PROSPECTS FOR CREATING LIGHTWEIGHT STRUCTURES BASED ON MAGNESIUM ALLOYS.

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Abstract: This article explores the prospects of developing lightweight structures based on magnesium alloys, focusing on their physical-mechanical properties and industrial applications. Due to their high strength, low density, and excellent machinability, magnesium alloys are widely used in the automotive, aerospace, and space industries. The study presents a comparative analysis of various alloys and identifies promising development directions.

Keywords: Magnesium alloys, lightweight construction, density, strength, corrosion, processing, aviation, automotive, structural material, innovation.

Аннотация: В данной статье рассматриваются перспективы создания легких конструкций на основе магниевых сплавов, их физико-механические свойства и сферы применения. Благодаря высокой прочности, низкой плотности и хорошей обрабатываемости магниевые сплавы широко используются в автомобильной, авиационной и космической промышленности. В исследовании проведен сравнительный анализ различных сплавов и обозначены перспективные направления развития.

Ключевые слова:Магниевые сплавы, легкая конструкция, плотность, прочность, коррозия, обработка, авиация, автомобилостроение, конструкционный материал, инновации.

Annotatsiya: Ushbu maqolada magniy qotishmalari asosida yengil konstruksiyalar yaratish imkoniyatlari, ularning fizik-mexanik xossalari va sanoatdagi qo‘llanilishi o‘rganilgan. Magniy qotishmalari yuqori mustahkamlik, past zichlik va yaxshi ishlov berish xususiyatlari tufayli avtomobilsozlik, aviatsiya va kosmik sanoatida keng qo‘llanilmoqda. Tadqiqotda turli qotishmalar taqqoslab tahlil qilinib, istiqbolli yo‘nalishlar aniqlangan.

Kalit so‘zlar: Magniy qotishmalari, yengil konstruksiya, zichlik, mustahkamlik, korroziya, ishlov berish, aviatsiya, avtomobilsozlik, strukturaviy material, innovatsiy.

Introduction

One of the important directions of modern industry is the development of products based on lightweight, durable and environmentally friendly structural materials. In this regard, magnesium alloys are attracting attention with their low

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density (around 1.74 g/cm³), high strength and good processing capabilities. Especially in the automotive, aviation and space industries, where it is important to reduce fuel consumption and increase overall efficiency by reducing weight per kilogram, magnesium alloys are recognized as one of the most promising materials. At the same time, these materials have sufficiently favorable properties in terms of electrical and thermal conductivity, and they are widely used in modern electronic devices and heat exchangers. In order to increase the mechanical strength of magnesium alloys, alloys of various grades are formed by alloying them with elements such as aluminum, zinc, manganese, silicon.

In recent years, research has been actively conducted on the creation of a new generation of lightweight structures based on magnesium alloys. In particular, they, in combination with microalloying, nanomodification, and coating technologies, allow for a significant improvement in mechanical properties. Magnesium alloys, despite their low density, have the ability to create structures that can withstand large loads. This allows structures based on them to be 25–30% lighter than parts made of heavy metals. However, since the corrosion resistance of magnesium alloys is relatively low, special surface treatments, protective coatings, and composite layers are applied to them. This article analyzes the physical and mechanical properties of magnesium alloys, their industrial applications, methods of alloying them, and the advantages of lightweight structures based on them. Based on the research, promising directions and practical recommendations are developed.

Research and methods: The main objective of the study was to analyze the physical and mechanical properties of magnesium alloys and assess the prospects for creating lightweight structures based on them. The study studied magnesium alloys of the AZ31, AZ91, AM60, ZK60 and WE43 brands, which are widely used in the automotive industry. Each alloy was evaluated in terms of composition, density, tensile strength, machinability and corrosion resistance. Based on analytical analyses, the most important indicators of the alloys were presented in tabular form. Also, the suitability of each alloy was assessed based on criteria such as deformation under tension, heat retention and structural stability. Experimental data were formed on the basis of laboratory tests and confirmed values from literature sources.

According to the results of the analysis, WE43 and ZK60 alloys have the highest mechanical properties and are recommended for use in structures under high loads. AZ91 and AM60 alloys, with their moderate density and good workability, are important for creating the lightest structures. The table below presents the main properties of the five selected main magnesium alloys. In

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addition, the relationship between the density (g/cm³) and the tensile strength (MPa) of these alloys is compared in the form of a figure. The graph shows that as the density increases, the mechanical strength also increases, which indicates the importance of finding the optimal balance between weight and durability.

Table-1

Main properties of magnesium alloys.

Alloy name	Density (g/cm³)	Strength (MPa)	Machinability	Corrosion resistant	Application Area
AZ31	1.78	260	Good	Average	Automotive Frames, Covers
AZ91	1.81	300	Average	Good	Engine Parts
AM60	1.80	280	Good	Good	Wheels, Bodies
ZK60	1.83	320	Difficult	Average	Sports Structures
WE43	1.85	350	Difficult	High	Aviation and Space Parts

Results and discussion: The results of the study confirmed the wide possibilities of creating lightweight but strong structures based on magnesium alloys. In particular, WE43 and ZK60 alloys showed high tensile strength (350 MPa and 320 MPa), which made them suitable for structural elements that can withstand high loads. These two alloys are able to maintain their properties when operating at high temperatures, especially since WE43 is alloyed on the basis of aluminum and rare earth elements (Yttrium, Neodymium), it is highly heat-resistant, which is also a prerequisite for the aviation and space industries. At the same time, AM60 and AZ91 alloys are widely used in automobile bodies, wheel disks and cladding parts due to their low density (≈1.80 g/cm³) and easy processing capabilities. ZK60, on the other hand, is effectively used in sports structures, for example, bicycle frames and racing car parts, due to its high elasticity and energy-absorbing properties.

One of the main advantages of magnesium alloys is an increase in overall energy efficiency by reducing weight. In the automotive industry, this means a reduction of up to 100 kg, which reduces fuel consumption by 5–7%. In aviation, a weight reduction of 1 kg provides energy savings equivalent to 3–5 kg of fuel. However, some limitations were also noted during the study: magnesium alloys, being highly active elements, are susceptible to corrosion, therefore, it is necessary to apply hard surface coatings, anodizing or special composite coatings to them. At the same time, the complexity of processing some alloys requires a technological approach for industrial use. These results show that, despite the great prospects for creating lightweight structures, magnesium alloys have certain engineering and

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technological compatibility when using them. In the future, their scope of application can be expanded by further improvement, in particular, by nano-modification, the creation of hyperalloyed compositions and the formation of hydrophobic surfaces.

Conclusion: Magnesium alloys are among the most important materials for creating modern lightweight structures. Studies have shown that these alloys, with their low density, sufficiently high strength and good machinability, create wide opportunities in the automotive, aviation, space and sports industries. In particular, high-performance alloys such as WE43 and ZK60 are suitable for complex structural elements due to their load-bearing capacity and heat resistance, while AZ91 and AM60 grades are advantageous in the manufacture of lightweight parts due to their low cost and ease of processing. However, magnesium alloys also have some significant disadvantages: low corrosion resistance, sensitivity of some to fire, the need for precision in processing, as well as the complexity of alloying technology. Therefore, the development of surface-strengthening coatings, composite alloys and advanced protection methods for their widespread industrial application is an urgent task. In addition, the functional capabilities of these materials can be further expanded through the use of new generation alloys, especially nanoalloys or modified compositions with environmentally friendly components. In conclusion, lightweight structures based on magnesium alloys are one of the effective alternative solutions for reducing weight, increasing fuel efficiency, and reducing environmental damage in the near future. Their scientific development and practical implementation will serve as the basis for new technological approaches in many industrial sectors.

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