Research Progress on the Application of Magnesium Alloy Materials

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Abstract

Magnesium alloy is widely used in automobile, aerospace, building structure and other fields because of its high specific strength, low density and good machinability. The wide application of magnesium alloy materials plays a key role in promoting structural lightweight and energy saving and emission reduction. Under the background of "double carbon", magnesium alloy materials have a broad application prospect. This paper analyzes the properties and classification of magnesium alloy materials, describes the forming process of magnesium alloy, analyzes the application of magnesium alloy in automotive, aerospace and other fields, summarizes the application of magnesium alloy in construction industry, and looks forward to its application prospects.

Keywords

Magnesium alloy; ratio of strength; material properties; forming process; building structure.

1. Introduction

The rapid development of the global economy has made resource shortages and environmental pollution issues that cannot be ignored. In the manufacturing sector, the lightweighting, greening, and functionalization of materials have become increasingly important [1]. Magnesium is one of the most abundant metallic elements on Earth, and compared to minerals like iron and aluminum, its resources are more secure. Global magnesium production is concentrated in China, with 95% of Europe's magnesium imported from our country. Fugu County in Shaanxi Province is rich in magnesium, with a raw magnesium output of 448,900 tons in 2021, accounting for nearly half of the national output and 40% of the global output. The 2023 Magnesium Industry Major Events Report pointed out that the magnesium industry has greater development potential under the "dual carbon" goals, and the state has also introduced multiple policies to promote the development of the magnesium industry. Magnesium alloys, with their excellent specific strength and superior machinability, stand out in many fields and are hailed as "green engineering materials of the new era." Their main application areas include construction, automotive, electronics, aerospace, and more [2-3]. This article analyzes the properties, classification, and forming processes of magnesium alloy materials, elaborates on their applications in various industries, and looks forward to the prospects of magnesium alloy materials in the construction industry.

2. Performance and Classification of Magnesium Alloy Materials

2.1. Characteristics of Magnesium Alloys

Magnesium alloys have low density, high specific strength, high specific stiffness, good shock absorption, good corrosion resistance, machinability, good casting performance, good thermal conductivity, and good electrical conductivity. The density of magnesium alloys is approximately 2/3 that of aluminum alloys and 1/4 that of steel. The application of magnesium alloy materials can effectively reduce the structural weight. Aluminum alloys and steel are

inferior to magnesium alloys in terms of specific strength, with the latter exhibiting higher loadbearing performance at the same mass. In terms of specific stiffness, magnesium alloys are comparable to aluminum alloys and steel, with similar resistance to deformation under external forces. Magnesium alloys are lightweight and high-strength, meeting the requirements for strength and stiffness while saving energy, reducing consumption, and minimizing pollution. Magnesium alloys have excellent shock absorption properties, superior to aluminum alloys, and can effectively absorb energy, achieving noise reduction and shock absorption effects.

2.2. Classification of Magnesium Alloys

By adding elements such as aluminum, zinc, manganese, zirconium, and rare earths, five different types of magnesium alloy series can be formed. The binary magnesium alloys mainly include magnesium-aluminum, magnesium-manganese, magnesium-zinc, magnesium-rare earth, and magnesium-zirconium series, while the ternary magnesium alloys mainly include magnesium-aluminum-zinc, magnesium-aluminum-manganese, magnesium-rare earth-zirconium, and magnesium-zirconium series. The AZ series is widely used in engineering, particularly the cast magnesium alloy AZ91 and the wrought magnesium alloys AZ31, AZ61, and AZ80. According to the performance classification of magnesium alloys, they can be categorized as: corrosion-resistant, heat-resistant, ultra-light, thermally conductive, high-strength, and highly ductile.

3. The application of magnesium alloys

3.1. Application of Magnesium Alloys in the Automotive Industry

Currently, although steel and aluminum alloys dominate the automotive industry, magnesium alloys are gradually emerging due to their excellent overall performance. Magnesium alloys outperform steel and aluminum alloys in several key performance indicators, particularly their lightweight characteristics, making them an ideal material. Using magnesium alloys to replace steel and aluminum alloys can effectively reduce vehicle weight and improve fuel efficiency, aligning with the current automotive industry's trend towards lightweighting, energy conservation, and emission reduction. Magnesium alloy materials can be used to make components such as valve covers, steering wheel frames, and exhaust pipes [4].Magnesium alloy materials have excellent shock absorption properties, capable of absorbing the energy generated during collision impacts, preventing significant deformation of the vehicle's internal structure, and ensuring passenger safety. The application of magnesium alloy materials in the automotive industry is becoming increasingly widespread, with the most common uses being in steering wheel frames, dashboard bases and steering columns, seat frames, and steering wheel shafts, most of which are die-cast parts.

3.2. The application of magnesium alloy materials in aerospace

Due to the lightweight and high strength of magnesium alloys, they are widely used in the aerospace field[5]. The applications of magnesium alloy materials in aerospace mainly include aircraft wall panels, hubs, pilot seats, aircraft generator parts, satellites, and space probes. Magnesium alloys have good energy storage and electrical properties, making them suitable for the energy subsystems of spacecraft[6].

3.3. The application of magnesium alloy materials in electronic products

Due to the lightweight and rapid heat dissipation characteristics of magnesium alloy materials, they are widely used in electronic products such as laptop casings, mobile phone cases, cameras, and communication devices. Ashraf et al. [7] summarized the current status and challenges of using magnesium alloy materials for electromagnetic interference shielding devices, discussed the impact of alloy composition, microstructure, thickness, and other factors on the

electromagnetic shielding effectiveness of magnesium alloys, and pointed out the advantages of magnesium-lithium alloys in electronic products. Wang et al. [8] studied the strength and plasticity of AZ61 plates with different rare earth contents and found that adding 0.9% rare earth not only improved the strength but also significantly enhanced the plasticity.

4. The application prospects of magnesium alloy materials in the construction industry

Magnesium alloy materials are widely used in building facades, construction formwork, and vibration damping energy dissipation structures. Magnesium alloy materials have characteristics such as high strength and ease of forming, making magnesium alloy curtain walls applicable in high-rise and super high-rise buildings, thereby playing a role in energy saving and consumption reduction. Compared to traditional steel and aluminum alloy curtain wall materials, the lightweight characteristics of magnesium alloys can significantly reduce the self-weight of building structures, strongly promoting the application of magnesium alloys in building structures. Magnesium alloy formwork is lighter than aluminum alloy formwork. For the same weight of raw materials, magnesium alloy formwork can produce one and a half times the area of aluminum alloy formwork. Magnesium alloy formwork is a green building material that aligns with green development strategies, is recyclable, and offers high cost-effectiveness.

5. Conclusion

In recent years, researchers have conducted some studies on the performance characteristics, anti-corrosion, and processing technology of magnesium alloy materials, which have significantly promoted the application of magnesium alloys in various fields. Due to their advantages of being lightweight, high-strength, highly malleable, and recyclable, magnesium alloys have been widely used in multiple domains. Applying them in building structures can achieve lightweight, functional, and green structures, which is of great significance for China's low-carbon development. In the application of magnesium alloys, it is necessary to balance the issues of cost and strength, accelerate the development of low-cost, high-quality magnesium alloy products, and continuously improve smelting technology and magnesium alloy materials in building structures is not deep enough and needs further improvement. At the same time, it is necessary to formulate comprehensive technical standards and relevant design specifications based on different types of buildings to promote their healthy and rapid development.

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