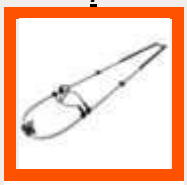
Author: Jaap Willem van Ingen



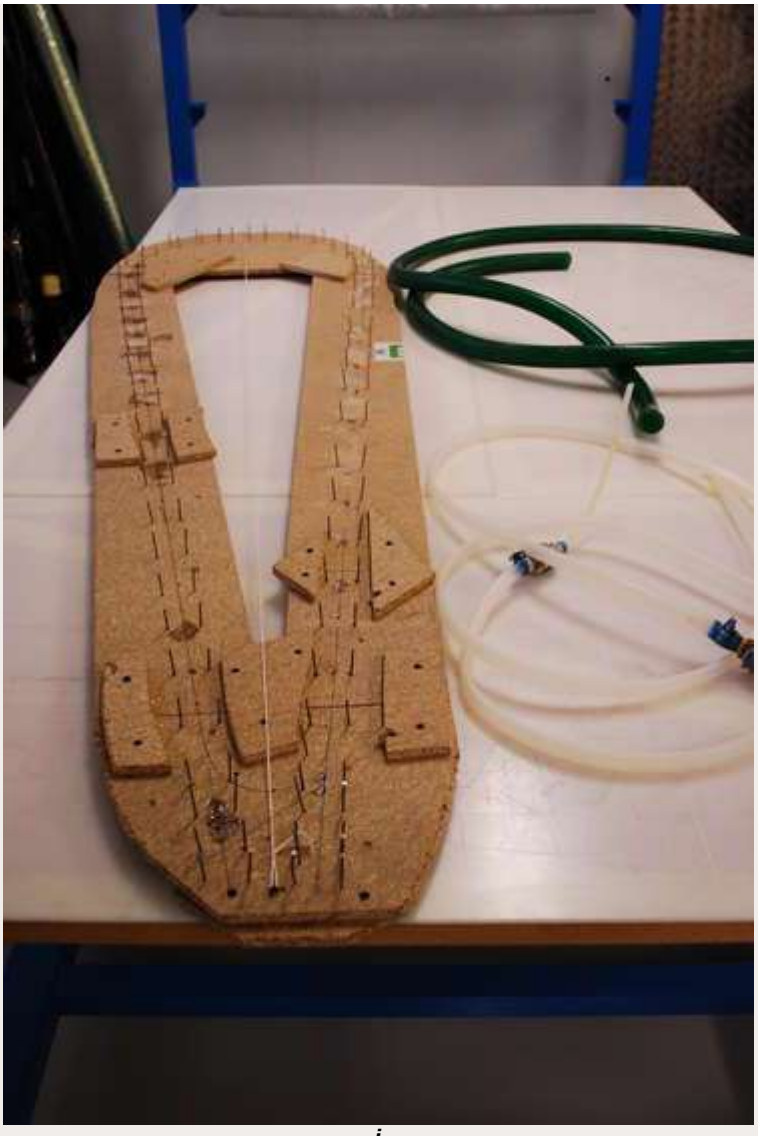
This story explains the method I used to make a 100% carbon windsurf boom.

Carbon windsurf booms nowadays are standard for race sails, but can often cost more than 1000 euro. Therefore I decided to try to make one myself for my Aerotech VMG 6.0 sail, using aerospace materials.

The result is a boom which is lighter and at least equally stiff compared to an industrially

manufactured boom. Combined with one of the best boom heads available (Streamlined), it makes an incredibly stiff combination and a pleasure to sail.

Step 1Chipboard & nails



The first step is to make a core.
I thought a bit about a foam core, but that would require a lot of shaping and sanding and eventually might be very fragile in the layup process.
To avoid this I developed a new method using glass fiber fabric, RT cure epoxy resin and a garden water pump hose...

The contours of the boom core are drawn onto a chipwood plate (or any kind of other scrap wood) Nails are hammered down into these lines with a spacing of about 2 inches. This "mould" and a tube which will fit between the nails is all that is needed to give the boom its shape.

Step 2Tubes

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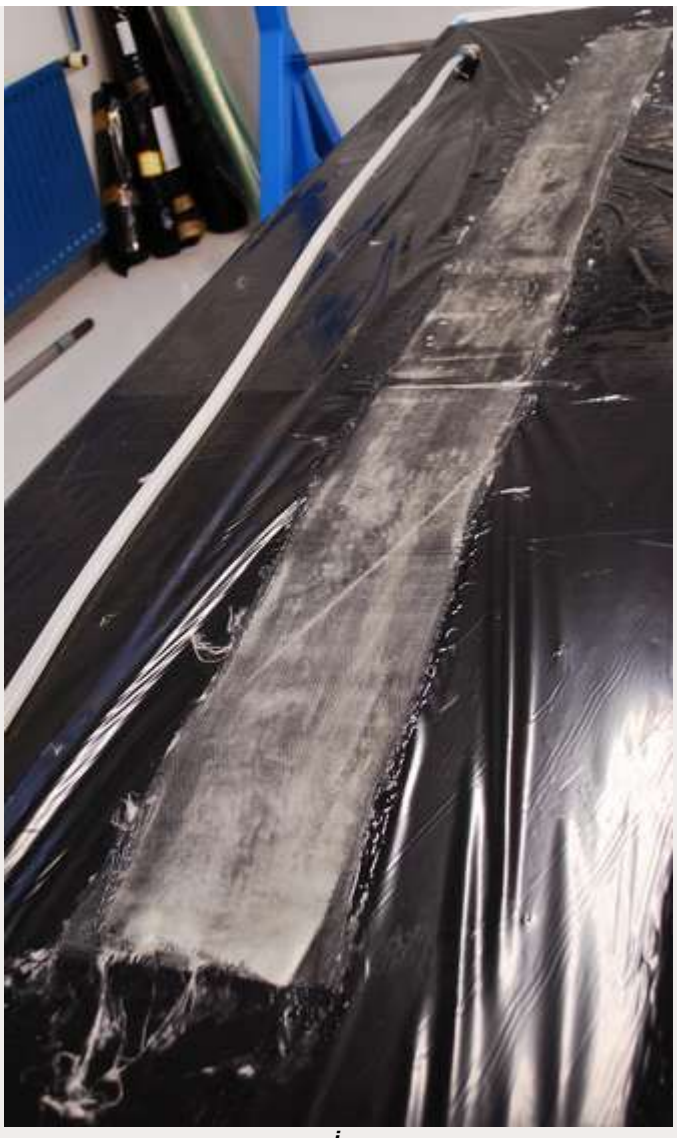
The tube I used was a flexible hose with an inner diameter of 25 mm. The tube is cut over its entire length using a knife. This is necessary to be able to insert the glass fabric later on.
Also needed is a 12 mm silicone inner tube which is provided with fittings at both ends. This inner tube will be pressurized.
Both tubes are treated with release wax.

All the mould parts are now ready. The next step is to make the glass pre-preg for the core.

Step 3Glass fabric & epoxy resin



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For the glass pre-preg a large table is covered with a foil. A glass layer (200 gr/m2) of about 140 mm wide is rolled out over the foil. A two component epoxy is mixed and poured onto the glass. The resin is spread out using a squeegee.

Step 4"Sticky sausage"

The next step is to roll the glass pre-preg twice around the slicone inner tube to create a "sticky sausage".

Step 5Stuffing

The "sticky sausage" must be stuffed into the outer tube through the lengthwise cut. At this stage you really want to wear rubber gloves and begin to wonder if all the efforts so far are waisted within a few minutes...
Just continue (it will work) and take care that the glass remains properly wrapped around the silicone tube while stuffing.

Step 6Tape wrap the outer tube

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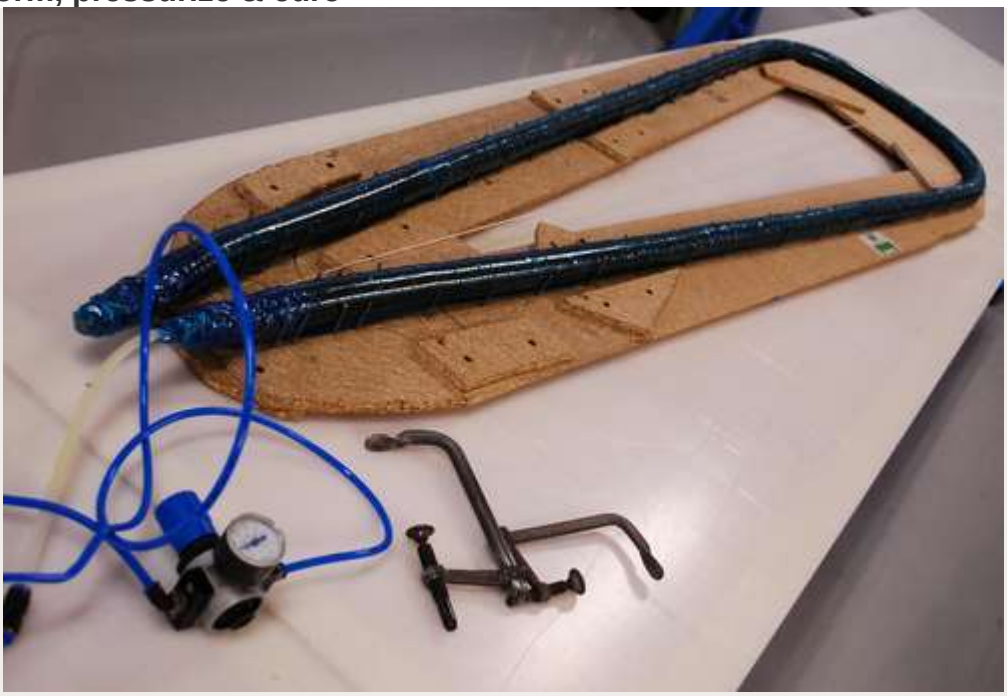
Once the glass and inner tube are inside the outer tube, clean the outer tube a bit and start wrapping the outer tube with tape. This seals the outer tube.
Note that the epoxy resin is curing during all the previous steps, so quickly transfer the sealed tube to the nail mould.

Step 7Form, pressurize & cure



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Force the sealed tube between the nails to give the glass pre-form its shape. When the tube is fixed, apply pressure to the innner tube.
Now the glass pre-preg (which, if you were fast enough, is still not cured), is forced to the inside of the outer tube and will remain in this shape once the resin is cured.

Use something sharp to puncture the tape wrap here and there to allow excess resin to squeeze out. Now let the epoxy resin cure overnight.

Step 818 hours later...

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Waiting for something to cure and to finally see what comes out is always exiting.
After removing the tape and peeling away the outer tube, a nice glass preform appears.

Step 9The finished glass core

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The glass core is lightly sanded and ready for the next step: lay up of the carbon pre-preg layers. Note that I left the silicone inner tube inside the glass core.

Step 10Carbon fibre pre-preg lay-up

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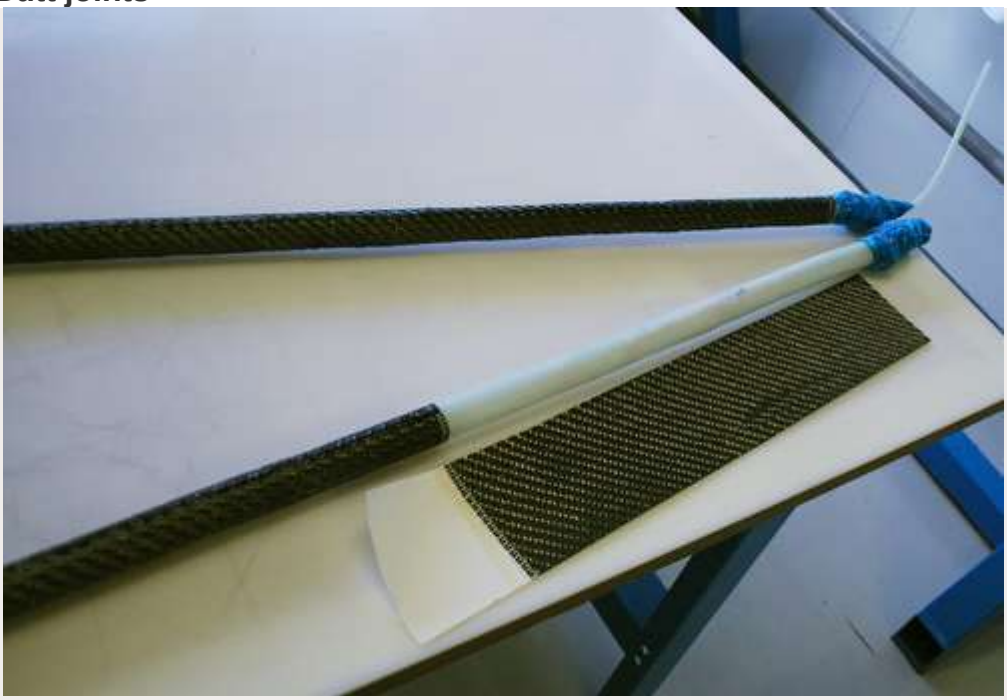
The carbon fibre pre-preg I used is a carbon fibre fabric with the epoxy resin already impregnated. This material must be stored in a freezer and is cured at 130C. It is an aerospace material which was left over from a R&D project (Material code: MTM44-1: http://www.advanced-composites.co.uk/PSG_Electronic_Files/Aerospace_PSG_Files/outofautoclave.html

The big advantage of this material compared to a wet lay up (as used for the glass core) is the tackiness of the material and its open time. This makes the lay-up far more easy and less stressful as the pre-preg only starts to cure when it is heated to 130C.

I cut 11 cm x 120 cm strips of pre-preg (0/90) and laminated three full layers onto the glass core.

Step 11Butt joints



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Since the pre preg strips have a limited length, joints between the layers will be present. I used butt joints on al the layer ends (in both directions) and made sure that the butt joints are not at the same locations between the different layers (which would seriously weaken the strength of the boom).

Step 12Get rid of wrinkles

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The first three layers are cured before laminating the subsequent layers.
During cure, the prepreg has to shrink in thickness direction To prevent wrinkles due to excess material I tightly wrapped the lay-up in tape with the **sticky side to the outside**.

Step 13High temperature cure of the first 3 layers

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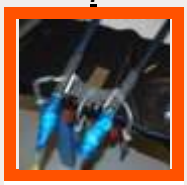
The prepreg I used must be cured at a high temperature. Normally in aerospace this is done by vacuum bagging the layup and curing in an autoclave or oven at high temperature (typically 120C to 180C).
Since I work in an aerospace R&D department this equipment was readily available and I used it to cure the first three layers.
During cure pressure was applied to the internal tube to prevent collapse of the glass core.

Step 14The end piece



After debagging and sanding an end piece is applied to close the boom.

To keep things simple I decided to make the boom at a fixed length and only suitable for my 6 m2 VMG. Adding an adjustable end piece would take to much time at the moment and would result in some loss of stiffness.

To close the boom I shaped a 4 mm carbon laminate and bonded this between the boom tubes at the end, using two component epoxy resin thickened with micro balloons.

Step 15Lay up and cure of the remaining carbon layers

The final layers are applied and are bagged and cured as described previously.

The total amount of basic layers is 7 (including the first 3). At the end piece there are 3 additional layers and at the boom head 6 additional layers, starting at the beginning of the bend and gradually building up to the boom head. The orientation of the layers is 0-90. Only at the end piece there is one layer at +/- 45 to counter shear forces. A cured layer is 0.3 mm thick with a fiber volume fraction of 50%.

Step 16Sanding

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Pffff... A fine example of a Dirty Job.

Step 17Coating

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The boom is coated with two coats of epoxy and two coats of polyurethane UV protective varnish, all applied with a roller.

Step 18The boom head

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A stiff carbon boom with a sloppy boom head is like a fighter jet with a propeller. So, I choose on of the best heads available today (Streamlined: http://www.streamlined.us/boom-heads.htm).
I prepared two local areas of the correct thickness (34 mm) at the boom head location. The streamlined boom head can then be easily mounted with a hex wrench.

Step 19Grip

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The boom diameter without grip is 29 mm. There are spare boom grips available which can be bonded, but they are made of 2 mm thick foam. This would make the boom to thick to my taste, so I

used the hockey stick tape (<0,5 mm tick and inexpensive).
I choose white to nicely go with my white VMG sail.

Step 20Pullies

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The flat end piece is perfect to mount two (or more) pullies for an adjustable outhaul system. Just drill holes and use stainless steel bolts.

Step 21Evaluation

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The boom sails very well. It is very stiff. Also the hockey stick grip is all right despite its small thickness. The total weight of the boom including grip and boom head is just under 2 kg. This is lighter than commercially available booms of this size (194 cm).

I realize the manufacture of this boom is quit complex and requires a good workshop to complete (vacuum equipment, large oven, per-peg stored in a refrigerator, bagging materials etc.). It took about 50 (work) hours to make the moulds and the first boom. The total time from first intent to sailing on the water was about 2 months.

If the carbon pre-preg and oven are not available, the carbon might also be applied using a wet lay-up method as described in the instructable about making a carbon bicycle:http://www.instructables.com/id/How-I-built-a-carbon-bike-frame-at-home-and-a-bam/ This would however take a lot more building time, because then each separate layer is wrapped with tape and then cured.

Thanks for reading.