Make a Carbon Fibre Blade

It will help to understand this article if the "Turbo blade" article is read first.

The following article describes the advantages of the carbon fibre blade and how to make one. Not for everybody, but, there are those who will enjoy the creative activity. It may seem a lot of work but if engaged one step at a time can be quite enjoyable. If the time is not available then a blade can be purchased from Gaco to go with the Trapezoidal shaft that is described in "A Superior Oar shaft". This shaft is quite easy and quick to make and is very stiff and light.

The original intention was to make the blade out of wood veneer but this made a compound shape difficult. So a fibreglass blade was designed and manufactured. Since then carbon fibre has been incorporated into the layup as some of the glass fibre blades failed. As well the shape of the blade has been radically altered as a result of new theories and experimentation.

Traditionalists may object but the photos of three types of blades indicate the sort of improvement that can be obtained using modern materials.

Oars from right to left are, Flat blade, Spoon blade and carbon fibre Turbo blade.

The flat blade is cheap and readily available. However it is cumbersome because the blade is heavy. The spoon blade is a nicely made oar that was commercially available in the middle of the last century, before outboards took over. The Turbo blade has been supplied to customers including a fit young lad who smashed the race record rowing around Dangar Island this year (2012). A review of the statistics for the oars illuminates my comments.

Blade	**Volume (1)** *cm^3*	**Area** *cm^2*	**Weight** *grams*	**Weight/unit area** *g/cm^3*
Flat	1150	640	577	0.90
Spoon	900	620	448	0.71
Turbo	370	800	300	0.37

(Assumes density of 0.5 for wood and 0.8 for carbon blade)

The effort to swing a heavy blade back and forth in the stroke can be experienced by simply not entering the oar into the water, that is, to do an air stroke. Since the blade is at the end of the oar and moves further and faster, changing its momentum absorbs larger amounts of energy. This I why it is important to keep the oar light but especially the blade.

It can be seen that the weight per unit area of the turbo blade is almost half that of the spoon blade. A skilful craftsman could possibly match the weight of the turbo blade with a light timber but it is doubtful he could match the strength, stiffness, durability, area and complex shape now being incorporated into the design.

The racing blade that is commonly used is 30% heavier than the turbo blade at 400 grams. The flat shape of the racing blade and the brute force of high performance rowers necessitate this extra strength. The turbo and sailing blades get much of their strength and stiffness from their compound shape in a similar way that an eggshell displays strength against compression. It is claimed that the racing blades are kept flattish to enable quick entry and exit from the water as rapid stroke making is desired. However this may be a reflection of the innate conservatism of the establishment. The turbo blade has not hindered rapid stroke making in our rowing boat races.

Function of the layup components.

1. Carbon fibre cloth: strongest material known to man contributes strength and stiffness to the blade. Because of the compound shape, acts mainly in tension but also compression.
2. Coremat: is a micro balloon impregnated, felt like material that adds thickness and stiffness to the layup without adding too much weight (resin impregnated relative density is 0.6, about the same as Douglas fir).
3. Chopped strand mat: chopped layers of straight fibreglass strands dispersed in all directions have higher compressive strength than woven material. Readings and experimentation confirm this. Previous failures have all been compressive.
4. Light woven rovings: these help consolidate the chopped strand mat and improve the finish.
5. Vinyl ester resin: stretches twice as far without failing as polyester, is about 10% lighter and has much better adhesive properties.

The following steps are used to make the mould.

1. Deciding which shape to use.
2. Purchasing materials.
3. Making a plywood backbone.
4. Gluing a foam shaping piece to the backbone.
5. Shaping the foam piece.
6. Fibreglassing the shaped foam.
7. Finishing and polishing the mould

Choosing the shape:

Read the article on the Turbo blade. This describes two shapes to choose from but others may be tried. It is fairly important to have a reasonable curve across the section to grip the water and increase strength.

Purchasing materials for the mould:

To make the mould you will need the following.

a. A 60cm (2ft.) by 20cm. (8") sheet of 12mm (1/2”) ply.
b. A 50cm. (1’8”) by 20cm. (8") sheet of 5mm (3/16”) ply.
c. A 50 cm. by 20 cm. by 25 mm (1”) sheet of plastic foam. (Polystyrene foam can be obtained from foam boxes used by your green grocer but must be glassed using epoxy or it will melt. Your fibreglass dealer can supply suitable foams such as polyurethane that can be used with vinyl or polyesters.)
d. A couple of meters of 200g/m^2 (6 oz.) woven rovings.
e. PVA wood glue.
f. Four litres (one gallon) of vinyl ester resin and catalyst.
g. Small fibreglass roller.
h. Kilogram (two pounds) of talc
i. 1kg. (two pounds) of micro balloons.

Making the mould.

1. Make the strong back as shown in the picture using the half inch ply and the 5mm ply with the grain at right angles to allow easy bending. If you have chosen a more extreme curve it will be necessary to cut slits in the foam, which will be filled by resin and micro balloon bog.

Mould ready for shaping.

The foam can be glued onto the ply using PVA glue. Note the holes that will be filled with epoxy micro balloon bog.

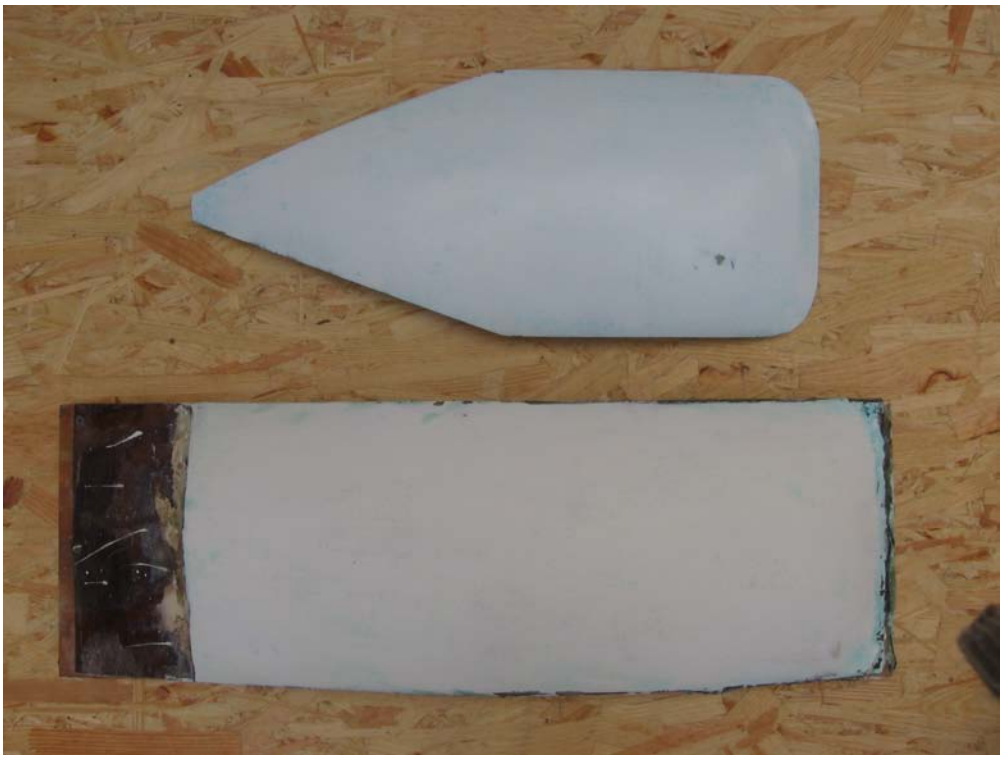
2. Rough shape the foam with a power planer or disc sander.
3. One way of doing the final shaping is shown.

Shaping.

The Sailing blade mould before fibre glassing.

Glassing and filling:

Polystyrene foam must be fibre glassed with epoxy and several layers of the 6 oz. cloth. This can then be filled when hardened with a bog of talc and epoxy using a broad spatula. A cheap plastic ruler can serve this function. Sand with increasingly fine paper and then with cutting compound till a smooth finish is obtained.



Sailing Blade mould after some use and ready to go. The auxiliary mould at the top has been taken from a moulded blade.

The two asymmetric moulds for the Turbo blade. The curve at the bottom of each blade (outside of picture) is less severe to allow cleaner entry and exit from the water.

Making the blade.

If you have no expertise in fibre glassing it is best to acquire a primer on fibreglassing **(3).** However make sure to paint resin onto the mould and succeeding layers before the next layer goes on to avoid air bubbles. Bring the resin through with the roller. Bias woven cloth seems easier to mould. If the cloth or coremat refuses to conform, cut darts in it where any bulge occurs.

To summarise:

1. The mould must be prepared by waxing and polishing three times with a mould release wax.
2. The mould should be coated with a PVA release agent.
3. Use Vinyl ester resin to layer the impregnate the following layup.
    a. 218g/m^2 (6oz) carbon fibre cloth.
    b. 2mm. coremat (aka sphericore or upica).
    c. 225g/m^2 (3/4 oz.) chopped strand mat.
    d. 136g/m^2 (4oz.) woven rovings.**(2)**

In cold weather place in the sun where ultraviolet rays catalyse the reaction. Do not do this in hot weather as the layup will overheat and bond to the mould. Once partly cured it can be placed in a warm indoor environment, without smelling, to prevent permanent under cure.

The finished job trimmed with an angle grinder cutting wheel, weighs only 200 grams (7oz.) and is pretty well unbreakable.

Conclusion

In spite of the exotic materials used Gaco has been able to retain traditional appearance by painting the blades with white polyurethane. Finish can be improved by adding a layer or two of epoxy undercoat first. The shafts are variously red or western red cedar or spruce. The oars are quite delicious to use and the Turbo oar especially gives extra impetus without extra effort.

It is interesting that boating people do not hesitate to splurge thousands on an outboard will scrimp when the propulsion is to be by oar. If the oar and rowlocks are well set up and of high quality the rowing experience turns from a chore to a delight.

(1) The volume was determined by displacing water from a tall kitchen garbage bin. The displaced water was weighed and this weight in grams was equivalent to its volume in cm^3.
(2) Chopped strand mat is quoted in ounces per square foot while woven material is quoted in ounces per square yard just to confuse us. Actual weights of the cloth can only be compared using the unit grams/ square metre (g/m^2).
(3) "The Glassfibre Handbook" by RH Warring is a suitable book. The internet does not seem to have any good sources.