ISSN: 1813-4890

Current state of aluminum alloy material development

Wenqing Li

Shandong Jiaotong University, Weihai 264200, China

Abstract

This article comprehensively analyzes the current application status of aluminum alloy materials in aerospace, transportation, and other fields, discussing the industrial scale and technological level of aluminum alloy materials in our country. It addresses the shortcomings in some key aluminum alloy materials in our country, as well as the deficiencies in original technologies such as the development of high-performance aluminum alloys, processing techniques, and intelligent control. The article systematically outlines the main issues currently present in aluminum alloy materials in our country. In response to the development trends in the automotive, maritime, and aerospace sectors, the market demand for aluminum alloy materials has been analyzed. Based on the current state of the aluminum alloy materials industry in our country, the following development strategies and recommendations are proposed: strengthen the construction of the R&D system and improve the development environment; optimize the structure to promote quality improvement, efficiency enhancement, and coordinated development; enhance supporting policy support; advance talent team building; and promote smart manufacturing and "Internet+" initiatives. Strengthen international cooperation, especially under the "Belt and Road" initiative. This provides important references for solving the "bottleneck" problem of aluminum alloy materials and for the development of aluminum alloy materials towards high-end and green directions.

Keywords

Aluminum alloy, intelligent control, coordinated development, international cooperation.

1. Introduction

Our country is a major producer and consumer of aluminum alloy materials. Aluminum alloy materials have a wide range of applications in transportation, marine, aerospace, and other fields. They are particularly irreplaceable in key lightweight components in sectors such as automobiles, aircraft, aerospace, and ships[1]. The vast majority of aluminum alloy materials in the country are mid-to-low-end products, characterized by high energy consumption, low efficiency, high costs, and low added value. The situation of vicious competition is difficult to change, and some high-end products still need to be purchased at high prices from abroad, which undoubtedly hinders the upgrading of our manufacturing industry. Although our country has significant advantages in fields such as communication and high-speed rail, the increasingly complex changes in the international situation have highlighted the risks of being "choked" in key materials, making independent innovation urgent. In the new industrial context, developing green and intelligent preparation and processing technologies for high-end aluminum alloy materials is of great strategic significance for supporting the sustainable and high-quality development of our key manufacturing industries[2]. This article mainly introduces the development and research status of aluminum alloy materials at home and abroad, analyzes the market demand for commonly used aluminum alloy systems, summarizes the current problems encountered in this field in our country and the future development goals,

ISSN: 1813-4890

and provides corresponding development strategies to promote the upgrading and progress of related industries.

2. Current Status of Aluminum Alloy Applications

2.1. Application of aluminum alloys in the transportation sector

Nowadays, the key issue facing the transportation sector is energy conservation and environmental protection. Choosing aluminum alloys in terms of materials is an effective means to truly achieve this goal[3]. Therefore, since 1980, aluminum alloy materials have begun to become the main materials in the transportation industry. Currently, the usage of aluminum alloy materials in the transportation sector has exceeded 25%, with the automotive industry alone accounting for over 15%. This has gradually made it the largest field for aluminum alloy material usage worldwide.

Aluminum alloys themselves possess excellent impact resistance, vibration resistance, and tensile strength, meeting the material selection standards for automobiles and high-speed trains. Additionally, the density of aluminum alloys is only 33% that of steel materials, which reduces the weight of the vehicle, decreases driving resistance, and consequently saves fuel consumption. Aluminum alloys themselves also possess good wear resistance and corrosion resistance, eliminating the need for rust removal. This significantly reduces maintenance and manufacturing costs. More importantly, compared to traditional steel, aluminum alloys are more convenient for recycling. Typically, the recycling value of a scrapped car with an aluminum structure is six times higher than that of a steel-structured car. Therefore, aluminum alloys are widely used in the structural components of motorcycles, trains, high-speed trains, and subways, as well as in air conditioning systems, and in the skins and armor plates of various types of yachts and cruisers.

2.2. Application of aluminum alloys in the aerospace field

In 1972, Alcoa successfully developed a new type of 7075 alloy using trace elements such as Ti and Mn, and applied aluminum alloy on the Boeing 747, smoothly opening the curtain on the large-scale production of aluminum alloy in aircraft. Currently, aluminum alloys have become the primary material for lightweighting spacecraft and aircraft, with approximately 76% of the structural components of civilian aircraft made from aluminum alloys. For example, the aluminum alloy usage in the Airbus A380 is about 71%. At present, almost all types of aluminum alloys on the market can be used in the aerospace field. Because AL-Zn-Cu has high strength and good machinability, it is often used as structural material for aircraft, such as load-bearing components and frames. AL-Li alloys, due to their low density and good low-temperature toughness, are widely used in the manufacture of cryogenic fuel tanks for rockets and aircraft.

2.3. Application of aluminum alloys in the electronics and electrical fields

Today, approximately 6% of the primary aluminum produced globally each year is used in the electronics and electrical fields, with aluminum alloys being the main material for electronic conductors. To delve deeper, firstly, in terms of price, aluminum alloys are significantly cheaper than copper alloys, which can strictly control the cost of laying cables. Secondly, because the density of aluminum alloys is lower than that of copper alloys, this allows aluminum alloys to achieve the required electrical conductivity while being lighter, thereby significantly reducing transportation costs. Additionally, the recycling rate of copper alloys is not as high as that of aluminum alloys, and they have higher corrosion resistance, which can reduce maintenance costs. Currently, aluminum-clad steel core aluminum stranded wires are commonly used in high-voltage transmission lines. This type of aluminum alloy has characteristics such as high strength and good conductivity. There is also a significant demand in the household appliance

ISSN: 1813-4890

sector and the computer field, especially for computer disk substrates and packaging materials for household appliances.

3. The future development trends of aluminum alloys

With the continuous advancement of technology and the ongoing process of economic globalization, it is believed that the aluminum alloy industry can achieve rapid development in the near future and begin to replace steel. Its development trend is mainly reflected in the following aspects: optimizing production capacity structure, concentrating on products with superior performance in terms of corrosion resistance, financial resources, human resources, and material resources, in order to meet the needs of the transportation sector, the electrical packaging sector, and the aerospace sector. Developing aluminum matrix composites. Under the premise of the original alloy properties, many new aluminum matrix composites exhibit better physical and mechanical properties, making them a major avenue for future development and research[4]. The development and popularization of comprehensive utilization technology, recycling technology, and recovery technology for aluminum alloys have led to continuously increasing recycling rates. Innovative process equipment, improved production and processing methods, enhanced aluminum alloy production quality, and accelerated production speed [5].

4. Conclusion

Aluminum is abundant in the Earth's crust, and aluminum alloys have advantages such as high strength-to-density ratio, good fluidity, strong filling ability, good castability, low melting point, good machinability, non-toxicity, and ease of recycling. Therefore, aluminum alloys have rapidly developed in many fields. However, with the rapid development of the automotive industry, the use of ordinary aluminum alloy materials to manufacture engine component pistons can no longer meet the demand, and there is an urgent need to develop high-temperature, high-strength aluminum alloys. Aluminum alloys can reduce the weight of the ship's hull, increase sailing speed, and save energy and reduce emissions when used in shipbuilding. To expand the application of aluminum alloys in the shipbuilding industry, new processes and products can be developed to lower production costs and enhance the welding performance, mechanical properties, and corrosion resistance of aluminum alloys.

References

[1] Dursun T, Soutis C. Recent developments in advanced aircraft aluminium alloys[J]. Materials & Design, 2014, 56: 862-871.

[2] Bai S, Huang T, Xu H, et al. Effects of small Er addition on the microstructural evolution and strength properties of an Al-Cu-Mg-Ag alloy aged at 200 °C[J]. Materials Science and Engineering: A, 2019, 766: 138351.

[3] Lumley R N, Polmear I J, Morton A J. Interrupted aging and secondary precipitation in aluminium alloys[J]. Materials Science and Technology, 2003,19(11): 1483-1490.

[4] Tang C, Luo B, Bai Z, et al. Effect of non-isothermal ageing on microstructure and mechanical properties of an Al-Cu-Mg-Ag alloy[J]. Materials Science and Engineering: A, 2022, 830: 142315.

[5] Nie J F, Muddle B C. Microstructural design of high-strength aluminum alloys[J]. Journal of Phase Equilibria, 1998, 19(6): 543