MOLDING YOUR OWN CARBON FIBER COMPONENTS

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TOOLS / EQUIPMENT REQUIRED:

Small hand held rotary tool with cutting disks and sanding / grinding wheels (a Dremel type tool with a flexible shaft is recommended),

Wet / Dry abrasive paper (240 grit, 400 grit and a polishing grit - say 1200),

Pane of glass (say 1.5 ft by 1 ft and thick enough to take reasonable handling loads without breaking - I used my wife's glass chopping board),

A few clothing vacuum bags (this is a must if you want to get a reasonable end product),

A powerful vacuum cleaner (I used my wife's with the filters removed to improve the vacuum),

A sharp pair of scissors (for cutting the glass and carbon cloth),

Hot water bottle and blanket (to speed up cure times),

A dust mask / respirator and eye protection (use when cutting / sanding).

MATERIALS REQUIRED:

Fiberglass cloth (6oz weight should be fine),

Carbon fiber cloth (I used a plain weave which was all the shop had - at $60 AU per roll metre it's not cheap),

Two part epoxy resin (I used WEST System epoxy which is a marine grade epoxy. Don't be tempted to use the cheaper polyester resin as this is not as strong as epoxy, does not wet out carbon as well as epoxy and cannot be exposed to high temperatures.),

Mold release wax (a carnauba based wax specific for mold release - do not use car polish),

Liquid PVA (for mold release - this is a specific PVA for mold release not the glue kind).

Thin PVC plastic sheeting (to avoid having resin sticking to things you don't want it to),

Roll of cling film (to use as a peel / release film),

Cotton cloth (to use as breather fabric),

Popsicle sticks (for mixing resin),

Some wax free plastic cups (for larger amounts of resin),

A small medicine cup (to measure out resin and hardener - I used a 50ml one and usually only mixed up small batches of 30ml or less),

Acetone (for clean up of uncured resin),

Some short length bristle brushes (use some that will not loose all their bristles when cleaned),

Latex gloves (to avoid a gooey mess all over your hands).

GENERAL SAFETY AND HEALTH PRECAUTIONS:

The reader of this article takes full responsibility for their own actions when following these procedures. Uncured resin and the resulting dust from cured resin and glass / carbon fibers may be toxic and have harmful effects when inhaled. Use common sense and follow the manufacturers guidelines.

Notes on resin mixing. Always add the hardener to the resin, not resin to the hardener. Use small quantities, i.e. only mix what you can use during the pot life (pot life is the time taken for a standard volume of mixed resin to "gel" at a standard temperature). Large volumes of mixed resin (say 100ml or more) generate excessive heat during the chemical reaction. This heat build up will cause to resin to gel quicker, may cause the mixing container to **MELT** and cause excessive resin vapors.

Notes on cured glass and carbon fibers: Take care when handling cured parts during sanding and cleanup. Fine fibers with cured resin act as splinters and may break off when imbedded in your skin. Carbon dust if left to sit on bare skin will cause a mild irritation - wash off with soap and water.

Notes on sanding / grinding carbon fiber: Carbon fiber dust can conduct electricity. Take precaution to prevent carbon dust from entering electrical equipment as this may cause short circuits and expensive repair bills.

MOLDING BASICS - Plug Preparation

A warning on part molding. Mold only parts with a positive draft angle, i.e. the part will not be locked into the mold due to it's shape. For complex parts I suggest multiple piece molds which can be disassembled for part release. These molds are beyond my current experience. Also note that the clutch cover has a positive draft and can be molded using a single piece mold. The original cover did prove to be difficult to remove from the mold. The carbon part was also difficult remove and I ended up destroying the mold in the process.

You can use you own original parts to create a mold. Start with smaller simple parts which are flat or have small uncomplicated curves. The first part that I attempted to make a mold from was the clutch cover and after three attempts I gave up and moved on to the heel plates.

Once you have chosen a part to mold you need to decide whether you want a female or a male mold. A female mold will give a smooth surface on the exterior side of the end product. So with that in mind I assume you'll use a female mold.

Take your chosen component and give it a good clean. The surfaces on both sides should be spotless and free of nicks, gouges or blemishes as these will turn out on the mold. If your part has any fastener holes, you can fill them with plasticine or a similar material. This will prevent resin flowing through the hole and locking your part to the mold. It also makes a nice impression in the mold and the final product so you know where to drill any fastener holes.

Apply mold release wax to the part in accordance with the product instructions. It's generally wax on and allow to dry, polish off and then allow to dry for 10 to 20 mins then apply another coat. Apply five to six coats and allow the final coat to dry for about one hour.

Apply a coating of liquid PVA release agent to the part and allow to dry. This allows the part to come away cleanly from the mold. It will wash off with soap and water or will peel away like a layer of "cling wrap".

MOLDING - Laying up and Vacuum Bagging

Before you mix any resin, ensure you have cut the required amount of glass cloth (sufficient to cover the part with an overlap of about 1.5 inches), prepared an area to put your vacuum bag where it can sit for a few hours and you have boiled the kettle (if you want to use a hot water bottle for a faster cure).

Have your bristle brush ready and a cup of acetone to clean the mixing cup and brush immediately after use.

The vacuum bag is required to hold the cloth in position and against the part / mold while the resin cures. The application of the vacuum also draws any air bubbles out of the layup ensuring a smooth mold surface. The vacuum also pulls out excessive resin and compacts the layup which gives a lighter and stronger part.

A basic vacuum bag configuration is shown in the Figure 1 below.

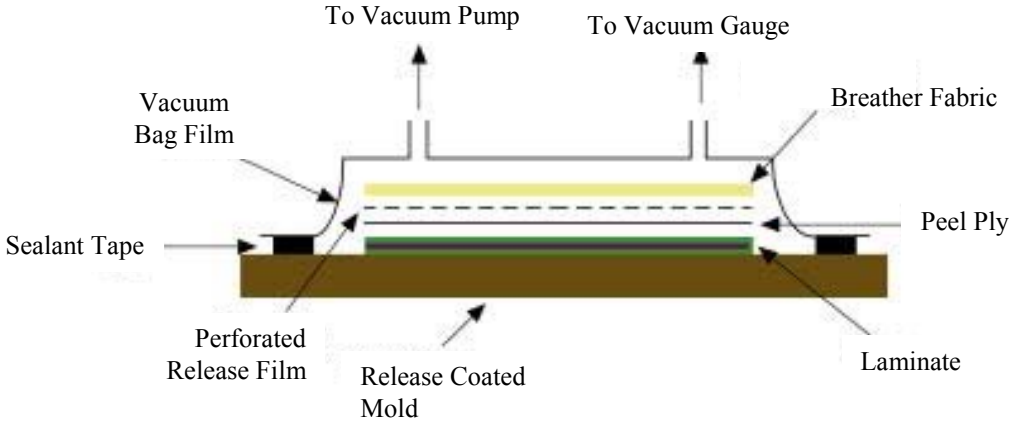

Figure 1: Vacuum Bag Configuration

While I don't expect you go to the effort of replicating the configuration shown in the figure above, we can make do with our clothing vacuum bag, some cling film as peel ply release film and some cotton cloth as a breather fabric ply.

Have your vacuum bag and vacuum cleaner (remove the filters to allow greater suction to be applied to the bag) ready. Have a friend ready to help you seal the bag and hold the vacuum cleaner to the bag port while you work the wrinkles out of the bag. I placed an old towel on the bottom side of the bag to protect it from being pierced by the glass plate. The towel will also prevent the bag from sealing within itself, i.e. it gives a route for the inside air to escape to the vacuum, i.e. a breather fabric.

Place a layer of the PVC sheeting on the glass plate or you can use cling film if you wish. Place your waxed part in the center of the plate.

Mix the required amount of resin for a single layer of glass cloth. Mix the resin well and let it sit for a bit to allow any entrapped bubbles to rise to the surface.

Place a single layer of glass cloth over the part and apply some resin with the brush (applying a single layer at a time allows the cloth to conform to the part better). Use a stippling action (dabbing action) rather than a brushing action as a brushing action will generally just move the cloth around. When the glass is completely wet out by the resin (it is no longer white but transparent), and you are satisfied with the work, place a layer of cling film (peel ply - see Figure 1 above) over the layup and then put a piece of cotton fabric over the top (this acts as a breather fabric ply to help the air within the bag escape to the vacuum port).

Place your part in the vacuum bag and seal. Apply the vacuum to the bag and slowly draw the air out, as the bag closes in on the part manipulate the bag to conform to all the curves and any tight radii of the part. Try to smooth out any wrinkles over the part as these will create resin ridges and will need to be removed before the next layer of glass is applied.

Once you are satisfied with the vacuum bag, let the resin cure overnight or if you prefer you can use a hot water bottle a blanket to allow enough heat to cure the resin in about 1.5 to 2.0 hours. Periodically check on the bag to ensure that it has not lost its vacuum, this is crucial in the first 30 mins of curing. Figure 2 shows a photograph of a vacuum bagged heel plate molding. Note that the blue color is the dye in the PVA release agent. The dye helps to show where you have applied the PVA.

Figure 2: Vacuum Bagged Heel Plate Molding - Rider, Right Hand Side

Once the resin is cured, remove it from the vacuum bag and remove all traces of the cling film. If any significant resin ridges are present remove them with abrasive paper. If the resin has been allowed to cure for more than 24 hours, lightly abrade the external surface and then wipe clean with acetone. This will expose a chemically active resin surface to promote good bonding of the next cloth layer.

Apply successive layers of glass to the mold and vacuum bag cure as you go. After you have at least two glass layers, you can apply more than one layer at a time. A total thickness of about four or five layers should be strong enough for the mold. Apply more glass around the edges to allow sanding back at a later stage.

Once the mold is thick enough and fully cured, remove the part from the mold. Be patient and take care. Use plastic wedges (I used my wife's plastic spatula) around the edges of the part to pop the bond between the part and the mold. This is a tricky process and can be frustrating. For a stubborn part try washing out the PVA layer with soapy water. If this fails you can tap the mold (from the part side only to prevent damage to the mold) with a wooden rolling pin or similar as this can provide the energy required to break the bond between the part and the mold.

MOLD CLEANUP

Once you have the part removed from the mold, trim the excess fiberglass from the periphery leaving about 1.5 inches from the edge of the part outline. Smooth out any sharp edges to prevent splinters occurring.

Clean the mold with warm soapy water and dry. Inspect the mold surface, it should be smooth and free of surface voids or areas where the cloth did not conform to the part. If the mold has significant areas of voiding then scrap it and try again. Small voids may be filled with resin and sanded back. Smooth the mold surface after any sanding with a high grit paper to polish out any sanding marks.

The mold should have a definite part outline a fraction of an inch high. Using a Dremel type tool with a sanding wheel carefully grind back this line to a smooth profile while leaving just the slightest ridge remaining (this will aid in defining the part outline for trimming). The profile should have a smooth contour to allow the carbon cloth to easily conform to the mold.

Clean the mold and allow to dry.

MOLD PREPARATION

Apply molding release wax to the mold as per the instructions given above for plug preparation.

Apply PVA to the mold as per the instructions given above for plug preparation.

Figure 3 shows a photograph of a completed heel plate molding, waxed and with PVA release agent applied. At this stage the mold is ready for layup of carbon fiber.

Figure 3: Completed Heel Plate Mold - Passenger, Right Hand Side

CARBON PART MOLDING - Layup and Vacuum Bagging

Using the process outlined above for laying up and vacuum bagging, cut a piece of carbon cloth large enough to fill the mold. Prepare the required amount of epoxy resin and apply the resin to the carbon cloth. Work the resin into the cloth and ensure that the cloth is completely wet out and the cloth conforms to the mold as best as possible. Use a stippling action with the brush rather than a brushing motion as a brushing motion will tend to disturb the cloth weave.

Place the layup in the vacuum bag and apply a vacuum as per the instructions given above for the mold vacuum bag process. Ensure that the bag conforms to the part with no significant wrinkles present. Pay attention to any tight radius areas to ensure the bag conforms to the radius instead of bridging across it.

Figure 4 shows a photograph of a vacuum bagged carbon fiber heel plate layup. Note that I did not use a breather fabric ply in this instance.

Figure 4: Vacuum Bagged Carbon Fiber Heel Plate Layup

Cure the resin overnight or by using a hot water bottle for 1 to 2 hours.

Once the resin is cured, remove the part from the vacuum bag and apply successive layers of carbon / epoxy. I used 6 layers for the heel plates and 5 layers for the clutch cover. Alternate the angle of the cloth fibers for the layup between 0, 90, +45 and -45 degrees and ensure that the layup is symmetrical. This will give a laminate that is strong in both directions as well as resistant to twisting forces.

Once the resin is fully cured, remove the part from the mold. Be patient and take care. Use plastic wedges around the edges of the part to pop the bond between the part and the mold. This is a tricky process and can be frustrating. For a stubborn part try washing out the PVA layer with soapy water. If this fails you can tap the mold (from the mold side only to prevent damage to the carbon fiber part) with a wooden rolling pin or similar as this can provide the energy required to break the bond between the part and the mold.

Wash the part in warm soapy water and inspect the exterior surface of the part. Hopefully the surface is smooth and free of air bubbles in the resin. If this is not the case then scrap the part and try again.

The carbon molding should have a nice visible line showing the original part outline. If the part had fastener holes these should also be visible as circular depressions in the molding.

Figure 5 shows a photograph of a cured carbon fiber heel plate layup, just removed from the mold.

Figure 5: Carbon Fiber Heel Plate - Prior to clean up

PART CLEANUP - Trimming and Hole Drilling

Using a Dremel type tool with a cut off disk trim around the part outline. Do not attempt to cut to the line exactly but leave a gap and sand the final profile smooth with a sanding wheel and abrasive paper.

Locate the center of any fastener holes using a small pilot drill (use the smallest you have and use a high speed). Drill from the outside surface and use a piece of scrap wood on the back side to prevent it from breaking away as you come through the surface. If you are satisfied that the hole is in fact in the central location, proceed to a larger drill bit. If the hole is not in the center, try to pull it to the center using the drill.

When drilling the hole to the final diameter use a slower speed (I used a cordless with a very slow speed) and initially drill from both sides and then final drill completely through from the outside of the part. This should give a clean hole with no break away on either surface.

Using the Dremel with a sanding wheel sand the part to just off the edge outline. Take care not to contact the outside surface of the part as this will obviously ruin the gloss surface. Final sand the edges using 400 grit abrasive paper with water.

Wash the part in warm soapy water and inspect your handy work. At this stage the part can be considered complete.

SURFACE FINISH - Gloss and Environmental Protection

If desired you can clear coat the part (I used Tectyl 501 made by Valvoline which is a clear coat for aluminium to prevent corrosion) to give a glossy outside surface. Note that this is recommended for numerous reasons:

a. The clear coat also gives a gloss finish. I applied three coats and sanded between with 1200 grit paper.

b. The clear coating forms an environmental barrier for the part and prevents moisture absorption by the resin.

c. The clear coat forms a barrier between the carbon fiber part and the aluminium or steel components that it is attached to. The carbon, if allowed to contact these metals will cause galvanic corrosion to occur to the metals.

d. The clear coat should have a UV filter additive (the Tectyl 501 coating claims to have one). All epoxies suffer from degradation from UV light exposure, this causes the epoxy to yellow. The UV filter in the clear coat should reduce this effect. Some companies that market carbon fiber components claim that it's the clear coat that causes the yellowing and hence they don't use any. This maybe so but in any case, epoxy will degrade from UV light exposure if left unprotected. The only way around this is to paint the component with an opaque coating.

WORKED EXAMPLES - Components made by the Author

996 Passenger Heel Plates:

The heel plates were relatively simple to make. Once the mold was made and prepared actual manufacture of the part only took a few hours. Figure 6 shows a photograph of the right hand side heel plate installed on the bike.

Figure 6: 996 Passenger Heel Plate - Right Hand Side

996 Rider Heel Plates:

Similar to the passenger heel plates, the rider heel plates were relatively simple to make. The added curves did however present more difficulty. Both molds and components were satisfactorily completed on the first attempt. Figures 7 and 8 show photographs of the left and right hand side heel plates installed on the bike.

Figure 7: 996 Rider Heel Plate - Left Hand Side

Figure 8: 996 Rider Heel Plate - Right Hand Side

996 Clutch Cover:

I actually tried to begin molding the clutch cover first. I eventually gave up to try the more simple heel plates. My first attempt was made too quickly. I used car wax as a release agent and no vacuum bag. Consequently the cover was glued to the mold. In a panic I used whatever I could find (a big screwdriver) to pry the cover from the mold. As a result I damaged the paint on the cover. The scratch marks were not completely sanded out and these turned out on my final product.

On my second attempt I used plaster of paris to make a mold. While the cover came away from the mold cleanly, the surface was porous with lots of tiny air bubbles on the surface. I attempted to make a glass part from this mold only to create a big mess of glass epoxy and plaster which refused to part.

On my third attempt I used the glass cloth and vacuum bag molding method. This time I used the vacuum bag but I did not use a breather fabric ply. The majority of the mold turned out ok, but the cloth did not conform to the mold at the tight radius at it's base. This is where I gave up and began molding the heel plates and the exhaust shield (as discussed below).

For my fourth attempt I used the vacuum bag with a breather fabric ply. I also filled the fastener holes with plasticine and put a bead of plasticine around the lower rim of the part to prevent resin getting drawn in between the underside of the part and the glass plate. The mold turned out great and the resulting carbon part a success. Figure 9 shows a photograph of the finished part. Figures 10 and 11 show photographs of the part installed on the bike.

Figure 9: Clutch Cover - Finished Part

Figure 10: Clutch Cover - Installed on Bike

Figure 11: Clutch Cover - Installed on Bike

Exhaust Heat Shield:

To make the molding for the heat shield, I covered the two fastener holes with tape. I filled the large craters (where the fastener holes are) with a mix of resin and glass cloth trimming mixed to a paste. When this had begun to gel I added a layer of glass cloth and put the layup in the vacuum bag. I added three more layers and thickened up the side areas. The mold actually turned out pretty good.

The problem with the heat shield is the tight radius at the lower side of the part and the two large craters where the fastener holes are. On my first attempt at molding a part. I used only one layer of carbon cloth and put the layup in the vacuum bag. I couldn't get the cloth to conform to the mold using only vacuum. The part had a good outside surface but there were large areas where there was no resin flow.

On my second attempt I used two cloth layers and then placed some cling film over the layup. I then put the original steel part over the top of the layup and pressed it into place and held it against the mold using F clamps. While the cloth did conform to the mold reasonably well, this method did not remove all the air bubbles from the resin. On the other hand, I did get a nice finish on the inside surface. Great! pity you don't see that side.

My third attempt used the F clamp method again, but this time I used excessive pressure on the clamps and this produced marks in the part. The absence of vacuum resulted in bubbles in the resin and the excessive clamp loads damaged the mold. At this point I gave up as I ran out of carbon cloth. If I were to try again I would use the vacuum bag method with a breather fabric ply. Figures 12 - 14 show the mold and my various attempts at failing to produce a satisfactory part.

Figure 12: Heat Shield Mold and First Attempt

Figure 13: Heat Shield - Second Attempt, Inside Surface

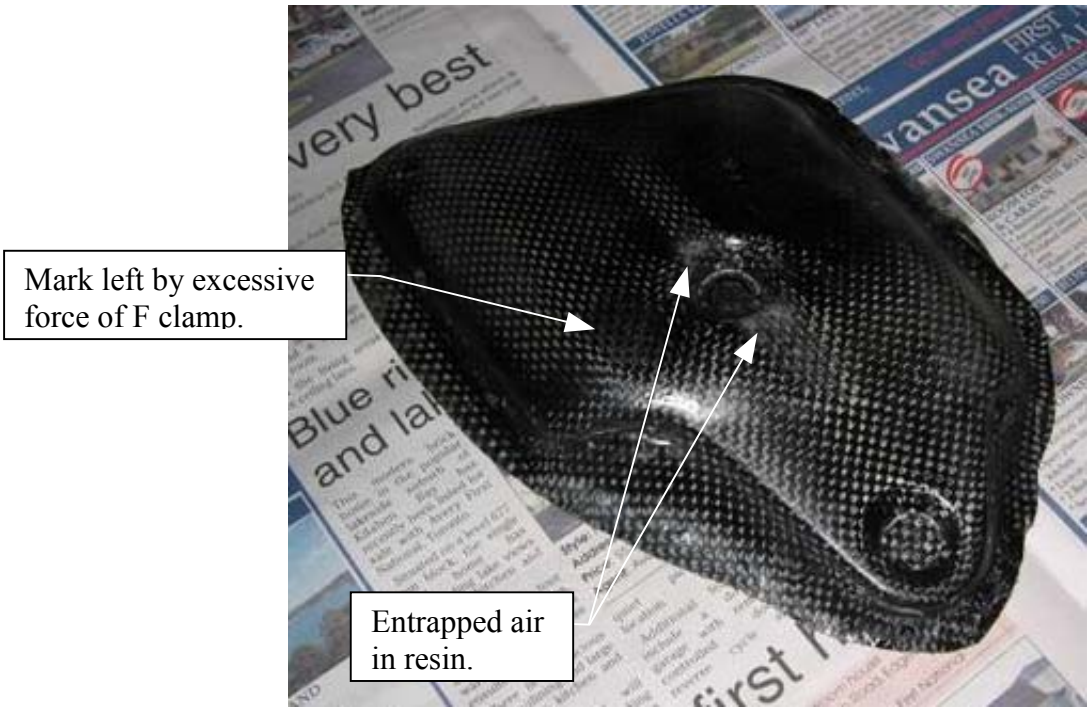

Figure 14: Heat Shield - Third Attempt

FINAL COMMENTS AND RECCOMENDATIONS:

Take your time, make sure you lay things out in the order that you intend to use them. Make sure you remember to clean your workspace and brushes immediately in acetone to prevent the bristles turning rock solid. If you spill resin on your hands wash it off using warm soapy water, don't use acetone on your skin as it will draw all the moisture out.

Most of the tools and materials I have listed above should be available at a hardware store or a fiberglass retailer. The fiberglass retailer should be able to offer advice if you need it.

Remember that the whole process should be enjoyable. Hopefully you'll get some successful end products that are worth keeping, without inflicting damage to your original parts (as I did).

Attached are a few addition parts I have made since first issue:

Figure 15: Headlight Support Brackets

Figure 16: Exhaust Heat Shield

Figure 17: Monster Rear Hugger – (before final trim)

If you need any further advice, have any questions, comments or have any suggestions I can be contacted via email at jwsparkes@hotmail.com.