APPLICATION OF A VARIABLE-AXIAL FIBER DESIGN

Lightweight Recurve Bow Riser rec 16º

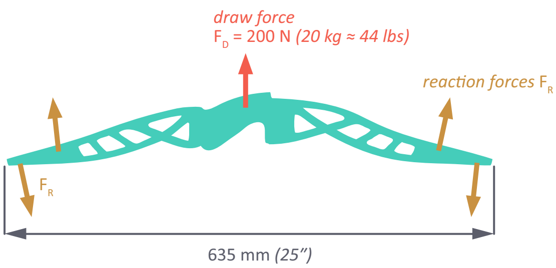
For at least 14,000 years people have used bows and arrows. At first, these wooden tools were used for providing sustenance. Today, archery equipment is made from high-tech materials such as aluminum alloys and carbon fiber composites to achieve high precision and efficiency in archery.

With modern bows, archers at Olympic Games are able to hit a 12 cm target at a distance of 70 m.

Idea

The majority of archers use aluminum alloy risers. The aim of the project is to reduce the weight of the risers by using variable-axial carbon fiber structures without loss of mechanical performance. The motivation to strive for less weight is that the archer needs fewer efforts to hold the bow on the extended arm. It also helps to balance the bow more easily.

To realize a new generation of carbon composite bow risers, Tailored Fiber Placement (TFP) technology can be used. Based on finite element (FE) simulation, a new tool for fiber optimization and design, and in collaboration with industrial designers, a new riser has been developed.



Boundary conditions of a recurve bow riser on the basis of a common draw force of 44 lbs.

Riser

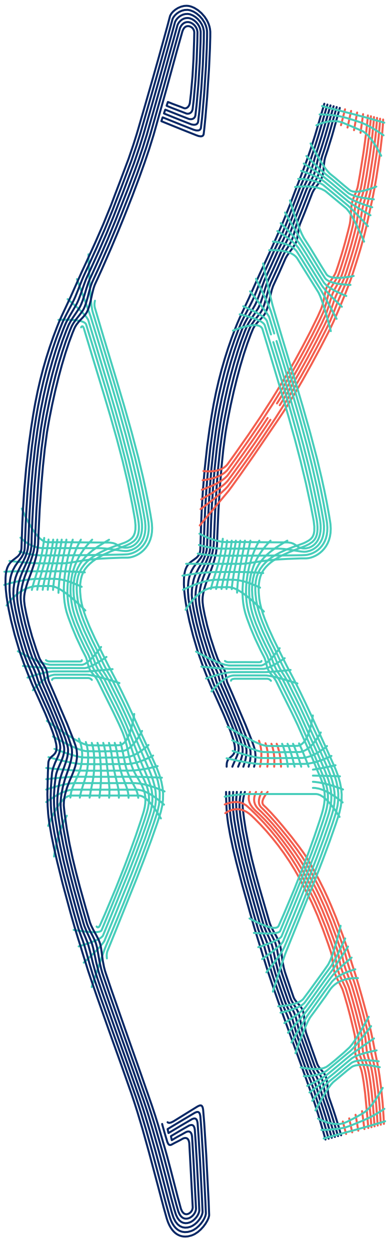
The riser is the center part of a recurve bow. The limbs are connected to this center part, whose main requirements are:

- Resisting high dynamic and static stress
- Absorbing vibrations and shocks
- Low weight along with high stiffness
- Unique design

The majority of current risers are made of aluminum, weighing 950 g to 1400 g. The currently best carbon risers are not lighter, weighing about 1000 g to 1350 g.

Top: Result of the topology optimization

Middle & Bottom: CAD model of the redesigned riser



Design and Development

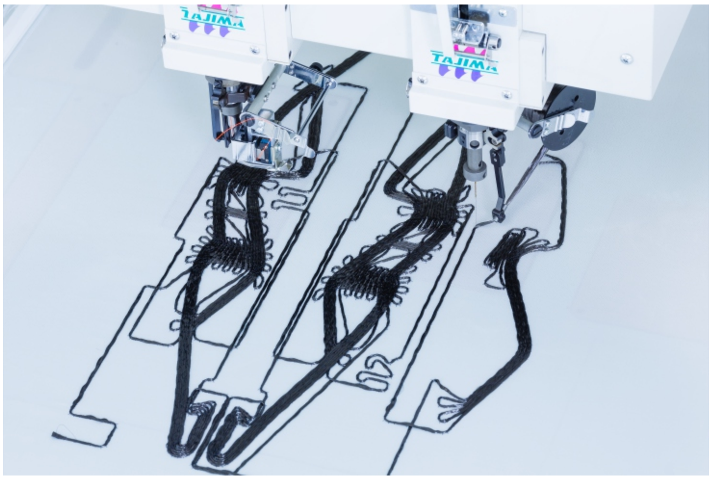
Following reverse engineering of a commercial aluminium alloy riser, the required component stiffness parameters were evaluated and used to further redesign the carbon composite part. In a first step, a topology optimization was carried out with the help of FE simulation software tools. Based on the resulting design proposal, design students of the HTW Dresden – University of Applied Sciences, Faculty of Design, defined the final shape.

Redesigned with inspiration from biology and the so-called catenary model, the elegant shape of the riser, now known as rec16, emerged. In a final step, the fiber path pattern of the 3D design of the riser was determined for TFP manufacturing process. The shape was assembled with up to eight carbon fiber preform layers.

Manufacturing

Using TFP technology, carbon fiber rovings can be placed at locally arbitrary angles along the highly stressed directions of the component structure. The result are complex curve-shaped preforms that can exploit the full potential of anisotropic reinforcement fiber composites. Finally, the manufactured preforms are placed in a mold and infiltrated by resin transfer molding (RTM).

Thus, the weight of a carbon fiber composite riser can be reduced by approx. 40 % compared to commercial reference products to approx. 600 g while increasing the mechanical efficiency. In addition, the material waste caused by manufacturing processes can be minimized, especially compared to milled aluminum alloy risers.



Fiber path pattern

Manufacturing of the carbon fiber preform by TFP technology

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