Cilt: 5 Sayı: 1 Yıl: 2026 Review e-ISSN: 2980-0064

Comparative Analyses of Materials Used in the Body Structure of UAVs

Bahri Kaan SARIKAYA[1*] **Oğuzhan YAYKIN**[2] **Ali TEMİR**[3] **Sezer ÇOBAN**[4]

[1] Iskenderun Technical University, Faculty of Aeronautics and Astronautics, Aircraft Maintenance and Repair, Hatay, Türkiye

Article Info

Received: 05.01.2026
Accepted: 15.05.2026
Published: 30.06.2026

Keywords:
UAVs,
Fuselage,
Material.

ABSTRACT

Unmanned Aerial Vehicles (UAVs) have an increasingly important role in many civilian and military fields such as defense, agriculture, logistics, and surveillance. With the advancement of technology, the performance, durability, and operational efficiency of UAVs have significantly improved. One of the most critical factors in meeting these expectations is the type of materials used in the manufacturing of the UAV airframe. The materials selected for the airframe structure directly affect the vehicle's weight, fuel or energy consumption, maneuverability, and overall reliability. This article examines the main materials currently used in UAV airframe structures and compares the reasons for their use from mechanical, structural, and economic perspectives.

İHA'ların Gövde Yapısında Kullanılan Malzemeler

Makale Bilgisi

Geliş Tarihi: 05.01.2026
Kabul Tarihi: 15.05.2026
Yayın Tarihi: 30.06.2026

Keywords:
İHA,
Gövde,
Malzeme.

ÖZET

İnsansız Hava Araçları (İHA), savunma, tarım, lojistik ve gözetleme gibi birçok sivil ve askeri alanda artarak ilerleyen bir öneme sahip olmaktadır. Gelişen teknolojiyle birlikte, İHA'ların performans, dayanıklılık ve operasyonel verimlilik oranları da önemli ölçüde artmıştır. Bu beklentileri karşılamada en önemli unsurlardan biri, İHA gövdesinin imalatında kullanılan malzeme türleridir. Gövde yapısında tercih edilen malzemeler, aracın ağırlığı, yakıt veya enerji tüketimi, manevra kabiliyeti ve genel güvenilirliği üzerinde etkilidir. Bu makalede, günümüzde İHA gövde yapılarında kullanılan başlıca malzemeleri incelemekte, bu malzemelerin kullanılma sebeplerini ve farklı malzeme türlerinin mekanik, yapısal ve ekonomik açıdan karşılaştırılmıştır.

To cite this article:

Sarıkaya, B. K., Yaykın, O., Temir, A., & Çoban, S. (2026). İHA'ların gövde yapısında kullanılan malzemeler. *Aerospace Research Letters (ASREL).* 5(1), 53-58.

***Corresponding Author:** Bahri Kaan Sarıkaya, bahrikaans@gmail.com

INTRODUCTION

Unmanned Aerial Vehicles (UAVs) have become an important field of research in terms of materials science and structural engineering due to their increasing use in military, civil, and commercial areas in recent years. The design of UAV airframe structures is directly associated with various parameters such as aerodynamic efficiency, structural strength, weight, and cost. For this reason, the selection of airframe materials has been systematically examined in the literature. In their study, Prabhat Singh (2020) analyzed UAV airframe systems using the finite element method (FEM), comparing carbon fiber reinforced polymer (CFRP) and aluminum alloys. The research results indicate that CFRP materials exhibit three times higher tensile strength and 40% lower density, leading to a significant improvement in vibration performance. In his 2025 study, Hu analyzed the fuselage and wing designs of fixed-wing, rotary-wing, and hybrid UAVs. The research states that carbon fiber composites increase energy efficiency by 25–40% thanks to their high stiffness (230–600 GPa) and low density (1.55 g/cm^3). Although aluminum alloys are less costly, they are insufficient in terms of strength. Additionally, it is emphasized that by combining 3D printing technologies with carbon fiber structures using thermoplastic matrices, lightweight airframes with complex geometries can be produced. In the study conducted by Kassimov et al. (2025), the mechanical and aerodynamic properties of carbon, aramid, and glass fiber reinforced composites were compared. According to the findings, the drag coefficient of carbon composites (Cd = 0.018) was approximately 28% lower than that of aluminum (Cd = 0.025), increasing flight endurance by up to 35%. Moreover, the vibration amplitude of carbon fiber plastics was measured as 0.4 mm, with a deformation rate of 1.2%; these values provide nearly twice the vibration stability of aluminum. The study conducted by Fahadh (2025) emphasizes that material selection should consider not only mechanical properties but also environmental and economic impacts. Although CFRP materials offer high performance, they are weak in terms of recyclability, whereas aluminum alloys are fully recyclable and therefore represent a long-lasting (15–20 years) and environmentally friendly alternative. In addition, graphene composites, basalt fibers, and natural fiber reinforced composites are highlighted as promising sustainable UAV materials of the future. In the research conducted by Yıldız (2018), durability/cost analyses of aluminum, carbon fiber, and fiberglass materials were carried out. Carbon fiber was reported to provide up to three times higher strength, but its production cost is approximately 200% higher than that of aluminum. In their 2022 study, Akbulut and Karabulut stated that hybrid material use can increase airframe rigidity, and optimizing heat resistance and fatigue life can enable the production of long-lasting UAV structures. A recent MDPI (2024) publication also reported that producing carbon fiber reinforced polymers via 3D printing reduces structural complexity and shortens production time by up to 40%. This development is considered an important innovation for rapid prototyping in small and medium-sized UAVs. The literature review demonstrates that the selection of UAV airframe materials requires a multidimensional evaluation in terms of performance, cost, and environmental impact. Carbon fiber–based composites currently offer the highest performance, while aluminum and glass fiber are known as low-cost alternatives. In the future, new-generation materials such as graphene, basalt, and natural fibers are expected to play a significant role in terms of both lightweight design and sustainability.The name and abbreviation of the journal should be added in the header of the page with the introduction. At the bottom of the page, there should be only the page number.

METHODOLOGY

In this study, the materials used in the airframe structure of unmanned aerial vehicles (UAVs) were first identified. A comparative analysis was then carried out based on the selected material types. In evaluating the material properties, existing academic sources, scientific journals, and recent articles were reviewed. Within this scope, studies in the literature were examined, and performance analyses of each material in terms of durability, efficiency, application area, and cost were obtained. The findings were interpreted by organizing them into a comparative table.

FINDINGS

The obtained data show that the most commonly used metals in UAV airframe structures are aluminum, titanium, and magnesium alloys. These materials are preferred due to their characteristics such as light weight, high strength, and ease of manufacturability. Aluminum alloys are generally used in medium-range civil UAVs because their high strength-to-weight ratio, low cost, corrosion resistance, and machinability allow them to be effectively utilized in the airframe structure and connection components. Magnesium alloys are used in areas exposed to vibration due to their lower density (approximately 1.7 g/cm³). These alloys reduce vibrations occurring during flight thanks to their high damping capability, thereby increasing stability. Titanium alloys, on the other hand, are mostly used in high-speed or high-altitude UAVs designed for military purposes. Titanium offers high heat resistance and corrosion resistance. Hybrid systems combining titanium and carbon fiber form one of the most efficient combinations in terms of service life and structural integrity. Despite these advantages, the widespread use of titanium is limited due to its high cost.

Table 1
Comparison of Metal Materials

Properties	Aluminum Alloys	Magnesium Alloys	Titanium Alloys
Density (g/cm³)	~2.70	~1.74	~4.50
Heat Resistance (°C)	150-200	120-150	400+
Vibration Damping	Medium	High	Low/Middle
Elastic Modulus (GPa)	68-72	43-45	100-115
Corrosion Resistance	Medium/High (with oxide layer)	Low (requires protective coating)	Very High
Ease of Repair	High	Medium	Low
Cost	Low	Medium	High
Application Area	Airframe structure, connection points, medium-range civil UAVs	Arms, components exposed to vibration	Engine mounts, high-temperature zones, military UAVs
Advantages	Low cost, durable, easy to machine	Lightest metal, high vibration damping	Most durable, high heat and corrosion resistance
Disadvantages	Heavier compared to composites	Prone to corrosion, limited mechanical strength	Very expensive, difficult to machine

Metal alloys in UAV airframe structures have increasingly been replaced by composite materials. This shift is due to the superior performance of composites in terms of light weight and aerodynamic compatibility. Carbon fiber reinforced polymers (CFRP), in particular, stand out for their high specific strength. CFRP materials, with low density (~1.6 g/cm³) and high elasticity, enhance both durability and aerodynamic efficiency. According to research, in high-altitude UAVs using carbon fiber airframes, the structural weight can be reduced to up to 40% of the total weight, which increases flight range by approximately 10–12%. Glass fiber reinforced polymers (GFRP) are less expensive than carbon fiber and are preferred in lower-cost UAVs. Although GFRP materials provide good strength, their specific strength is lower compared to carbon fiber. Aramid-based composites (Kevlar, Nomex) are used in the internal structure of UAVs due to their energy-absorbing capabilities. However, these materials are sensitive to moisture and require specialized resin systems.

Table 2
Comparison of Composite Materials

Property	Carbon Fiber Reinforced Polymer (CFRP)	Glass Fiber Reinforced Polymer (GFRP)	Aramid Fiber Reinforced Polymer (Kevlar/Nomex)
Density (g/cm³)	1.55-1.65	1.90-2.10	1.35-1.45
Heat Resistance (°C)	200-300	150-200	200-250
Vibration Damping	Moderate	Good	Excellent
Elastic Modulus (GPa)	200-250	50-80	70-130
Corrosion Resistance	Very High	High	Very High
Ease of Repair	Difficult	Moderate	Moderate
Cost	High	Low	Medium-High
Application Area	Fuselage shell, wings, tail structures, high-altitude UAVs	Medium-scale civil UAVs, wing coverings	Internal surfaces, impact-absorbing components
Advantages	Best specific strength, high stiffness, low weight	Economical, easy to manufacture, high impact resistance	Economical, easy to manufacture, high impact resistance
Disadvantages	Expensive, difficult to repair, directional strength	Expensive, difficult to repair, directional strength	Expensive, difficult to repair, directional strength

Recent studies indicate that hybrid composite systems (CFRP + Ti, CFRP + Mg) exhibit better performance compared to conventional systems. The advantage of these structures lies in their ability to combine the strengths of different materials. Additionally, flax fiber reinforced composites developed using bio-based resin systems have been found to offer strength-to-weight ratios comparable to carbon fibers while reducing the carbon footprint by 30% during production.

DISCUSSION

The data obtained in this research clearly demonstrate the differences in cost, performance, and manufacturing characteristics among metals, composites, and hybrid materials used in UAV airframe structures. Traditionally, metals such as titanium, magnesium, and aluminum alloys have been widely used in the aerospace sector; their advantages, including high strength-to-weight ratio, machinability, and corrosion resistance, have made them the primary structural materials for many years. However, modern UAV designs, which demand light weight and aerodynamic efficiency, reveal the performance limitations of metal alloys. Composite materials, particularly carbon fiber reinforced polymers (CFRP), offer superior performance compared to metals due to their high specific strength, low density, and excellent stiffness. Studies show that the use of CFRP significantly reduces airframe weight, increasing flight range by approximately 10–12%. Nevertheless, high production costs, complex repair procedures, and direction-dependent mechanical properties limit CFRP's suitability for all UAV scales. Lower-cost GFRP and aramid-based composites with high impact damping properties are advantageous for mid-range UAVs and internal structural applications. Hybrid composite systems (CFRP–Ti, CFRP–Mg) can be considered next-generation solutions that enhance structural efficiency by combining the strengths of different materials. Hybrid structures provide features such as high-temperature resistance and improved stiffness, making them especially suitable for high-altitude, long-range, or high-speed military UAVs. Additionally, bio-based resins and natural fiber reinforcements (e.g., flax fiber) reduce environmental impact, representing eco-friendly alternatives aligned with future sustainable aviation goals.

CONCLUSION

Overall, the selection of UAV airframe materials largely depends on the mission, structural requirements, and cost considerations. While metal alloys remain important for safety and low-cost applications, composite and hybrid materials offer superior performance, lightness, and energy efficiency. Future studies focusing on improved manufacturing processes, enhanced repair methods, and the expansion of sustainable composite alternatives will play a critical role in developing stronger, lighter, and environmentally friendly UAVs.

Author Contributions

Research Design (CRediT 1) Author 1 (70%) – Author 4 (30%)

Data Collection (CRediT 2) Author 1 (30%) – Author 2 (35%) – Author 3 (35%)

Research - Data Analysis - Validation (CRediT 3-4-6-11) Author 1 (30%) – Author 2 (35%) – Author 3 (35%)

Writing the Article (CRediT 12-13) Author 1 (70%) – Author 4 (30%)

Proofreading and Improvement of the Text (CRediT 14) Author 1 (50%) – Author 4 (50%)

Conflict of Interest

There is no conflict of interest among the authors of this study.

REFERENCES

Aabid, A., Parveez, B., Parveen, N., Khan, S. A., Zayan, J. M., & Shabbir, O. (2022). Reviews on design and development of unmanned aerial vehicle (drone) for different applications. Journal of Mechanical Engineering Research and Development, 45(2), 53–69.

Beyaz, A. (2024). Material and Airfoil-Based Wind Dynamics Analysis for Fixed-Wing Agricultural Unmanned Aerial Vehicles (UAV). Ziraat Mühendisliği, (379), 16-24.

Buldum, B., & Çağan, S. (2017). Study of ball burnishing process on the surface roughness and microhardness of AZ91D alloy. Experimental Techniques, 1–9.

Çağan, S. Ç., & Buldum, B. B. (2018). İnsansız hava araçlarında kullanılan malzemeler. Dumlupınar Üniversitesi Mühendislik Dergisi (DÜMAD), 9(693325), 1–12.

Çağan, S. Ç., & Buldum, B. B. (2019). İnsansız Hava Araçlarında Kullanılan Malzemeler. Dünya Multidisipliner Araştırmalar Dergisi, 2019(1), 35-52.

Das, S. (2018). Mechanics of 3D composites. University of Cambridge.

Eryıldız, E., & Eker, A. A. (2015). Savunma sanayinde kullanılan ileri kompozit malzemeler ve uygulama alanları. International Journal of Engineering Research and Development, 7(4), 8-12.

Hairi, S. M. F. B. S., Saleh, S. J. M. B. M., Ariffin, A. H., & Omar, Z. B. (2023). A review on Composite Aerostructure Development for UAV application. Green Hybrid Composite in Engineering and Non-Engineering Applications, 137-157.

Hassanalian, M., & Abdelkefi, A. (2017). Classifications, applications, and design challenges of drones: A review. Progress in Aerospace sciences, 91, 99-131.

Hu, C. (2025, August). UAV Wing Structure: Status and Future Trend. In 2025 2nd International Conference on Mechanics, Electronics Engineering and Automation (ICMEEA 2025) (pp. 1102-1117). Atlantis Press.

İlaslan, A. G. Y., & Kandemir, İ. (2021). Kanat gövde tipindeki bir insansız hava aracının yapısal tasarımı ve analizi. Avrupa Bilim ve Teknoloji Dergisi, (28), 775-780.

Li, Y. (2019). Identification of Commercial UAV Used in Bomb Attacks Using Airframe Material Analysis and Electronic Component Restoration. University of California, Davis.

Mishra, A., Pal, S., Malhi, G. S., & Singh, P. R. A. B. H. A. T. (2020). Structural analysis of UAV airframe by using FEM techniques: A review. International Journal of Advanced Science and Technology, 29(5), 195-204.

Öztürk, A. M., & Gündoğdu, Ö. (2020). İHA Kanatlarında Kullanılan Cam ve Karbon Elyaf Takviyeli Kompozitlerin Yapısal Performanslarının Sayısal Simülasyonlar ile İncelenmesi. Journal of the Institute of Science and Technology, 10(3), 1928-1942.

Pramanik, A., Basak, A. K., Dong, Y., Sarker, P. K., Uddin, M. S., Littlefair, G., ... & Chattopadhyaya, S. (2017). Joining of carbon fibre reinforced polymer (CFRP) composites and aluminium alloys–A review. Composites Part A: Applied Science and Manufacturing, 101, 1-29.

Shepherd, P., & Williams, C. (2017, September). Shell design considerations for 3D printing with drones. In IASS Annual Symposium 2017: Interface: architecture, engineering, science.

Sucuoğlu, H. S. (2025). DESIGN and ANALYSIS of OPTIMIZED QUADCOPTER TYPE DRONE STRUCTURE. Innovative Approaches to Engineering Problems, 1(1), 4-11.

Yilmaz, M. A., Hasirci, K., Gündüz, B., & Irez, A. B. (2025). Advanced composite wing design for next-generation military UAVs: A progressive numerical optimization framework. Defence Technology, 48, 141-155.

Yiğit, E., Yazar, İ., & Karakoç, T. H. (2018). İnsansiz hava araçlari (İha)‘nin kapsamli siniflandirmasi ve gelecek perspektifi. Sürdürülebilir Havacılık Araştırmaları Dergisi, 3(1), 10-19.