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EFFECTIVE INNOVATION IN FIBERGLASS FOR U.S. TRANSPORTATION AND DESIGN INDUSTRIES

Abstract

The article is devoted to effective innovations in the field of fiberglass materials for the transportation and design-oriented industries of the United States. The purpose of the study is a comprehensive study and scientific substantiation of innovative technologies of fiberglass composites, including the author's Precision Fiberglass Innovation System (PFIS) methodology. In the course of the scientific study, general scientific methods of cognition were used: analysis and synthesis, induction and deduction, systems approach, comparative-analytical method, modeling and forecasting. The results of the study show that within the framework of the work, a comprehensive systematization of technological, economic and applied aspects of the development of fiberglass composites as of 2026 was carried out, and the dynamics of the growth of the global composites market were quantitatively substantiated - from 13 million tons in 2023 to 14.42 million tons in 2026 with a projected volume of 496 billion US dollars by 2030. The key technological drivers of this growth have been identified and the main types of fiberglass materials have been identified, including: pultruded GFRP profiles, recycled glass fabric composites, wind-resistant GFRP systems and polyester fiberglass profiles for transport. A detailed analysis of their mechanical, operational and recovery properties has been carried out. In particular, the ability of wind-resistant composites to restore up to 89–95% of their initial characteristics after reactivation has been proven. A separate scientific novelty is the developed author's Precision Fiberglass Innovation System (PFIS) methodology, which is

proposed as a strategic tool for innovation management in the field of fiberglass composites production. It is shown that PFIS, combining engineering modeling, materials analytics, and manufacturing process optimization, provides a 20–40% reduction in component mass, an increase in design efficiency by more than 25%, and also creates economic prerequisites for the growth of the US domestic composites market with a potential of over $18 billion and the possibility of creating 20–50 thousand jobs. The practical significance of the study lies in the possibility of widespread implementation of PFIS as a tool for optimizing composite materials in industrial and transportation applications.

Keywords

Fiberglass, composites, innovation, transportation, PFIS.

Problem statement

Fiberglass technologies (fiberglass plastics and composite materials based on them) occupy a key place in modern materials science due to the combination of high specific strength, corrosion resistance and flexibility of shaping [12]. In the transport and design industries of the United States, these materials have become the basis for creating structures that meet the growing requirements for energy efficiency, safety, weight reduction of products and visual differentiation of products [5]. The active development of innovations in the field of fiberglass occurs at the intersection of engineering, technological and design approaches, which forms a new paradigm for the use of composites in industrial production [11]. Despite the widespread implementation of fiberglass technologies in the US transport industry (automotive, aviation, maritime transport), optimizing the ratio between the operational characteristics of materials and the economic feasibility of their use remains a problem. Innovative solutions often focus on increasing strength or reducing weight, but do not systematically take into account the product life cycle, including maintainability, disposal and environmental impact.

This creates a gap between the technological potential of fiberglass and the practical limitations of its large-scale use [6]. In the design industry, the problem manifests itself in the need to combine complex aesthetic forms with technological reproducibility and stable product quality. Innovative fiberglass materials allow the implementation of non-trivial design concepts, but the lack of unified approaches to integrating design solutions into production processes leads to increased costs and technological risks [2]. This is especially true for serial production, where design innovations must be consistent with engineering and technological constraints [4].

Thus, the scientific problem is the need for a comprehensive analysis of effective innovations in fiberglass technologies, which would simultaneously take into account technical, economic and design factors in the context of the US transportation and design industries. The absence of such an integrated approach hinders the full realization of the potential of fiberglass as a strategic material for modern industry [8].

Analysis of recent scientific research and publications

The issue of effective innovations in glass fiber technologies is a new area of research. It has not yet received sufficient coverage in the scientific literature, and therefore the available studies relate to related aspects of the application of glass fiber composites in various engineering contexts.

In the scientific aspect, significant contributions have been made by authors such as V. Amfilochiou, T. Debsharma, I. De Baere, F. Du Prez and W. Van Paepegem [1], who investigated the interlayer crack resistance of a repairable glass fiber windbreak for wind energy applications. G. N. Petropoulos, P. Tsokanas, A. Kotrotsos and V. Kostopoulos [7] focused on environmental aspects – they proposed an innovative method for recycling glass fiber-epoxy composites. J. Qureshi et al. [9] conducted a comprehensive review of recycling methods for fiber-reinforced polymer composites, which is key to understanding the life cycle

of materials in the context of sustainable production. S. I. Talabi et al. [11] analyzed the current state and prospects for the development of pultrusion technology, which is one of the leading methods for manufacturing fiberglass elements.

In addition, A. Vedernikov, L. Gemi, E. Madenci et al. [12] studied the effect of drawing speed on the mechanical properties and morphology of pultruded flat fiberglass laminates, which is extremely important for transportation and architectural design. B. Shafei and colleagues [10] considered the use of glass-fiber reinforced polymer in the reinforcement of bridge structures, which emphasizes the high structural efficiency of such materials.

To analyze market trends and practical cases of fiberglass use, materials from leading industry online resources such as CompositesWorld, ACMA, SAE International, Energy.gov, The ICCT, Osti.gov and Mndot.gov were used. They highlight real examples of fiberglass use in projects such as Ferrari Land, new generation buses, architectural facades, lightweight components for cars, etc.

Despite the presence of a significant number of individual publications on the topic, there is a lack of material on the use of innovations in the manufacture of fiberglass for the transport and other industries. Therefore, using various methods of scientific knowledge, the information was analyzed, grouped and systematized, which is presented in the light of the research topic.

The purpose of the article is to study and scientifically substantiate innovative technologies of fiberglass composites.

Presentation of the main material

Fiberglass composite materials are rapidly expanding in various industries due to the combination of high strength and low weight, as well as resistance to corrosion and loads [12]. In the last century, these materials have become key in the transport, construction and aerospace industries, which has led to an increase in demand for lightweight and durable structural solutions.

As of 2026, the global composite materials market continues its steady development in accordance with the forecast growth rates that arise from the available data on market trends. According to the basic indicators shown in Fig. 1., the global composites market volume, measured in tonnage, is approximately 14.42 million tons in 2026, which reflects a steady growth rate compared to 2023, when this figure was 13 million tons. This growth continues the trend of increasing demand for lightweight composite materials, which is due to the expansion of their use in transportation, energy, construction and other industries.

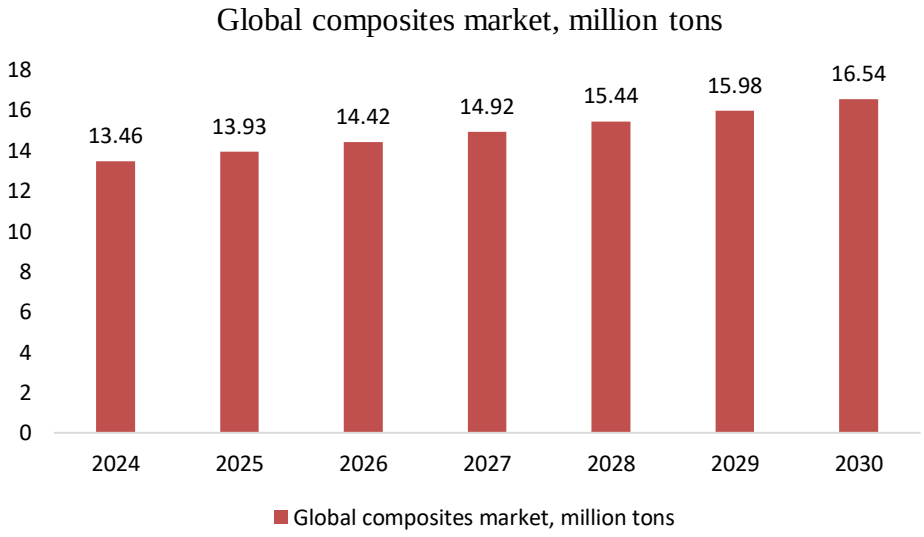


Fig. 1. Composite materials market, in million tons

Note: calculated by the author based on data [1]

At the global level, the composite materials market will be estimated at 496 billion USD by 2030 (Fig. 2).

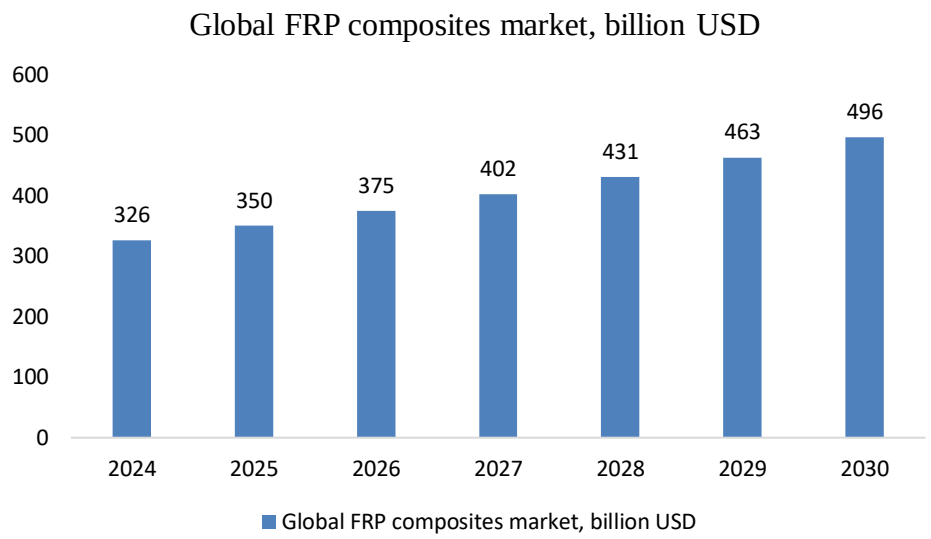


Fig. 2. Global composite materials market, USD [1]

As noted in the study by S. I. Talabi [11], the formation of various types of composite profiles from fiberglass is possible due to a wide range of production technologies that ensure structural stability, the required geometry and controlled quality of materials [11].

Today, there are a large number of technological approaches to the creation of fiberglass materials, and these approaches form varieties of the final product.

First of all, it is worth mentioning pultrusion as one of the most effective technologies that ensures the production of composites with a stable cross-sectional shape and high-performance characteristics. Another important direction is the creation of composites based on recycled glass fabrics, as described in the study by G. N. Petropoulos, where the restoration of reinforcement allows the re-formation of materials without significant loss of their strength [7]. Also attracting attention are wind-resistant fiberglass composites that combine high fracture toughness and the possibility of repair, as emphasized by V. Amfilochiou and co-authors [1]. Proprietary technologies for the production of fiberglass are also being actively implemented. Among these, it is worth mentioning the Precision Fiberglass Innovation System (PFIS) methodology, aimed at the systematization

and strategic application of these technologies, ensuring their optimal use in critical sectors and increasing the stability of innovative processes in the field of composite production. As noted in the sources [1,7,11,12], the main types of fiberglass materials that arise depending on the technology of their creation are: pultrusion GFRP profiles; composites based on recycled glass fabrics; wind-resistant GFRP composites; fiberglass polyester profiles for transport structures (see Table 1).

Table 1

Technical characteristics of types of fiberglass materials

Type of material	Key technical characteristics
Pultruded GFRP laminates	strength depends on pulling speed; resin viscosity has a significant impact; high speeds may cause defects; properties improve after heat treatment
Composites from recycled glass fabrics	clean fiber recovery; potential for reuse; fabric structure is preserved; matrix degradation achieved with mild reagents
Vitrimeric GFRP composites	high fracture toughness; reparability; recovery of mechanical properties up to 89–95%; structural stability
Polyester GFRP profiles for transport	reduced weight; thermal insulation properties; corrosion resistance; low noise and vibration levels
PFIS (Precision Fiberglass Innovation System) methodology	systematic approach to optimizing the production and use of fiberglass materials; employs analytics and engineering modeling for precise technology selection; enhances innovation stability and component efficiency in critical industries

As noted by the U.S. Department of Energy [5], the International Council [6] and American Composites [3], the above technologies form the basis for the widespread use of fiberglass materials in the transportation industry. According to the U.S. Department of Energy [5], fiberglass composites allow for a 25–35% reduction in the weight of individual components, which contributes to a significant improvement in passive fuel efficiency.

In transportation systems, as described in the study of the International Council on Clean Transportation [6], a 10% reduction in weight can reduce fuel consumption by 6–7% if the engine is adapted to the new weight, and by 4–5% if no adaptation is made.

In this context, the author's PFIS methodology is of particular value, as it provides strategic control over innovations in composite materials and directly affects economic indicators, in particular, the formation of the US composites market with a volume of over $ 18 billion and the creation of 20–50 thousand highly skilled jobs.

As noted in the materials on PFIS, its application allows to achieve a weight reduction of components by 20–40% and increase the efficiency of structures by more than 25%, which makes the technique an important tool for the technological development of the transport industry.

Consider the advantages of using lightweight materials, as demonstrated in Table 2.

Table 2

Weight reduction indicators for using lightweight materials

Material	Weight reduction potential
Magnesium	30–70%
Carbon fiber composites	50–70%
Aluminum materials	30–60%
Titanium	40–55%
Glass fiber composites	25–35%
High-strength steel	15–25%

Source: [5]

The use of composites in mass transport is of particular importance. As shown in the practical experience of using composite panels in the production of electric buses, the use of fiberglass has provided a significant reduction in the mass of structures, improved thermal characteristics and increased corrosion

resistance, which are critical parameters for transport solutions in countries with active operation of public transport [3]. This example demonstrates the practical value of composites for transport systems in developed countries, including the USA, where there is a trend towards an increase in the share of electric vehicles and a decrease in the overall carbon footprint.

Fiberglass composites are increasingly being integrated into the fields of design, architecture and industrial aesthetics, which is confirmed by the examples provided in your file. As H. Caliendo notes in a study dedicated to the Ferrari Land project [2], the use of FRP cladding made it possible to form complex geometric shapes of facades and provide them with long-term operational stability, combined with low weight and high structural reliability. According to the author, it is the ability of fiberglass to imitate metal, stone or other materials with a significantly lower mass that makes it one of the key solutions in modern architectural design, where it is important to combine aesthetics with technological efficiency. In many cases, its use expands the capabilities of architects in creating complex facade systems and decorative elements that remain resistant to external influences.

As described in the study [4], fiberglass is also widely implemented in the retail industry, where it replaces traditional metal structures in the cladding of retail facilities. This experience emphasizes that the transition to composite panels allowed Husky to abandon the multi-stage installation of metal elements in favor of a single-stage production of the facade shell, which reduced the installation time and significantly extended the service life of the product. As noted by engineer R. Anisimovich [4], the use of fiber-reinforced polymers was a natural continuation of the company's development in the direction of modernizing the design and optimizing technical characteristics. This decision demonstrates that fiberglass is able to effectively perform decorative and structural functions at the same time, which strengthens its role in industrial design. The sphere of theme

parks is also actively integrating fiberglass composites. As described in the article by H. Caliendo [2], fiberglass panels allow you to create large-scale decorative structures. They are able to retain their shape, are resistant to weather conditions and do not require intensive maintenance. These qualities are important, in particular, not only for the transport industry, but also for the entertainment industry. Flexibility and the ability to accurately convey complex architectural lines make it possible to use the material for the construction of attractions, thematic areas and facade solutions.

In turn, in industrial design solutions, fiberglass is used in both large infrastructure and small architectural forms. As shown in the study [4], its use allows you to create long-term structures that are not subject to corrosion and provide stable performance even in difficult environmental conditions. These features contribute to the wide introduction of the material in urban design segments, including external decorative panels, exhibition structures and elements of public space.

As A. Vedernikov notes, the further development of fiberglass composites will be determined by the improvement of pultrusion technologies, in particular, the transition to high-speed modes that ensure the stability of the structure and the preservation of the mechanical properties of the material even with a significant increase in the drawing speed [12]. Scientific results demonstrate the possibility of automating the process and precisely controlling the geometry of the profiles, which makes it possible to form new-generation materials with increased uniformity and polymerization efficiency. This approach opens up prospects for scaling up production in the transport and construction industries, where the need for lightweight and durable structural elements is growing.

The study by G. N. Petropoulos emphasizes that future technologies in the field of fiberglass composites are closely related to environmental approaches to their processing [7]. The use of chemical degradation of the matrix using hydrogen

peroxide makes it possible to restore fiberglass fabrics without damaging the structure and with minimal energy consumption. As the author notes, the preservation of reinforcement architecture and mechanical characteristics makes this method strategically important for the formation of closed technological cycles. Such an approach can become the basis of sustainable production practices and contribute to the reduction of waste in the transport, energy and infrastructure sectors.

An important direction of development is the creation of wind-resistant composites, which, according to V. Amfilochiou, combine high fracture toughness, repairability and the ability to be reprocessed without significant loss of properties [1]. The author emphasizes that the restoration of mechanical characteristics within 89–95% after reactivation makes these materials promising for structures that require long-term operation and the possibility of local repair. Such composites are able to provide a new standard of functionality in automotive and industrial design, creating the prerequisites for the emergence of technological solutions with a high level of adaptability and reduced operating costs.

Conclusions

Analysis of the dynamics of the development of the composite industry indicates a stable growth in global demand for fiberglass materials. Based on forecast calculations, it was established that the volume of the composites market in 2026 will reach more than 14 million tons, which reflects the gradual expansion of the industry's production and technological capabilities. The financial dimension of the market demonstrates the same positive trend: estimates indicate that the global FRP composites segment will approach half a trillion US dollars by 2030, which is an indicator of the growing role of lightweight materials in the technological modernization of the industry. The totality of these data confirms that composite solutions are increasingly integrated into key production chains, meeting modern requirements for energy efficiency and structural optimization.

The generalization of the research results allows us to identify a range of innovations that form an updated paradigm for the use of fiberglass materials. Leading solutions include high-speed profile forming technologies, environmentally friendly methods for restoring reinforcing structures, and the development of matrices capable of reactivation. In this context, the author's PFIS methodology deserves special attention, which structures the modernization processes and optimizes the choice of technological solutions, ensuring an increase in the efficiency of structures by tens of percent. As a result, the methodology not only enhances the technological capabilities of production, but also makes it possible to integrate composites into critically important sectors with a predictable engineering return.

The further development of the field of fiberglass materials will be determined by a combination of technological adaptability and economic feasibility. It is expected that in the coming decades, key growth areas will be concentrated around the expansion of the use of composites in transport engineering, in particular in electromobility and aviation structures, where the potential for mass reduction exceeds 20–40%. The fields of architectural design and infrastructure construction will also gain significant momentum for development, since materials with high corrosion resistance and durability will become the basis for creating new types of structures. As a result, market trends, scientific results, and innovative methods indicate the formation of a sustainable growth trajectory that will determine the future of the composite industry as one of the most dynamic areas of modern technology.

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