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COMPOSITE MATERIALS USED FOR KAYAKS

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ABSTRACT

Composite materials are quite popular in kayak construction, especially for the hull of the boat, offering a number of advantages over traditional materials. Composite kayaks are those made from resin-impregnated laminates of fiberglass, aramid fibers, carbon fiber, or a mixture of these and other high-tech synthetic fabrics.

Keywords: composite materials, race kayak, fiberglass, carbon fiber, epoxy, kevlar.

1. INTRODUCTION

A kayak is a lightweight craft that works well on moving or still water, as well as near the coast. It originated in the icy regions of Greenland. There are two distinct types of kayaks, each of which can be further subdivided: sea kayaking or touring and racing or sport kayaks.

The touring kayak cruises in an environment dominated by wind, while the river kayak moves in an environment dominated by current [1].

Race kayaks are specialized kayaks designed for use in competitive kayaking events. These kayaks are typically narrower and longer than recreational kayaks, and are designed to be extremely fast and agile in the water.

Sprint races and long-distance races are two competitive kayaking competitions that use race kayaks. Kayakers participate in sprint races over a short distance, usually 200 or 500 meters, to complete the race as soon as possible as soon as possible. In long-distance competitions, kayakers may cover lengths of many kilometers to maintain a fast speed throughout the competition.

Nevertheless, race kayaks are a necessary piece of gear for competitive kayakers, and the way they are built has a big impact on how well they perform on the water.

Composite materials are the assembly of two or more materials on a macroscopic scale (macroscale) to form a third with improved qualities. These macroscale materials, such as fibers and resins, together possess advantages that their components do not. A properly designed and produced composite material can exhibit, among others, improved strength, stiffness, toughness, damage resistance, wear resistance, corrosion resistance, fatigue life, and thermal insulation than its base constituents [2].

Composite materials have become increasingly popular in kayak construction, especially for the hull of the boat, offering several advantages over traditional materials (fiberglass or plastic).

2. COMPOSITE MATERIALS

Kayak hulls are commonly made of polyethylene, thermoformed ABS-acrylic, fiberglass, or aramid (Kevlar). For racing kayaks, a combination of fiberglass, carbon fiber, and epoxy resin is typically used.

Very fine glass strands are woven into a cloth (Figure 1) to create fiberglass, a durable and lightweight material. The high-performance requirements of race kayaks are then well-suited to this fabric when it is coupled with epoxy resin to produce a rigid and long-lasting material.

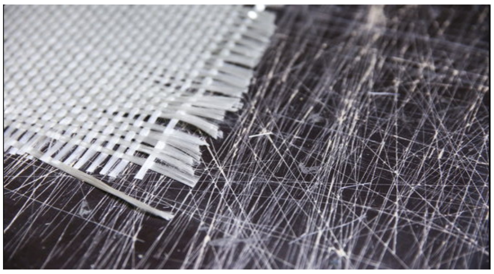


Figure 1 Fiberglass

Another material that is frequently utilized in race kayaks is carbon fiber, visible in Figure 2. High-performance kayaks are perfect candidates for it because it is even stronger and lighter than fiberglass. Carbon strands are heated, stretched, and then woven into fibers to create carbon fiber. Carbon fiber is similar to both Fiberglass and Kevlar in that it is a polymer reinforced with carbon fibers of Carbon.

One material high in carbon is graphite. Graphite strands are often used for carbon fiber. Similar to Glass Polymer Composites, Carbon Fiber usually consists of an epoxy, carbon mat, or loose carbon fibers and a hardening catalyst. Carbon Fiber is stronger than fiberglass in compression and tension. Carbon fiber also has a higher overall yield strength and good heat resistance. Carbon fiber shares the high-end market with Aramid fiber (Kevlar). It is very lightweight and strong.

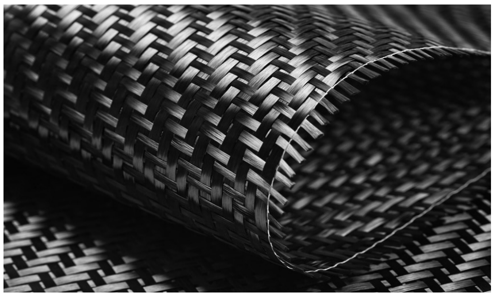


Figure 2 Carbon fiber

Carbon fiber is often used for high-end, lightweight kayak construction. This composite of carbon fiber mat and resin has a fair amount of flex or elastic modulus, but is still much more brittle than polyethylene. It is, however, very strong and very lightweight. Carbon fiber is an excellent choice for sea and expedition kayaks. Because the hull weighs less (but still retains the same wetted area and volume), it can carry more weight in and on the hull [3].

Kevlar, as can be seen in Figure 3, is a material created by mixing terephthaloyl chloride and para-phenylenediamine, resulting in aromatic polyamide (aramid) yarns. By dissolving the yarns and spinning them into ordinary fibres, they are further refined. Kevlar becomes a strong and flexible material when woven. When the resin layers and the woven Kevlar layers are bonded together, a 'stiff' material is created that is light and 20 times stronger than steel. In addition, it outperforms specialised metal alloys [4].

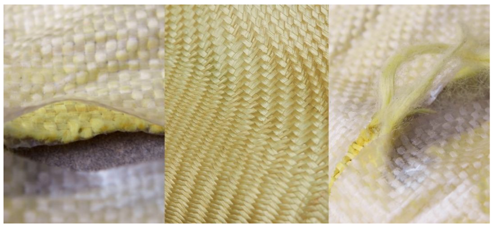


Figure 3 Kevlar fiber

3. THE MANUFACTURING PROCESS FOR KAYAKS

Two molds are used in the construction of a kayak: one for the hull and one for the deck.

3.1. Gelcoating

The deck and hull pieces receive their shape and glossy surface from the molds. In reverse order, materials are inserted into the polished and waxed molds, beginning with the application of gelcoat (the pigmented resin that gives the boat its color and glossy exterior). Before the boat itself is laminated, the gelcoat must be allowed to cure to a firm coating for the optimum finish.

3.2. Laminating

The process of building the kayak's shell by applying multiple layers of fabric reinforcements (usually fiberglass, Kevlar, carbon fiber, or some combination of the three) and a liquid plastic resin to the mold is referred to as "laminating" the part. The structural properties of the boat are determined as much by the materials used as by the process used to wet the fabric with resin.

In a composite material, the ultimate force the material can withstand is determined by the reinforcement fibers used. Reinforcement fibers are only strong along the length of the fiber, so each layer of fabric placed in the laminate must be carefully aligned in the direction of the loads that will be applied to the kayak. Fibers that don't run in the direction of any load will add significant weight to the boat without making it any stronger. Additional reinforcements are often used around the cockpit since these areas are highly loaded during rescues involving a swamped boat. Since the strength and stiffness of the kayak are largely a function of the laminate's thickness, a thick core material is often added between the layers of fabric. The core material is low in density and permits a thicker (and therefore stronger and stiffer) shell to be made without the weight penalty of extra layers of reinforcements. .

3.1.1. Lamination by hand

The earliest method that has been successful for a very long period. Gelcoat is applied to the mold and allowed to cure, as in Figure 4. It is still tacky since it won't completely cure when exposed to oxygen. Before the entire layup is completely wetted out with resin, the first layer is placed in the mold. The remaining layers are applied using the same method. It is then given time to cure after repeating the process until the layup is complete. This procedure is popular when fiberglass mat is used in the layup.

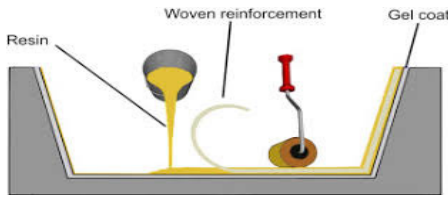


Figure 4 Hand lamination

3.1.2. Vacuum bagging

It is also hand laid into the mold, but the consolidation is put under pressure from a vacuum bag, as in Figure 5, improved resin-to-fiber ratio is the result. A greater skill level and a little more time are required to pull this off. If vacuum bags are used, there are two ways to carry out the laying programme. The standard method of laying by hand and then bagging, and the wet bag method are shown in Figure 6. In a hand-laid and bagged layup, all of the fiberglass and resin is put into the mold, and then a layer of peel ply release fabric and a layer of bleeder cloth. The stack is put under vacuum and then allowed to cure.

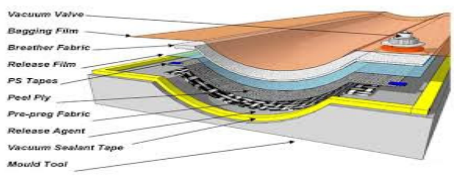
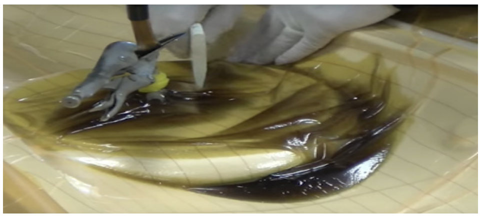


Figure 5 Vacuum bag



Figue 6 Wet bag method

3.1.3. Resin infusion

Resin infusion, Figure 7, where vacuum is the vehicle for transmitting resin into the consolidation. Resin is forced into the matrix by the combination of a positive pressure atmosphere outside the matrix and a negative pressure atmosphere inside the matrix. The layer of laminate is dry when it is introduced into the mould. Beneath the vacuum bag is a layer of non-stick fabric and a carefully planned system of flow media and inlet lines. To get rid of extra air and any potential moisture, the reinforcement is placed under vacuum. The resin is drawn into the consolidation by the vacuum after it has been under vacuum for some time, often two hours. The resin is used to replace the remaining air, and the result is quite accurate [5].

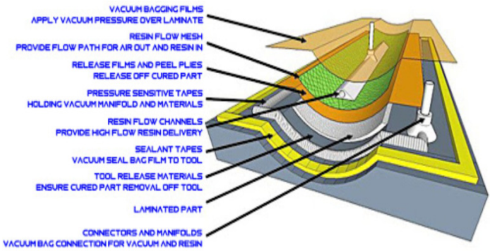


Figure 7 Resin infusion

3.2. Post-curing

Post curing involves placing the boat into a heated oven, Figure 8, that slowly ramps up the temperature and cooks the part for eight hours. The high heat of the oven helps to chemically link the individual molecules in the resin (a reaction called "cross-linking"), making the laminate even stronger and stiffer.

Post-curing also helps to improve the finish of the part by preventing print-through, a condition where the texture of the underlying fabric can be seen through the gelcoat. Print-through is caused when the laminate heats up (often from the sun) and shrinks unevenly. By post-curing our parts, we can control the rate of heating and help prevent the future development of print-through in the future. Post curing is only possible with epoxy resins because inferior resins like vinyl ester and polyester cannot survive the high heat of the oven without deforming [6].

Figure 8 Curing oven

3.3. Trimming and Seaming

Once the molds are taken out of the oven, the infusion materials are separated from the laminate and the part is removed from the mold. The cockpit and hatch openings are cut into the deck, and the edges of each piece are cut and sanded, a process visible in Figure 9. After the hull, hatches and skeg components are installed, the hull and deck are finally prepared for joining or " seaming ".

Figure 9 Trimming, Seaming

3.4. Final Assembly and Outfitting

After the hull and deck are joined, as shown in Figure 10, the boat is laid on end, and thickened resin is poured into each end. The solid resin end pours reinforce the tips to prevent damage and provide a solid area through which a rudder can be attached. The final structural elements to be installed are bulkheads, the vertical dividers that separate the boat into different water-proof compartments. The different compartments provide water-tight storage for supplies, but they're also essential to keeping the boat afloat when the cockpit is flooded.

Bulkheads can be made of foam, plastic, or a composite laminate. In a boat that's not stiff enough, a rigid composite bulkhead can cause the boat to break or permanently distort, since they do not deform together with the boat. For these boats, flexible bulkheads made of foam or thin plastic must be used. Because our boats are very rigid, we can fiberglass composite bulkheads in place without any problem. The rigid bulkheads make the final structure of the kayak even more rigid and resistant to distortion under load. With the structure of the kayak finally complete, the remaining outfitting (seats, foot braces, and deck rigging) is installed [7].

Figure 10 Final assembly

4. COMPARISON BETWEEN CARBON-FIBER, KEVLAR-FIBER AND GLASS-FIBER

The comparation between this composite materials will be done for the following criteria: Tensile strength; Density and strength to weight ratio; Young modulus; UV degradation; Fatigue resistance; Abrasion resistance; Adhesion to matrix; Colour and weave.

4.1. Tensile strenght

The maximum stress that a material can support, while being stretched, before if fails. The composite materials mentionated are brittle and fail with almost no distortion. Stress is the force, strain is the deflection due to stress.

	Fiber strength [MPa]	Laminate strength [MPa]
Glass fiber	3450	1500
Carbon fiber	4127	1600
Kevlar	2757	1430

4.2. Density and strength-to-weight ratio

When we compare the density of our 3 materials, we see a significant difference. If you compare 3 samples with the same dimensions, you'll see that Kevlar fiber is lighter, carbon fiber is next, and glass fiber is the heaviest.

In other words, any structure where we need a specific strength, we can use a smaller/thinner piece of Kevlar or carbon fiber than if we use glass fiber.

	Density [kg/m^3]
Glass fiber	2540
Carbon fiber	1750-1930
Kevlar	1380

4.3. Young modulus (E)

One technique to describe materials is through the use of Young's modulus, which is a measure of an elastic material's stiffness. It is defined as the uniaxial stress to uniaxial strain ratio, which has just one direction (distortion in the same direction)[8].

Young's Modulus is:

$$E = \frac{\sigma}{\varepsilon} \quad \text{[Pa]}$$

where:

σ - stress;

ε - strain.

	Young modulus (GPa)
Glass fiber	30-40
Carbon fiber	125-181
Kevlar	70.5-112.4

4.4. UV degradation

Aramid fibers (Kevlar) will degrade in sunlight and a high UV environment. Carbon fiber or glass fiber isn't very sensitive to UV radiation.

It is fairly irrelevant, however, because neither Kevlar, glass, nor carbon fiber is often used on its own in boatbuilding applications. They are embedded in a matrix that degrades in UV light. This is the case with epoxy resin, which will lose strength if left in sunlight, becoming chalky. Polyester and vinyl ester resins are more resistant to UV exposure, being weaker than epoxy.

4.5. Fatigue resistance

If a part is forced to bend and straighten repeatedly, it eventually gives way due to fatigue. While carbon fiber is somewhat susceptible to fatigue and tends to fail catastrophically without showing many signs of damage, Kevlar is more resistant to fatigue. Fiberglass is somewhere in the middle and can be quite resistant to fatigue, depending on the type of glass and configuration.

4.6. Abrasion resistance

Kevlar has strong abrasion resistance. This makes it difficult to cut. Suppliers often sell special scissors and very strong scissors for Kevlar fabric. One of the common uses of Kevlar is as a protective glove for use in areas where the hand may be cut by glass or when using sharp blades.

4.7. Adhesion to matrix

Both carbon and glass fiber have no trouble sticking to epoxy however the aramid-epoxy bond is not as strong as we would like. This reduced adhesion allows water penetration to occur. The result is the Kevlar tends to absorb water. This combined with is not ideal adhesion to epoxy means that if the surface of a Kevlar composite is damaged (such as with a sharp blow) and water can get in, then it is possible that the Kevlar will absorb water along the fibers are weaken the composite[8].

4.8. Colour and weave

Kevlar in its natural state has a light golden colour. It can be coloured, and many wonderful shades are currently available. Glass fibres have also been manufactured in coloured versions. Carbon fibre is always black. It can be mixed with coloured aramid, but cannot be coloured as such.

Following the analysis of each indicator, the results of the comparisons were recorded in the table.

	Glass fiber	Kevlar	Carbon fiber
Cost	Excellent	Fair	Poor
Weight to strength ratio	Poor	Excellent	Excellent
Tensile strength	Excellent	Excellent	Excellent
Compressive strength	Good	Poor	Excellent
Stiffness	Fair	Good	Excellent
Fatigue resistance	Good-Excellent	Excellent	Good
Abrasion resistance	Fair	Excellent	Fair
Sanding/Machining	Excellent	Poor	Excellent
Conductivity	Poor	Poor	Excellent
Heat resistance	Excellent	Fair	Excellent
Moisture resistance	Good	Fair	Good
Resin adhesion	Excellent	Fair	Excellent
Chemical resistance	Excellent	Fair	Excellent

Which composite material is better?

If your application needs *strength*, you can use Kevlar or fiberglass, but if price is the deciding factor, fiberglass is the right choice.

If your application needs *stiffness*, *strength* and *light weight*, your choice should be carbon fibre. But if price is the deciding factor, fibreglass is again the right choice. And the examples can go on depending on your criteria.

5. CONCLUDING REMARKS

Composite kayaks are both visually appealing and efficient to paddle. Composite construction allows for sleeker lines than rotomolding or thermoforming, and composites are stiffer than plastics, making them faster and more responsive on the water.

Composites, particularly premium layups like carbon fiber and aramid, are also lighter on your shoulder—but not on your wallet. These are the most expensive hardshell kayaks. Nonetheless, the durability of composite kayak materials means that a one-time investment can last your entire paddling career.[9]

Fiberglass is the original, tried-and-true composite material. The excellent strength-to-weight ratio and affordable cost of fiberglass make it the most popular choice for premium sea kayaks.

Kevlar offers similar strength and stiffness to fibreglass, but is lighter and more expensive. Aramid and blends of fiberglass and aramid are more common in lightweight touring kayaks, exploration kayaks, and surf skis.

Carbon fibre is the lightest (and most expensive) composite material for kayaks. Although it is typically used for elite kayaks and racing kayaks, ultra-lightweight recreational and touring kayaks are also available in carbon.

REFERENCES

[1]. Stuhaug, D. *"The Complete Idiot's Guide to Canoeing and Kayaking", Canoe and Kayak Magazine*, pp. 46, July 6, 2004.
[2]. Carey, J.P. *"Handbook of Advances in Braided Composite Materials: Theory, Production, Testing and Applications (Woodhead Publishing Series in Composites Science and Engineering 72)",* pp. 11, 2017.
[3]. https://www.outdoorsnb.com/pages/kayak-materials.
[4]. https://technologystudent.com/joints/kevlar2.html.
[5]. https://joeyschott.blogspot.com/2020/03/closing-gap-how-your-kayak-is-made.html.
[6]. http://walruskayaks.squarespace.com/blog/an-introduction-to-composite-kayak-construction.html.
[7]. http://walruskayaks.squarespace.com/build_process/.
[8]. https://www.christinedemerchant.com/carbon-kevlar-glass-comparison.html
[9]. https://paddlingmag.com/boats/kayaks/what-are-kayaks-made-of/#Composite_kayaks

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