Manufacturing of Rowing Shells

Homework #7: Self Selected Homework

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Summary: Rowing shells for sport were originally made from wood, but as time has progressed, manufacturers sought ways to make shells lighter and stiffer, leading them to use mostly carbon fiber. In this industry, much of the work to mold the shells to their shape is done by hand with the assistance of technology. This report discusses how racing shells are made as well as the impact on different levels of engineers.

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***History***

Rowing, for sport, began around the 17th and 18th centuries in England, but was used as a means of transportation in ancient civilizations. For centuries the hull, the main frame of the boat or shell, was made out of overlapping wooden planks (“Rowing Equipment and History - Olympic Sport History”). By the 1800s, in order to increase the speed and swiftness of the rowers in the boat, shell makers began to look toward other materials as an option to build their shells. In 1867, composite shells were made “…from a form of papier-mâche composed of layers of paper saturated with a varnish or glue, which hardened once they were dry” (“Racing Shells”). This technique did not last very long because it was expensive to refurbish the composite material that had a tendency to wear and crack. Boat makers reverted to using thin spruce and cedar to make shells, which they nailed together and painted with many layers of marine varnish, but this process took many days and any mistakes meant scrapping the shell and starting anew. After the second World War, new innovations allowed for a change in the craftmanship and production of rowing shells. Today, most modern racing shells are made from reinforced plastics or carbon fiber.

***Materials***

Most of the major racing shell makers, like Wintech, Pocock and Vespoli, use similar materials to make their product. These companies, and others, use uni-directional carbon, woven carbon, fiberglass, Nomex Core, and Kevlar. Each material is used for a different type of shell, depending on how the final shell will be used, its size, whether it be a 1 man scull or an 8 man sweep, and finally the price of the shell (Materials).

***Manufacturing of the Rowing Shell***

Rowing shells are primarily made by hand by many different workers. Every hull is laid into molds that can be seen in Figure 1. A layer of honeycomb is laid in between each sheet of epoxy infused carbon fiber. The carbon must be kept refrigerated as it hardens when heated, the layers are then vacuumed bagged so that the layers will conform to the mold. This vacuum bagging process bonds the layers of carbon fiber and honeycomb in the shape of the mold, creating a stiff and very light structure. Next, an oven is lowered over the mold to cure the epoxy at 250 degrees. After the boat has fully cooled and the oven is removed, it has enough strength to be removed from the mold and is able to sit on its own. This is how the outer shell of the entire boat is made, the molds change based on the size and type of the boat, single, double, quad, all the way up to coxed 8.

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A picture containing indoor, wall

Description automatically generatedA picture containing ceiling, indoor, floor, airport

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**Figure 1:** Floor space at a Vespoli racing shell factory, showing the molds used to create racing shells (left). Vacuum bagging of the shell to bond the layers of honeycomb and carbon fiber (right).

After the shell has finished molding, the other components of the boat must be added. Figure 2 shows several of the components that must be added to a racing shell. The rudder tube and fin, which are used by coxswained boats to steer, are bonded to the boat using high strength resins and glues so that they are securely bonded for the boat to last for years. The shells decks are added next, the decks lie under the sliding seat of each oarsman. For eight and four man boats these decks exist in two separate pieces that must be connected in the center, but for single and two man boats they are just one piece. The decks are made in their own molds and cured a similar manner to the hull. The decks are then laid onto the hull in the proper position and attached via resins and glues that keep them bonded to the hull for the shell’s life.

A small boat in a body of water

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Deck

Seat with sliding track

Riggers

Shell

**Figure 2:** Components of a single (one-man) racing shell. Beneath the riggers just barely visible are the foot stretchers.

Once the decks have been installed, the boat is flipped over so that the underside of the boat and its sides can be sanded down. After this, the shell receives a coat of primer, is re-sanded, then will be painted again before being shipped to the customer. The shell is shipped to the customer in protective shrink wrap, without the riggers attached, without the fin on the boat, and without the seats on the deck to avoid damage to the boat, or anything it could encounter, during travel.

The riggers are made from extruded stock metal (typically aluminum) that usually comes shipped from a third party. In the factory, these are welded together to create the proper rigging shape for the two different types of shells. To ensure quality fit of these parts, they are fitted into the boat before they are packed and shipped to the customer.

***Machined Parts***

The foot stretchers, which are the foot plates used in rowing shells with a pair of special shoes attached, are machined using CNC mills. These parts have several different sized holes for adjustments to be made, and holes for the shoes to attach to, thus making them on a CNC mill saves time for employees so they can do more of the hands-on work throughout the factory.

***Business and Economics***

The manufacturing of rowing shells was heavily influenced by the NCAA’s recognition of Title IX in 1997, this mandate increased the amount of money college’s and university’s put into women’s rowing programs increased dramatically. For example, Pocock boats, which manufactured wooden boats for many years was selling only about 50 boats per year and “was

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close to shutting down” (“A Shell Game”). Because Title IX measures compliance based on the proportion of money allocated to women’s sports versus men’s sports, it is difficult for other women’s sports like softball or soccer to spend the same amount of money as the huge sports of men’s football and basketball. The answer for many athletic directors lie in women’s crew: “Crew can indeed cost a pile when a boathouse, training equipment, coaches and all other paraphernalia that goes with messing about in $35,000 boats are added up” (“A Shell Game”). After this, the number of women’s collegiate rowing programs nearly doubled, and while collegiate programs started to grow, high school programs grew as well, and this niche of the rowing community is still growing today. The increase in programs also meant a higher demand for rowing shells and “…Pocock’s annual sales had grown to 240 boats and the company was grossing $2 million annually” (“A Shell Game”).

***Relevance to Engineers***

For a beginning engineer, the importance of this topic would be learning about how the alternating layers of honeycomb and carbon fiber increase the strength and stiffness of the shell, while keeping it lightweight. It is an interesting concept that multiple layers of thin material can create a stiff part but can still be extremely lightweight for optimal speed. In addition, the information presented about how the shell and its many components are shipped to the customer is important to recognize. The shell has to be without its various components so that the boat or any of the various attachments do not get damaged before delivery.

For an experienced engineer, the value of this topic is that this is a global industry, many racing shells are made within the US, but one of the best racing shells, used by many Olympic teams and increasingly by the best university teams, is the German Empacher. This is useful to recognize because it demonstrates that even products with a seemingly niche market can be global industries.

***Learnings***

I learned more about how a product is made that I have been heavily using since I was 15 years old.

I chose to research how the rowing shell was manufactured because I was on my high school’s rowing team and still row in Philadelphia on breaks when I have a chance. We once learned the process of how the oars we used were made from the president of Croker Oars, so I have always been interested in learning more about the production of the rowing shell itself. When completely rigged, an 8 man rowing shell weighs just over 200 pounds, this carries 9 women or men comfortably, well over 1000 pounds. I have always found this fascinating and wanted to learn more about how something so lightweight can still be stiff and able to move so quickly through the water. I learned that the layering and vacuum sealing of the carbon fiber and the honeycomb is one of the more crucial aspects of the shell making process, and that these boats are actually in a mold.

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