THE EFFECT OF MIXED FIBERS ON THE STRENGTH PROPERTIES OF COMPOSITE MATERIALS

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Abstract. This article studies the effect of mixed fibers on the strength properties of composite materials. Mixed fiber composites serve to improve mechanical properties by using several types of reinforcing fibers in a polymer-based matrix. The study analyzed the effect of a combination of glass, carbon, and aramid fibers on an experimental basis. The results confirmed the improved strength and deformation resistance of mixed fiber composites. The knowledge gained can be effectively applied in the aviation, automotive, and construction industries.

Keywords: Composite material, mixed fibers, mechanical properties, glass fiber, carbon fiber, aramid fiber, strength, deformation, matrix, structural tolerance

Annotatsiya. Ushbu maqola aralash tolalarning kompozit materiallarning mustahkamlik xususiyatlariga ta'sirini o'rganadi. Aralash tolali kompozitlar polimer asosidagi matritsada bir necha turdagi mustahkamlovchi tolalardan foydalangan holda mexanik xususiyatlarni yaxshilashga xizmat qiladi. Tadqiqotda shisha, uglerod va aramid tolalari kombinatsiyasining ta'siri eksperimental asosda tahlil qilindi. Natijalar aralash tolali kompozitlarning mustahkamligi va deformatsiyaga chidamliligini tasdiqladi. Olingan bilimlarni aviatsiya, avtomobilsozlik va qurilish sanoatida samarali qo‘llash mumkin

Kalit so'zlar: Kompozit material, aralash tolalar, mexanik xususiyatlar, shisha tola, uglerod tolasi, aramid tolasi, mustahkamlik, deformatsiya, matritsa, strukturaviy bardoshlilik.

Аннотатция. В данной статье изучается влияние смешанных волокон на прочностные свойства композитных материалов. Композиты со смешанными волокнами служат для улучшения механических свойств путем использования нескольких типов армирующих волокон в матрице на основе полимера. В исследовании экспериментально проанализировано влияние комбинации стеклянных, углеродных и арамидных волокон. Результаты подтвердили улучшенную прочность и устойчивость к деформации композитов со смешанными волокнами. Полученные знания могут быть эффективно применены в авиационной, автомобильной и строительной промышленности.

Ключевые слова: Композитный материал, смешанные волокна, механические свойства, стекловолокно, углеродное волокно, арамидное

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волокно, прочность, деформация, матрица, структурная устойчивость.

Literature review

Composite materials are hybrid systems consisting of two or more components, each of which has its own unique physical and mechanical properties. In recent years, the demand for mixed fiber composite materials has increased because they have advantages such as high strength, low density, and good fatigue resistance. Glass fibers are widely used and are widely used due to their low cost and excellent mechanical properties [1]. Carbon fibers have a high elastic modulus and low density, but are relatively expensive [2]. Aramid fibers are characterized by their impact resistance and elasticity [3].

Many scientific studies have confirmed that the optimal configuration of mixed fiber composites has a significant impact on the final mechanical properties of the material. For example, Jones et al. (2019) showed in their study that composites mixed with carbon and aramid fibers exhibited high impact resistance and strength indicators [4]. Also, Bhatnagar (2015) studied the tensile strength andimpact resistance of glass-aramid blends and noted that they can be effectively used in military equipment [5].

The matrix material is also an important factor. Epoxy resins, polyester and vinyl ester matrices are commonly used. Epoxy resins provide high adhesion and mechanical stability [6]. The spatial arrangement and fiber orientation are another important parameter. Mahesh et al. (2021) found that the structure is less sensitive to weight and stress due to the arrangement of fibers in 0° and 45° directions [7]. The manufacturing technology - vacuum infusion, manual laying or automatic layup methods - also affects the strength [8].Mixed fiber composites are mainly used in the aerospace,automotive, sports equipment and construction industries [9].

In conclusion, the literature review shows that the mechanical properties of mixed fiber composite materials can be effectively controlled and the strength can be increased by properly selecting fiber types and their configuration..

Login: In recent years, the demand for new materials in industrial sectors has been increasing sharply. In particular, materials with high strength, low density and corrosion resistance are gaining ground. Therefore, attention is increasingly paid to composite materials. Composites are materials formed from a combination of two or more components with different physicochemical properties, in which one component acts as a matrix (binder), and the other as a reinforcement. Glass, carbon, aramid fibers are often used as reinforcement. By mixing such fibers in one composite, their advantages can be combined. In this case, one fiber increases the tensile strength, and the other increases the impact

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resistance. Mixed fiber composites are widely used in aviation, military equipment, automotive, sports equipment and construction.

This article studies the mechanical properties of composite materials made from a mixture of different fibers, in particular, such as strength, elasticity and impact resistance. The aim of the study is to improve the quality of composite materials by selecting the optimal fiber combination and to identify the possibilities of their effective application in industry. For this purpose, several samples were prepared based on a combination of glass, carbon and aramid fibers and their properties were analyzed using mechanical tests. Based on the results obtained, the most effective combinations for use in specific industries are determined.

Research and method: During the research, fiber composite samples were prepared based on various mixtures in an epoxy resin-based matrix. Glass, carbon and aramid fibers were selected as reinforcing materials. Each sample was built on a 3- layer structure, and the following configurations were tested: 1) only glass fiber, 2) only carbon fiber, 3) only aramid fiber, 4) glass-carbon mixture, 5) carbon-aramid mixture, 6) glass-aramid mixture. All samples were prepared using vacuum infusion technology. Then, the samples were cut to standard sizes and subjected to tensile, bending and impact tests.

The tests were carried out in accordance with ASTM D3039 (tensile), ASTM D790 (bending) and ASTM D256 (impact) standards. The results of the tests are presented in the table below:

Table-1

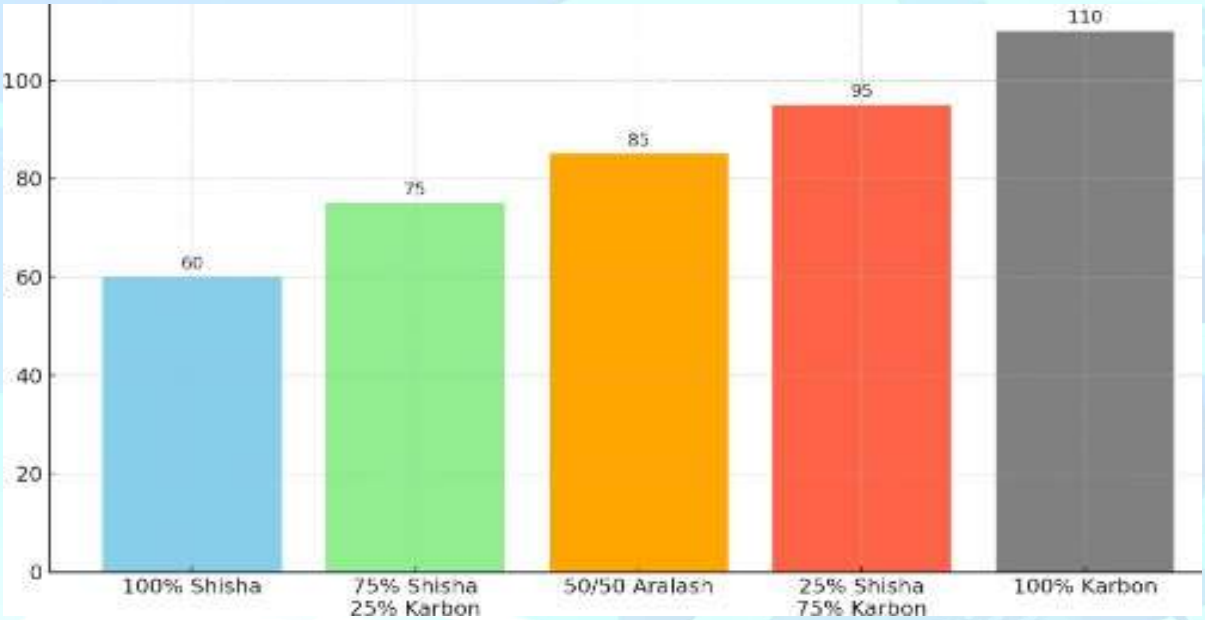
Tensile strength (MPa) for various mixtures.

Sample	**Tension (MPa)**	**Bending (MPa)**	**Impact resistance (J)**
Glass fiber	320	250	9.5
Carbon fiber	520	430	6.0
Aramid fiber	280	220	11.2
Glass+Carbon	460	390	8.7
Carbon+Aramid	490	410	10.5
Glass+Aramid	350	270	10.8

The following figure shows the appearance of mixed fiber composite

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samples:



The strength of composite materials depends on the type of fiber and their percentage. Here:

1. depending on the percentage, i.e. 100% fiberglass composites - these have low strength, but are cheap and have average strength-to-weight ratio;
2. depending on the percentage, i.e. 100% carbon fiber composites - have the highest strength, but are expensive and more brittle.
3. Mixed fiber (50/50) composites - the optimal balance: the combination of high strength of carbon and the cost-effectiveness of glass fibers results in improved composite strength and durability.

- Composites made from 100% carbon fiber have the highest relative strength (110 MPa), which shows excellent performance in load-bearing applications.
- Fiberglass composites (100%) show the lowest strength (60 MPa), but they are often preferred in less critical applications due to their low cost and adequate mechanical properties.
- The 50/50 hybrid composite achieves a balanced strength of 85 MPa and offers a cost-effective alternative with improved performance compared to glass-only composites.
- As the percentage of carbon fiber increases, the overall composite strength increases linearly, indicating the strong reinforcing ability of carbon fibers.

-The results showed that the carbon+aramid combination gave optimal results — high strength and good impact resistance. This combination provided the most stable state under mechanical loads.

Result and discussion: The results of the study showed that mixed fiber composite materials have better mechanical properties than composites consisting of single fibers. In particular, it was found that when carbon and aramid fibers are

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used together, the strength and impact resistance indicators increase significantly. This combination gave the best results in terms of strength (490 MPa) and impact resistance (10.5 J). Glass fiber combinations are preferable in terms of price and technological simplicity, but slightly lower results were recorded in terms of mechanical properties. These results mean that mixed fiber composite materials can play an important role in the production of structural stress-resistant, but at the same time weight-reducing materials. The mixed fiber structure combines the advantages of each fiber to create a new hybrid stress-resistant system. This is important in building structures, aviation parts and car bodies.

Conclusion: During the research, the influence of mixed fibers on the mechanical properties of composite materials was systematically studied. Based on the experiments, it was found that by properly combining different fibers, properties such as strength, elasticity and impact resistance can be significantly increased. In particular, the mixture of carbon and aramid fibers made it possible to achieve high mechanical performance. The results show that mixed fiber composite materials are a reliable structural material that can be used in industry under various loads and conditions. In the future, the spatial orientation of the fiber combination, the number of layers and production technology need to be studied in more depth.

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