aluminum, which provides the necessary resource guarantee for the development of China's aerospace pillar industry and the development of new magnesium alloys.

2.3. Application of ultra high strength magnesium alloy in the world
Due to the few varieties, low strength and poor plasticity of magnesium alloys, the comprehensive development of magnesium and magnesium alloys has become an international consensus, and there are three main R & D directions: reducing production cost, researching and developing product preparation process, anti-corrosion and surface treatment, improving mechanical properties of alloy at room and high temperature, developing new materials, further developing applications in aerospace field, rapid solidification and subsequent processing. The reason why rapid solidification is regarded as one of the important research directions is that rapid solidification can be used to study the basic principle of solidification process and prepare ultra-high performance non-equilibrium materials. Generally, the strength of magnesium alloy prepared by rapid solidification is more than 500 MPa and the specific strength is more than 250 MPa (gcm³), so it is called ultra-high strength magnesium alloy. In recent years, the application of rapid solidification in magnesium alloy has achieved gratifying results. The tensile strength of ultra-high strength magnesium alloy has reached 935Mpa, and the specific strength has reached 480Mpa (gcm³), which is far higher than that of ultra-high strength titanium alloy (tensile strength 1167Mpa, specific strength 260Mpa (gcm³)). It is found that the metastable phase below 300°C can be obtained by adding y and hree into magnesium alloy. This kind of alloy has excellent room
temperature, high temperature properties and corrosion resistance after strengthening by metastable phase under the condition of ensuring the same process properties.

At present, magnesium alloy materials for aerospace applications include AZ91E、QE22、ZE41、EQ21、EZ33 and WE43. Its typical applications include BR710 engine box parts (part size 1400mmX500mmX700mm, mass 34kg), main drive box of tiger helicopter (size 600mmX500mmX800mm, The mass is 57kg) and tail navigation system box, t117 gas turbine engine drive system parts (size is Φ350mmX4000mm); Eurofighter tail navigation casting (size is Φ450mm X350mm) prepared by qe22; engine box parts (size is 400mmX320mmX650mm) prepared by ZE41, It is reported that the ultra-high strength magnesium alloy has been used in a variety of key parts of aircraft thruster cold chamber in the United States and Israel. The parts of ultra-high strength magnesium alloy are made by pressure forming and mechanical connection. However, all the manufacturing processes of aerospace and aircraft parts made of ultra-high strength magnesium alloy are highly confidential. The research work of ultra-high strength magnesium alloy in China has just started. In order to develop China's aerospace technology, especially the manned aircraft and space laboratory, the research and development of ultra-high strength magnesium alloy has important practical significance.

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3.1. summary

Mg Li alloy is the lightest alloy at present and its density is generally 1.35-1.65, which is 1/2-2/3 of aluminum alloy system, 3/5-3/4 of ordinary magnesium alloy, which is lighter than many inorganic and organic substances such as glass rubber. Mg Li alloy has high specific strength, specific rigidity, elastic modulus and good high and low temperature toughness. At the same time, it also has the advantages of damping and damping, heat conduction, electromagnetic shielding, high energy particle penetration resistance, excellent mechanical processing performance and easy to return, etc. it has advantages in aviation, aerospace, automobile, 3C There are great potential for development in industries, medical devices and other fields. It can partly replace aluminum and aluminum alloy materials which are currently used in aerospace field, and have a wide application prospect.

3.2. The problems and technical difficulties of Mg Li alloy

① The melting cost of Mg Li alloy is high: the melting equipment and technology of Mg Li alloy are complex, so it needs further exploration.

② Mg Li alloy has low absolute strength: it is necessary to further improve the mechanical properties of Mg Li alloy by alloying and new processing methods.

③ The temperature range of Mg Li alloy is low (not higher than 423K), while the temperature range of Mg Li alloy is lower. This severely limits the use range of Mg Li alloy.

④ The mechanical stability of Mg Li alloy is poor: This is the difficulty to be solved for Mg Li alloy. It is necessary to further study the aging mechanism of Mg Li alloy, and improve the mechanical stability of Mg alloy by new ideas and new technology.

⑤ The corrosion resistance of Mg Li alloy is very poor: the stress corrosion sensitivity of Mg Li alloy in humid atmosphere is very high. When mg-13li-al alloy was subjected to ring stress corrosion test in 0.01% NaCl solution, the alloy was corroded into powder. It can be seen that the surface treatment technology of Mg Li alloy has become the key factor restricting the wide application of Mg Li alloy.

4. Selection and analysis of magnesium alloy materials in products

Mars exploration is a hot spot in the space competition among big powers. From China's "tianwen-1" to the United States' ‘willpower’, Mars exploration has attracted worldwide attention. The detector consists of four pairs of ranging antenna, each of which consists of a transmitting antenna and a receiving antenna. Eight beams are generated; the antenna is fixed on the cabin board. The function is to transmit and receive microwave energy in the corresponding frequency range.
Combined with the practical application requirements and esa-ps-03-203-44 magnesium alloy and its composites, the magnesium alloy (ZK60A T5) with the highest mature performance and strength is selected. The allowable load is 285mp, the density is only 1.8g/cm3, and the density is 2/3 of that of aluminum. The surface treatment process of electroless nickel plating after integral processing has good mechanical properties and anti-corrosion properties in addition to lightweight products. Through modal analysis and experimental verification, the product has good performance.

5. Concluding remarks
With the rapid development of aerospace, military industry and automobile industry, the traditional light alloy materials such as aluminum, magnesium and ferroalloy can not meet the design requirements of high-performance spacecraft, aircraft, missile and automobile. The demand for new light materials with light weight, strong rigidity, high strength and toughness, high temperature resistance and corrosion resistance is increasing day by day. The new magnesium alloy and magnesium lithium alloy materials are characterized by light density, strong matching adaptability of coefficient of thermal expansion, and can change the coefficient of thermal expansion according to the change of carbon content. At the same time, they have excellent thermal conductivity and corrosion resistance. In addition, magnesium alloy materials also have low density, excellent performance of vibration reduction, heat dissipation and anti electromagnetic interference. Because of its high specific stiffness and strength, it has a wide application prospect in the field of aerospace vehicles.

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