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INTRODUCTION

We had the great honor of organizing the 2nd International Conference on Innovative Academic Studies ICIAS 2023. It was truly a great pleasure for us to greet a lot of participants from many different countries attending ICIAS 2023! We firmly believe that the conference will become an important international event in the field of cross-industry discussion about innovations in Academic Studies.

ICIAS 2023 was organized by All Science Academy located in Konya, Turkey.

Three cooperating organizations supported the four-day conference. There were 388 papers accepted for presentation at ICIAS 2023, contributed from different countries. We had plenary speeches and several well-known scientists and experts, to give invited talks at differentsessions.

The purpose of ICIAS 2023 was to provide a forum for the participants to report and review innovative ideas, with up-to-date progress and developments, and discuss novel approaches to the application in the field of their own research areas and discuss challenges of doing science.

We sincerely hope that the exchange of ideas on doing research, science and improving education will help the participants, and international cooperation sharing the common interest will be enhanced.

On behalf the Organization Committee of ICIAS 2023, we would like to heartily thank our cooperating

Racing Canoe Design with Carbon and Glass Fiber Composites: Improving Performance through Fabric Selection and Sequence

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Abstract – The purpose of this study is to design and select alternative materials for professional sports competitions from easy to repair polymer matrix composites that can offer high performance and lightness, have the optimal resistance to corrosive environments, and have ideal impact strength. The study employed 3D PET (Polyethylene terephthalate) foam as the core material and carbon and glass fiber reinforced epoxy matrix as the surface of sandwich composite structure. The sandwich composite samples were created by layering different combinations of twill (T) and unidirectional (UD) textiles manufactured with carbon and glass fibers. Flexural and impact tests were used to evaluate four distinct sandwich composite combinations. Four different sandwich composite combinations were produced and evaluated using flexural and impact tests. The sandwich composite surfaces were created using a combination of 2 layers of carbon twill fabrics (T1), 3 layers of carbon twill-UD-twill fabrics (T2), 3 layers of glass twill-UD-twill fabrics(T3) and 3 layers of carbon twill-glass UD-carbon twill hybrid fabrics (T4). The results indicated that the T3 carbon samples had the highest flexural strength, while the T1 carbon fiber-based twill sandwich composites had the lowest results. Additionally, it was observed that the T4 hybrid samples had a higher impact strength compared to the other samples. Overall, the test results revealed that the T2 carbon sample had the most suitable mechanical properties and was the best option for meeting the design needs of a performance-oriented racing canoe.

Keywords – Kanoe, Carbon Fiber, Glass Fiber, Epoxy, Vacuum Bagging, Sandwich Composite, Fabric Sequence

I. INTRODUCTION

Despite our world's decreasing energy resources, energy demand is increasing, which causes energy costs to rise gradually. For this reason, there is a tendency towards systems where clean and alternative energy sources are used. Composite materials, with their properties, offer new solutions in many sectors and have become an alternative to traditional materials. Nowadays, the most effective parameter to be used in the design of canoes to be used for sporting purposes in order to improve the performance and efficiency of the boat is the process of reducing the boat's weight. In order to achieve this, the use of carbon fiber reinforced, aramid fiber reinforced, and carbon/aramid hybrid composites with higher specific strength and elasticity compared to polyethylene in the hull, keel, rudder, and cockpit designs keel, rudder and cockpit designs of boats is becoming increasingly common. One reason for this is that it is not possible to repair thermoplastic boats that have been damaged. Nowadays when examining the boats and ships

produced by leading shipyards and yacht manufacturers , it is seen that the boats produced are made of polymer matrix composite materials, similar to those of foreign made professional canoes. As a result of the projects carried out by Özata Shipyard which a local company were produced carbon fiber reinforced catamaran type passenger ships [1]. Besides Japanese classification society ClassNK and Nakashima Propeller Co. announced the first carbon-fiber propeller to be used as a main propeller on a merchant ship [2].

Diesel engines are currently used on large sailboats in use today. The use of lighter materials in these yachts will provide results such as low fuel savings and therefore low carbon dioxide emissions.

The canoes produced in our country are for amateurs and are made of thermoplastic materials. It is not produced for sporting purposes. In our country, there isn't canoe class that is manufactured in accordance with the class rules determined by the International Canoe Federation and used in competitions. These canoes are imported to our country from abroad. It has been found that a patent attempt has not yet been made on the design and production of "professional canoes" in our country. Nowadays, wooden materials are used in special production canoes and thermoplastic materials are used in mass production canoes. However, due to the difficulty of repairing thermoplastic canoes, their lower specific strength and rigidity than composites, and the difficulty of manufacturing wooden canoes, composite canoes are becoming more and more common abroad. Canoes used in professional competitions are generally made of carbon and aramid reinforced composites. Glass fiber isn't preferred because its specific strength is lower than these materials and it is more brittle.

II. Materials and Methods

Sandwich panels are in the class of structural composites used in the design of light but high-rigidity and strength beams and panels. Describe in detail the materials and methods. A sandwich panel consists of a thick core layer sandwiched between and bonded to two outer layers or surfaces. The outer layer is made of materials such as thick aluminum alloys, fiber-reinforced plastics, steel, and plywood, which can withstand tensile and compressive stresses and provide strength and rigidity to the structure. The core layer is made of lighter materials with lower elastic moduli. Common core materials include rigid polymer foams (such as polyurethane, PET, and PVC), wood (such as balsa), and honeycomb structures [3].

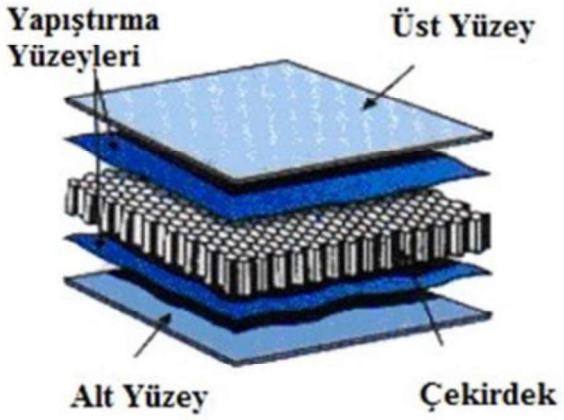


Fig 1. Sandviç panel yapısının şematik gösterimi[4]

A. Material

For the production of sandwich composites, 3D PET foam is used as the core material, and a carbon and glass fiber epoxy matrix is used as the surface composite of the sandwich structure. The vacuum bagging method is used for the production of sandwich composites.

In today's foam core sandwich composite applications, the core material is expected to be lightweight, have high mechanical strength, be flexible, and have a long service life. In recent years, PET foams have gained significant importance as core materials for sandwich structures due to their properties such as lightweightness, high mechanical properties, flexibility, and long service lives.

In addition to their high mechanical strength, the lower cost of PET foams compared to PVC foams makes them more attractive, and their application areas have become more diverse [5]. The surface of the 3D PET foam used is shown in Figure 2.

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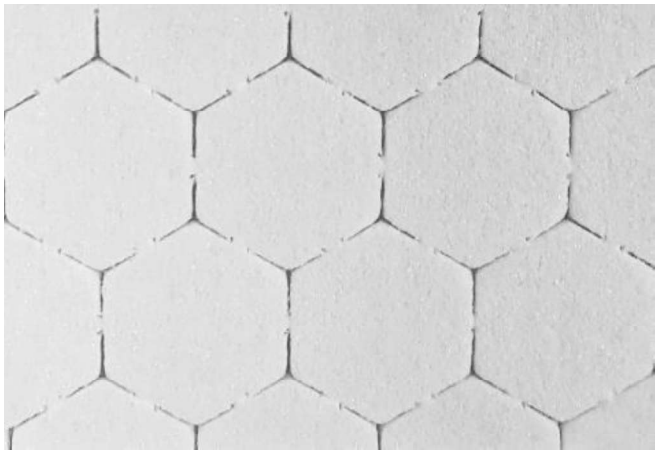


Fig. 2. 3D PET foam surface

Epoxy resin, which is identified as the matrix material, is one of the most widely used resins in the production of a wide range of composite parts. Epoxies have better properties than other resin groups in terms of mechanical properties and resistance to environmental effects [6].

B. Vacuum Bagging Method

Composite material (typically in the form of sandwich structures) is first placed into a mold, then a vacuum bag is placed on top as the upper layer. As the air inside is absorbed, the vacuum bag applies atmospheric pressure to pull down on the material placed. In the next stage, the entire composition is placed into an oven to be heated for the curing process of the resin. This method is often used in conjunction with fiber wrapping and layering techniques. Vacuum bagging method is also used in composite material repair procedures [7]. This method is described as combining hand-layered composite with vacuum bagging. The schematic illustration of the vacuum bagging method is shown in Figure 3.

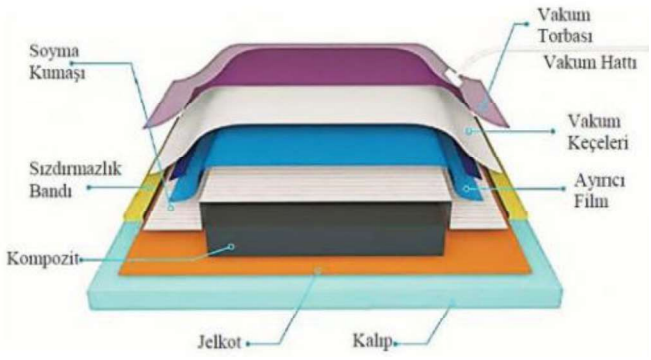


Fig 3. Components of a vacuum bagging system[8]

The samples were produced in a certain number of layers and in a certain sequence as shown in Table 1.

Number No	Fiber Material/ Knitting type	The number of layers	Core Material
T1	Carbon Fiber/ 3K Twill(200gsm)	4	3D PET Foam
T2	Carbon Fiber/ 3K Twill(200gsm)	4	3D PET Foam
	Carbon Fiber/ 12K UD(300gsm)	2	
T3	Glass Fiber/ Twill(163gsm)	4	3D PET Foam
	Glass Fiber/ UD(330gsm)	2	
T4	Carbon Fiber/ 3K Twill(200gsm)	4	3D PET Foam
	Glass Fiber/ UD(300gsm)	2	

In the first stage, the fibers were cut to the appropriate size for the sample to be produced. These fibers were weighed with a assay balance. The amount of epoxy-based lamination resin to be used was determined based on the weights measured. The peeling fabric was placed on the glass table, which was preferred as a mold, and then the fibers were laid one by one and the epoxy-based lamination resin was impregnated, taking care not to leave any dry areas. Then, as the core element in Figure 4, PET foam was also laid and epoxy impregnated.



Fig 4. After the core foam is placed between the sample, the fiber is laid on it and the resin is absorbed into the PET foam and the laid fiber.

In the T1 sample, 2 layers of carbon twill fiber were impregnated with epoxy-based lamination resin, a total of 4 layers, and then PET foam was placed on top of it, and epoxy-based lamination resin was impregnated with 2 more carbon twill

fibers. Three layers of carbon twill-unidirectional-twill fibers were stacked, for a total of 6 fibers in the T2 sample, and then PET foam was put together and the same 3-layer fiber series was repeated on top of it. In the T3 sample, 3 layers of glass twill-unidirectional-twill fibers were arranged, with a total of 6 layers of fiber, and then PET foam was put together and the same 3-layer fiber series was repeated on it. In the T4 sample, 3 layers of carbon twill-glass unidirectional-carbon twill fibers were arranged, with a total of 6 layers of fiber, and then PET foam was put together and the same 3-layer fiber series was repeated on it.

Finally, after ensuring the tightness, the specimen is left under vacuum as seen in Figure 5.



Fig 5. By using vacuum nylon and sealing tape, the process of ensuring the tightness by creating vacuum underneath it and leaving it under vacuum

III. TESTLER

Bending and impact tests were performed on the samples, which became sandwich composite plates, to observe their mechanical properties.

A. *Bending Test*

In accordance with the ASTM C393 standard, the bending test was performed on 12 samples cut into bar shape in a total of three pieces each, with a size of 18x3 cm2.The bending test was applied to the bar-shaped samples. The sandwich composite samples were loaded in a standard manner, as shown in Figure 6, and the results of the bending stress and the modulus of elasticity in bending were obtained from the load and deformation data obtained after the test and analyzed.



Fig 6. Bending Test Setup and Test Moment

B. *Drop Weight Impact Test*

The impact test was carried out using ASTM D7136 standard, with a total of 12 samples cut in 10x10 cm² square section from each specimen. Three samples were placed on a flat surface, and an impactor was dropped on each sample to apply 5, 7 and 10 J of energy in the first stage. Additionally, 7, 10 and 15 J of energy were applied to samples 2, 3 and 4.



Fig 7. Drop-Weight Impact Test Setup

IV. DISCUSSION

Although the production of polymer matrix composites is difficult and expensive, their use in the aerospace, maritime, space, and automotive industries is rapidly increasing due to their high energy damping capability, lightweight, high slide, and bending stiffness properties. Carbon fiber masts are commonly used in yachts, especially those produced for racing. Although metal and plastics are widely used in the maritime sector, polymer composites are considered an attractive alternative to metallic materials due to their high rigidity and strength properties, as well as their high resistance to fatigue and shock forces.

Fiberglass boats are easy to manufacture and are lighter than wooden or metal boats. They have low maintenance, and with proper care, they can have a lifespan of around 50 years. To increase their durability, carbon or kevlar materials can be used. Due to their lightness, fuel costs are lower, towing is easier, and costs are lower [9].

In this study, an alternative material was used to achieve high performance and lightweight characteristics, ideal resistance to corrosive environments, impact resistance, and easy repair. The material selection for the design of composite canoes for professional competitions was carried out using polymer matrix composites. The first steps of composite canoe production in domestic production were created, and the design was made in accordance with the rules of the International Canoe Federation. The aim is to provide a more affordable canoe for canoe sports in Turkey, thereby reducing dependence on foreign canoe sports and contributing to the development of the Turkish economy.

IV. CONCLUSIONS

The studies conducted during the project were for the purpose of selecting materials for a competition-focused racing canoe.Therefore, the material to be selected must have a very high bending strength. The second parameter in terms of material design is the impact resistance, which was selected by considering the response to an accident. Based on these parameters, bending and impact tests were carried out.The data obtained as a result of the bending test are shown in the graphs in Figure 8 and Figure 9.

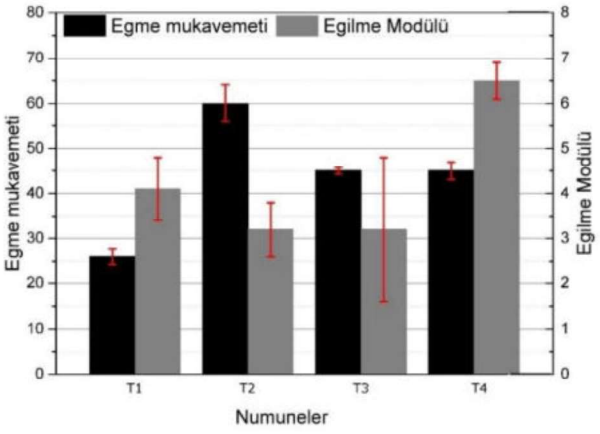


Fig 8. Bending Resistance and Bending Modulus Graph

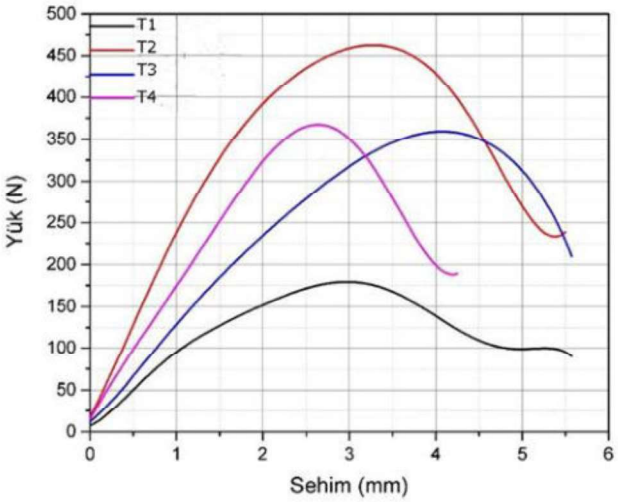


Fig 9. Load (N) - Deflection (mm) Graph for Bending Test

When the graphs are examined, it is seen that the T1 sample has the lowest flexural strength, while the T2 sample has the highest flexural strength. The T2 sample is completely composed of carbon fiber and PET foam, and it has a considerably higher bending strength compared to the T3 and T4 samples, which contain glass fiber.

The data obtained as a result of the impact test are shown in the graph in Figure 10.

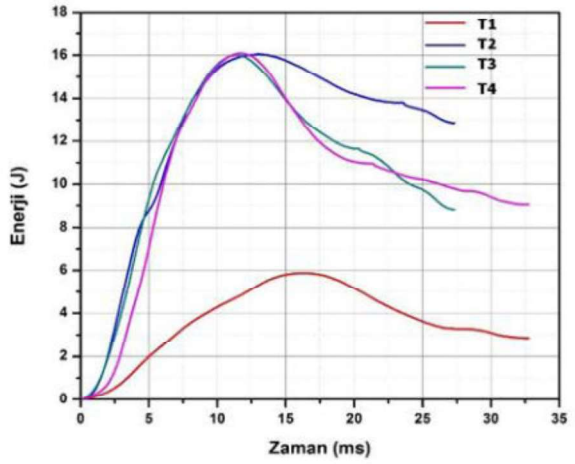


Fig 10. Energy-Time Graph Obtained from Impact Test

When Figure 10. is examined, it is understood that efficient results can't be obtained from the T1 carbon sample. It is also seen that T2 and T4 samples have a higher impact strength when compared to other samples. When the test results were examined in general, it was determined that the T2 sample was the sample that best met the design needs and had the most suitable mechanical properties.

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