

## Home Building a Carbon Moth - Part 2 - Foils (c) 2009 Bruce McLeod

### Why do you want to build your own foils?

Before you start making your own hydrofoils you need to ask yourself this question. Like most things in life, there are pros and cons to everything. This is definitely true when it comes to making your own foils.

From the outset you are going to need time, patience, and a high tolerance for failure, if you don't have all three then stop reading now.

#### Pros

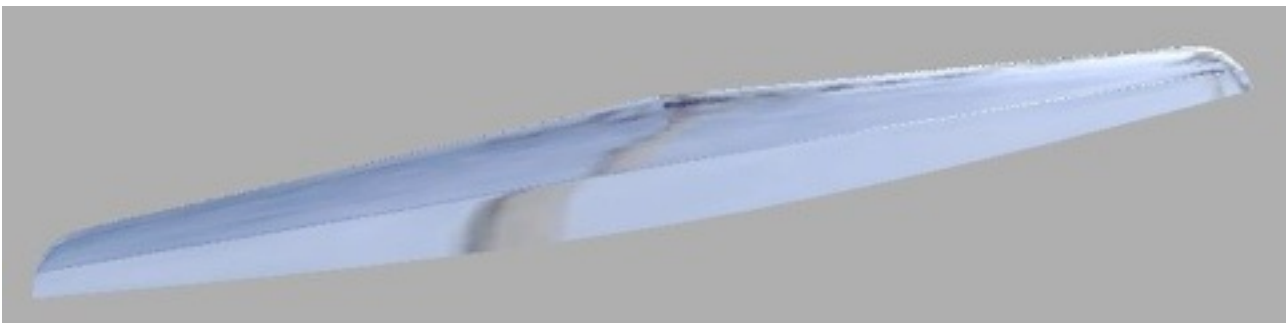
- Home building is cheaper
- You can use your own designs which might be faster than everyone else
- You can try your own ideas

#### Cons

- You WILL have failures and breakages, and as a result you may end up spending more than you would have done if you had simply purchased foils in the first place
- You have a steep learning curve across all aspects of making foils: design, construction, setup and repair
- Your design might be slower than everyone else
- Your foils might be weaker and heavier than production made ones

### The Design

Ok I am going to assume that you have your design, and that you have either CNC machined moulds or you have hand crafted moulds that you can use.



If you want to go the hand-crafting route I would recommend that you make 3 half plugs, one for the vertical (assuming a straight non-tapered section) and two for the horizontal (one for the top, and one for the bottom), assuming you are going to cut your flap in later. Otherwise you might actually want to make four moulds for the horizontal, (flap top & bottom, foil top & bottom).



Once you have your plugs, then you want to mould them. For our moulds we just used gelcoat and chopped strand mat, however it is recommended that you use specifically designed mould tooling resins. Contact your local composites supplier for specific advice on what you should use.

### **The approaches**

There are two approaches you can use, when it comes to moulding ... an "all in one hit" approach where the entire foil is moulded complete, or a "make then assemble" approach where you make all the parts one by one and then assemble them. In this document I will cover both approaches.

### **The Laminate schedule**

This is one area where I must admit I am still learning and like all things there are compromises that must be considered. The main trade-off in this area is weight vs strength and stiffness. Professionally built foils are made using pre-preg and/or high modulus pre-preg whereas home built foils are commonly built using wet-layup techniques, this from the outset implies that home built foils will have a lower strength per kg than professionally built foils.



#### My first and second foils (Main and rudder built 2006)

My first foils had approximately 6 layers of 300 gsm UNI's plus 1 layer of 200gm kevlar per side, with a single layer of S-glass on the outer skin for finishing. These foils had a balsa / chopped strand / bog core and failed at the exit of the hull due to twisting load. The rudder is still intact, however it has become "soft" and flexes too much in twist to be used anymore, without maintenance.

#### My third foil

The resin used for my third foil was faulty and it was discarded after the resin failed to cure.

#### My fourth foil (Main foil built Jan 2007)

My fourth foils was built to replace the failed first foil (the bottom half of which is at the bottom of Lake Macquarie at Sunshine) had the same 6 layers of 300 gsm, plus an additional 6 layers of 300 gsm at the top where the previous foil broke. These foils are still in one piece, and apart from T-joint issues due skipper error they have worked as designed. The inner core was bog with no balsa or other structure. This foil weighs approx. 5kg.

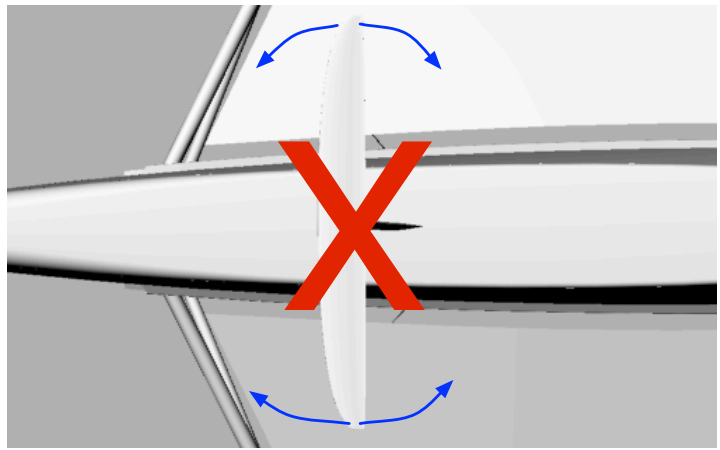
#### My fifth foil

My fifth foil was built in sections and then assembled, as shown in this document. This foil was built to a target weight of 2.5kg. The skin thicknesses were reduced back to 6 x 200gsm skins per side, however two solid pulltrusion rods were added to the core of the foil to increase the strength and stiffness. This laminate schedule has proven to be sufficiently stiff, however it has had some twisting issues due to incorrect fibre orientation (See below) this was rectified by adding two additional layers of 200gsm to the outside of the foil after it was completed.

## Fibre orientation

Probably the single biggest mistake that I made on my foils is failing to understand the need to have fibres oriented at 45° to prevent the foil twisting, as show in the diagram, which is bad.

A lack of fibres oriented at 45° allows the foil to twist along the length of the vertical well beyond expectations, resulting in a boat that is unstable when being turned whilst foiling.



This is also a likely cause of my first foil failure which broke off at the hull.

## Schedule recommendation

I am not an engineer and your final laminate schedule is up to you, however my recommendation is that a foil should be constructed from a minimum of around 6-7 layers of 200gsm with the inner 1-2 and outermost 2-3 layers being oriented at 45° to the vertical, with a pulltrusion or timber core. The other layers should consist of unidirectional fibres running from the top to the bottom of the foil. You may also want to have additional "half layers" at the top of the foil, particularly where it leaves the hull.

## **Method 1 - The single "big bang" layup**

The basic method of constructing my first 4 foils was to have a three piece mould that consisted of two L's and a flat. This allowed single uni-directional fibres to run from the top of the foil, down around the T join and out to the tip of the foil horizontal.

Making foils using this big-bang method is like making stir fry, i.e. most of the effort is in the preparation, cutting everything to shape.

All the cloth was pre-cut to length, then both sides were laid-up. the void was then filled with an epoxy filler mixture and the two halves then bolted together. the foil bottom was then laminated, along with the flap hinge rubber and attached to the mould, after more filler was added.



The mould was then bolted together and left to cure for 24 hours before the mould opened and the completed foil was removed, ready for trimming and final finishing and setup.

## **Method 2 - The step by step layup**

The step by step layup is recommended as it allows greater control and more time to get the details correct.

### Step 1 - laminate the skins

Each skin is laminated, and vacuum consolidated individually. Vacuum bagging allows a lighter, stronger finished laminate than would be possible otherwise. Methods for vacuum bagging are well known and will not be repeated here.



### Step 2 - Trim and fit

Once the separate skins have been moulded, then they need to be trimmed and fitted together, so they are as designed. In some cases you might wish to trim after your parts are assembled, however typically trimming should be done at this stage.



#### Step 4 - Internal structure

At this point you will want to fit and install the internal structure. Some foil makers like hardwood timber, personally I prefer carbon pulltrusion from CST composites. For my foils I like to have a minimum of 2 15mm x 7mm pulltrusions that run the full length (or as much as possible) of the foil. On the horizontal you will also need to fit the T-join or any supporting structure for a 2 piece foil.



I also use this stage to glue in a tube for any control rods that may be required in the verticals. Once the structure is in place, if you want to include any foam to make the foil float, it should be added at this stage.

#### Step 4 - Join the skins together

At this stage you will want to glue the skins together. Care must be taken to ensure that there is enough glue to ensure that the skins are well bonded and won't come apart. Personally I use Epiglu for this task, but you should talk to your local composites supplier for recommendations.



Step 5 - Cut and re-attach the flap

i personally use a flexible rubber hinge, however others use kevlar that has been impregnated with Sikaflex, and others such as Bladerider use just Sikaflex by itself. For my technique it requires that I cut the flap off the otherwise completed horizontal using a dremel and then glueing it back on using a rubber hinge and Sikaflex.



### Step 5 - Join the horizontal to the vertical

Once the vertical and horizontal are completed, they can be joined. For strength I recommended that you recess the vertical into, or through the upper skin of the horizontal. I use Epiglue for this purpose, then add three layers of 90 gsm oriented at 45° over the join, taking care to keep the T as thin as possible. At this stage you MUST be accurate and you MUST ensure that the foils are at 90° to each other and that the static angle of the vertical relative to the horizontal is correct and as designed. I suggest that you make a jig for this purpose.



### Step 6 - Finishing details

From this point on you need to make and fit the bell-crank, pushrod and barrel nut in the foil. If you don't want to make these yourself you can typically purchase these parts from a production supplier such as: Aardvark, Bladerider, Fastacraft, or Mach 2. The method of fitting a barrel nut is described in detail in the Bladerider barrel nut replacement guide and as a result will not be repeated here.

Your foils should then be filled, sanded, undercoated and panted using a high quality 2 pack paint.

### **T Joins**



Probably the single biggest engineering challenge is the T-join. My early foils consisted of two stainless L plates which were bonded into the foils to form a T. These will bend if there is an impact, as opposed to breaking, however the carbon around them will split and require repair.

The other option is to create a carbon fibre T. To do this you will need to include a significant amount of fibres, with the majority oriented at 45° to the foils. I

would recommend that you should include two T's of around 25mm each.



Once the T's are in you should then put some additional layers of carbon on the outside, of the joint with care to ensure that the thickness does not increase.