Fiber glass methods for furniture

Donald Bjorkman
FIBER GLASS METHODS FOR FURNITURE

BY

DONALD CARL BJORKMAN

Candidate for the Master of Fine Arts in the
College of Fine and Applied Arts of the
Rochester Institute of Technology
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Advisors:
William Keyser
Wendell Castle
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INTRODUCTION

There are many writings dealing with plastics and reinforced plastics. From them you can find what processes there are, what chemical reactions occur during cure, types of molds, properties of the molded part, types of release agents, and a long list of technical and scientific information dealing with reinforced plastics. I have not been able to find a book that gives practical step-by-step procedures that the craftsman can use to turn his designs into reality.

Finding the need for such a booklet I have undertaken to write one. I have researched all the material I have been able to find, selecting the bits of information that are pertinent to the procedure of fiber glass construction of furniture. With this information, and practical demonstrations of glass lay-up by Mr. Shirer of John Shirer Incorporated, I worked with the material keeping a record of each procedure. This information was then compiled into this thesis.

The handling of fiber glass as a material for furniture is not a simple procedure that the amateur craftsman should attempt. It is involved and takes time and patience. For this reason I have omitted certain steps that will be obvious to the qualified person.

Donald C. Bjorkman
CHAPTER I
THE DESIGN

The process of designing does not have rules, laws, and principles in the sense that the natural sciences have, but there are methods that can be followed that will help one conceive a useable design. Whether one designs using elevation or perspective sketches is incidental; the thing is to sketch and sketch to scale. When one has a design problem, he should sketch many ideas. Anything that comes to mind put down on paper. Some may be hideous conglomerations, but paper is cheap, and good ideas can sometimes be worked out from a bad sketch.

Things to remember while designing are the basic elements in any type of design: shape, color, texture, line, unity, balance, and proportion. Proportion is one of the most critical elements in furniture design. Pick your favorites out of the sketches you have made. Criticize them; be your harshest critic. Ask yourself if the design meets the basic elements of design. Do all members have reason for being, aesthetic as well as functional? Does it perform the function it was designed for? If seating, does it look comfortable? And above all don't plagiarize your designs.

Another thing to take into consideration while designing is that the finished unit must be removed from the mold. Undercuts make this difficult, if not impossible. Therefore allow at least one degree and preferably two degrees
draft. Undercuts, when used, require a split mold which becomes more involved then a one piece mold.

When you have decided upon your best design, make scale drawings (Fig. 1). Some fascinating things happen when a sketch is drawn to scale. This is one of several steps where errors can be eliminated. If you are doing seating, try out the angles and curvatures in a seating delineator, if one is available, making any corrections that might be necessary. Then make your scale drawings, scaling from the seating delineator to the drawings. At this point you must again criticize the design, for it has probably been changed since its conception.

If the unit is a free form piece, such as the chair I worked on in conjunction with this writing, a scale model should be made. This will give an accurate three dimensional view which one would otherwise not get until the chair was completed.
Fig. 1 Sketching of chair. Finished drawings are taken from these drawings after scale model proves satisfactory.
CHAPTER II

THE SCALE MODEL

The following materials will be needed for the making of the model:

Clay - any type of fire clay or "plasticene"

Plaster - pottery or molding plaster

Cheesecloth

Tincture of green soap

Cutting wire

Clay sculpturing tools

Plastic mixing container for plaster

From the sketch, approximate seating angles can be arranged on the seating delineator (Fig. 3). The satisfactory angles can be drawn to quarter scale. From this a positive scale model of clay is made using a longitudinal template of cardboard as a guide (Fig. 4). The clay can be worked with sculpturing tools and then smoothed with the hands dipped in water. When the desired shape is obtained a soupy mixture of plaster should be mixed and sprinkled over the clay mold, which has been covered with tincture of green soap. Then cheesecloth that has been dipped in the plaster is draped over the clay model. Air bubbles are worked out with the fingers and hands. This is allowed to dry. Pour additional layers of plaster on model until desired thickness is obtained. When dried, usually overnight, the plaster model should be easily removed. Save the clay mold. Trim edges of plaster model to desired shape with coping saw. File and sand outside to smooth contour.
Another method is to bend soft aluminum screening to the shape you want. Then dip the screen in a slurry of plaster. Continue dipping until the desired thickness is obtained, then finish as in the previous method.

If any changes are needed, they can be made when scaling up to full size, unless the model reveals a lost cause. If so, "back to the drawing board."

By making a base for the scale model and priming with primer-surfacer, sanding, and painting with the desired color lacquer, a complete model can be made that should duplicate the chair (Fig. 5).
Fig. 2 Material needed for making of model.

Fig. 3 Checking out contour of chair for comfort in seating delineator.
Fig. 4 Making of clay mold from which plaster model is made.

Fig. 5 Plaster model done in quarter scale.
CHAPTER III
FULL SIZE MODEL

Producing the scale model in full size is the next step. The first phase of making the full size model will require the following items:

1/2-3/4 inch flakeboard or plywood
Metal lath
Cardboard for templates
Glue
Tin snips
Hammer
Nails

Take the clay positive that was used in making the plaster model and slice it with the cutting wire at pre-determined station points (Fig. 6). Station points should be situated transversely every four to six scale inches. Templates can be made by holding cardboard against the cut side of the clay mold and tracing along the edge with a pencil (Fig. 7). This will give an outline of each station point which can be scaled up to full size on cardboard. These in turn are cut out and used as full scale templates (Fig. 8).

The station templates can then be transferred to the three-quarter inch chipboard or a cheap grade of plywood. The stations should be made one-half inch smaller than the templates to allow space for the addition of metal lath and plaster. Cut out stations and nail and glue together on a flakeboard base (Fig. 9). The metal lath can then be cut, fitted, and stapled into place (Fig. 10).
Fig. 6 If model is satisfactory the clay mold is cut with wire at predetermined station points.

Fig. 7 Each station profile is then traced onto cardboard from the clay sections to make scale templates.
Fig. 8 Scale templates are then scaled up to full size on heavy cardboard. Photo shows templates for chair.
Fig. 9 Frame work of full scale model made of flakeboard.

Fig. 10 Metal lath is fit and stapled over frame.
The second phase will require:

Plaster - potters plaster preferred
Cheesecloth or burlap
Trowel
Templates - full scale templates previously prepared
Stanley "Surform" file
Files - for plaster
Flexible scraper made from an old bandsaw blade
Sandpaper

A slurry of plaster is mixed. Cheesecloth or burlap is dipped into the slurry and draped over the metal lath (Fig. 11). When this sets up, additional layers of plaster can be trowelled on to model. A thorough wetting with water must proceed each addition of plaster once plaster has set up, to prevent cracking and improve adhesion. The plaster can be rouged down with "Surform" files and checked periodically with templates to find high and low spots and to obtain the desired shape (Fig. 12 & 13).

This process is continued until desired shape is obtained. Then the plaster should be sanded smooth. You will find that the model will still contain small dips, holes, and other flaws.

The loft template method is another way of making the model. Stations are cut to full size from one-quarter to three-eighths inch plywood. The metal lath is then stapled to cleats that have been placed one-half inch from top edge of the stations. The stations are then used as screeds to shape the
Fig. 11 Cheesecloth dipped in a plaster slurry is draped over metal lath to make a base for more plaster.

Fig. 12 Roughing down high spots with "Surform" file.
Fig. 13 Checking profile of model with templates.

Fig. 14 Materials needed for finishing model.
plaster. One problem that may be encountered with this method is that the plywood screeds may transfer marks to the fiber glass mold. A more complete description of this method is given in the Handbook of Reinforced Plastics.

The third phase will require:

Automotive primer-surfacer
Automotive body putty
Lacquer thinner
Wet or Dry production paper
Putty knife
Rubber squeegee (piece of thick rubber)

Spray model with a heavy coat of lacquer-type primer-surfacer.

Areas that are low spots will show up on sanding. These can be filled with body putty applied with a rubber squeegee, then sanded and sprayed with primer-surfacer again. This process is repeated until all minor flaws are removed. When plaster is completely sealed with paint, wet or dry production paper can be used wet for sanding (Fig. 15). The last coat should be sprayed with primer that is quite thin. Wet sand with 400 wet or dry production paper to a smooth finish. Then rub, using a damp cloth and pumice.

The smoother you want your finished piece, the smoother the model must be, for all imperfections are transferred to the mold and then to the piece itself. If you plan to completely cover the unit with upholstery, then
the process does not have to be carried to an extreme finish. But keep in
mind that the rougher the model, the more difficult it is to remove the
mold from the model, and naturally the finished piece from the mold.
Model in photograph has been finished with automotive lacquer, rubbed,
and waxed (Fig. 17). This gives an excellent finish, but if there is still
moisture in the plaster it may cause the lacquer to bubble. Using primer-
surfacer only, lessens the chance of this happening.

If you only want to make a one-of-a-kind object the following can be
simplified by taking the finished piece directly from a plaster mold. The
finished side will be the side against the mold. If the outside is the side
to be finished, a female plaster mold will be needed; this may prove to be
a difficult task as convex surfaces are easier to work then concave surfaces.
The maximum number of lay-ups possible on a soft plaster mold would pro-
bably be two or three.

The full size model is now complete, and the fiber glass lay-up of the
mold may now be made, as described in the next step.
Fig. 15 Sanding of primer-surfacer with wet or dry production paper.
Fig. 16 Spraying of model.

Fig. 17 Finished full size model.
CHAPTER IV
THE MOLD AND FIBER GLASS LAY-UP PROCEDURE

There are several methods for molding fiber glass. These can be generally categorized in about six descriptive groupings:

- Manual fabrication
- Match die molding
- Extrusion
- Filament winding
- Centrifugal molding
- Miscellaneous procedures

The grouping which we are interested in is manual fabrication. In this method lay-up is done by hand in an open mold. The lay-up can be cured at room temperature without pressure, or pressure can be applied by vacuum bag-molding the part. The mold is so constructed that a hold-down ring can be clamped to its perimeter to hold down the vacuum bag. Vacuum is then applied to the bag creating atmospheric pressure to the lay-up. Pressure bag-molding is similar to the vacuum method except that a pressure plate is used in place of the hold-down ring. This allows pressure to be applied between the bag and the plate. Higher pressures are obtainable with the pressure bag method.

The simplest method, and that explained in the following, is the hand lay-up method, curing at room temperature without pressure. The following
is a list of the materials necessary for this procedure which can usually be obtained from local fiber glass outlets:

- Prepared wax
- Release agent - prepared polyvinyl alcohol (P. V. A.)
- Polyester resin - without wax
- Fiber glass matte - two ounce
- Woven roving - for heavy cross-sectioned pieces
- Catalyst - Methyl Ethyl Keytone Peroxide
- Solvent - Methyl Ethyl Keytone
- Containers - one pound coffee cans will hold one quart. They usually have reinforcing creases which mark off 1/2 pint increments
- Cheap paint brush
- Stirring sticks
- Measuring spoons - metal
- Rollers - special metal rollers shown in picture

The next step is to wax the model with specially prepared wax, to allow polyvinyl alcohol to wet-out when sprayed over it. Three coats of wax should be applied, with buffing between each coat.

The following procedures should be done in a well ventilated area. The applying of the release agent is a delicate job. It should be sprayed on at about forty-five pounds air pressure. A very light coat should go on first and be allowed to dry. It will look like very small beads of water when first sprayed on. These should wet-out on drying. When first coat is dry, spray on second thin coat. This process is repeated until the color of the release
agent starts to show. If too heavy a coat of P. V. A. is applied it will bridge, or pull, and if you want a smooth finish this is not desired. If errors are made in applying the release agent they can be easily removed with water and a sponge. Another waxing and buffing is recommended before the next attempt.

All precautions from dust and other airborne particles should be maintained as in any spray painting.

The mixing of polyester resin and catalyst is a matter of measuring, following directions, and "Edisonian" research. The latter will become obvious as you work with the resin.

When applying thin coats of resin as for gel coats, the maximum amount of catalyst is used. When casting thick sections, a minimum of catalyst is used. When the room temperature is high, less catalyst is needed and cooler temperatures require more.

Each manufacturer of polyester resins has a recommendation as to the amount of catalyst to use. The following is given as a point from which to start and is figured with the room temperature at 72 degrees Fahrenheit.

One quart of resin - two teaspoons of catalyst

Maximum of four teaspoons to a quart

Minimum of one teaspoon to a quart

When P. V. A. is thoroughly dry the gel coat may be applied. It is recommended that a prepared gel coat be bought, but you can mix your own by adding "Cab-O-Sil" for thickening, and a milled color if coloring is wanted.
The more vertical the surface to be covered, the thicker you will want your gel coat to keep it from running to the low spot in the mold. Mixing of gel coat is given in detail in Chapter V.

The gel coat can be brushed on (Fig. 19). Because of the thinness of this coat of resin, add the maximum amount of catalyst. Pot life will be about ten minutes. Make sure all air bubbles are brushed out. Allow coating resin to set to a gel. Then apply second gel coat. Two or three coats are recommended. When last coat has set to a gel, lay out pre-cut glass matte over the gel coat and pat down (Fig. 20). The stickiness of the coating resin will hold the matte in place.

Add recommended amount of catalyst to resin (two teaspoons per quart). Saturate matte with resin by pouring it over the matte and brushing it out (Fig. 21). Leave low spot on the mold until the last. When matte is completely wetted-out, roll out air bubbles taking care to remove all (Fig. 22). This is especially critical for first coat of matte that goes over gel coat.

For a beginner, it is recommended that one coat of glass be applied at a time. As you become accustomed to the procedure this can be increased. If lay-up is allowed to set before second thickness is applied, all burrs or high spots should be removed with a rasp or "Surform" file as these burrs will prevent the second layer of matte from lying flat.

Once previous work has set always apply a coat of resin and allow to gel before adding another layer of glass. Otherwise matte will slide and
not stay in position when resin is applied. If a thick cross-section is desired a layer of twenty-four ounce woven roving can be used (Fig. 24). This should be preceded by two coats of two ounce matte to prevent the texture of the woven roving from telegraphing through the finish. This should be followed by two more layers of two ounce matte to keep a balanced structure, which prevents warpage.

Thicker areas can be achieved by adding strips of woven roving and matte, remembering to keep a balanced construction. Use resin with wax for last coat so that it will air dry.

To remove mold from plaster model drive soft wood wedges around edge, between mold and model. A better method is to lay-up a metal tire stem into the mold at its approximate center. These stems are used on truck wheels and can be purchased at wheel shops. The problem may be in holding the stem in place while laying-up the fiber glass. This can be remedied by removing the core and running a long screw through the stem into the model making sure not to crack the plaster.

Upon completion of the mold it should release from the model when air pressure is applied to the valve stem which has had the screw removed and the valve replaced (Fig. 26). The mold may break away in certain areas and not in others. These loose areas will have to be clamped down and more air pressure applied until the mold breaks loose completely. If the releasing agent has not been applied properly you may have to chip the plaster out of the mold piece by piece.
When mold has been trimmed to desired shape and placed in an appropriate frame to hold it steady, you will have a finished mold (Fig. 19). A sabre saw can be used to trim mold. Retain valve on mold, for this will be used to blow units out of the mold.
Fig. 18 Materials for lay-up procedure.

Fig. 19 Applying colored gel coat to prepared form. Same procedure is used for making mold as for actual chair.
Fig. 20 Laying out pre-cut glass matte over gel coat.

Fig. 21 Applying resin to glass matte.
Fig. 22 Rolling out air bubbles.
Fig. 23 Air bubbles that won't roll out will have to be cut. Care must be taken not to scratch through gel coat with scissors.
Fig. 24 Addition of woven roving for fast build-up.
Fig. 25 Roving drapes well. Little fitting is necessary and can be done during lay-up.
CHAPTER V
LAY-UP OF FINAL UNIT

Now that the mold is complete and mounted in a support, preparation for laying-up of the final unit can begin, that is if the mold came off the model in good shape. If not, defects will have to be repaired.

If there are large air bubbles or voids in the mold they should be filled with a fiber glass putty and sanded smooth. Smaller defects can be filled with auto body putty, sprayed with primer-surfacer, and sanded as was done to model in Chapter III. Remember to finish to as smooth a finish as you want on final product.

Mold should then be waxed with a prepared wax, being sure to fill valve stem hole with wax, and coated with polyvinyl alchohol. When release agent is thoroughly dried, brush on gel coat. A prepared gel coat can be used, but if you need a special color or want to save a little money you can prepare your own. The following is a list of materials needed:

Resin, without wax
Milled color - one pound per gallon of resin
"Cab-O-Sil" - filler for thickening, Cabot Corporation
Styrene - thinner
Covered container
Mixing sticks
Mix resin and color together thoroughly. One pound of milled coloring
to one gallon of resin will give you a strong opaque color. Use more for light colors, like yellow; less for dark colors. The gel coat will probably need thickening to keep it from sagging off verticle surfaces. Two cups of "Cab-O-Sil" per quart of gel coat will give a point which to start. The consistency of thick pancake batter will give the best sag-proof results.

Brush on evenly over release agent, brushing out air bubbles (Fig. 19). Repeat as was done for mold. Pay special attention to edges, for you probably will want to give them a small radius after removing piece from mold. Build up gel coat on edges so that when edges are sanded down you will not go through the color.

From here procedure is same as the lay-up of mold.

The last layer of matte should be laid up with resin that has had wax added to it. Resin can be purchased with the wax already added. When the exothermic heat is generated the wax comes to the surface and forms a micro-thin layer. This prevents air contact to the resin and you get a tack-free surface.
CHAPTER VI
FINISHING

If any finishing is desired on the inside of the piece it is best to work on it while it is still in the mold. The unit may prove difficult to hold down while working on otherwise.

A flexible disc sander will remove large bumps. Low spots can be filled with fiber glass putty and sanded smooth. It will be necessary to hand sand, using a cork backing block.

A gel coat using resin with wax can be mixed and sprayed over sanded surface. This will have to be thinned, using small amounts of styrene as a thinner. The spraying technique is similar to that for enamel. Caution must be used to prevent sagging. Good ventilation is necessary when spraying this volatile mixture. Remember to mask off areas where you do not want paint and to clean spray gun with M. E. K. immediately after using.

Two manufactures produce coating resins that air dry, tack-free. They are:

Gel-Kote with Glidpol # 3305 added, Glidden Company
Laminac 4110, American Cyanamid Company

If you plan to use one of these coating resins I would suggest using their comparable gel coating also. This will give a better chance of the colors matching.
Unit should now be ready to remove from mold. Make sure valve is screwed into valve stem. Apply sixty to ninety pounds of air pressure with an air chuck attachment (Fig. 26). Finished piece will probably break loose in one area first, requiring that spot to be clamped down. Repeat until entire unit is loose. The edge of unit that was at outer edge of mold will be sharp. As you will remember an extra heavy gel coat was applied at this point. This allows rounding off the edge without sanding through color coat.

If a lustrous finish is wanted the piece can be buffed with a lambs wool buffing boot on a flexible disc sander (Fig. 29). White rubbing compound is desirable, especially if finish coat is a light color. Wipe compound over a foot square area with a soft cloth. Then buff with disc buffer in circular motions, gradually advancing into compound covered area. Clean wool boot periodically with wire brush, such as a file card. Repeat buffing procedure until desired finish is acquired.
Fig. 26 Removing lay-up from mold. Air pressure is applied to finished piece forcing it loose from mold.
Fig. 27 Piece being lifted from mold after being broken loose with air pressure.
Fig. 28 Chair as it looks after removal from mold. Note that outside is finished when it comes out of mold.
Fig. 29 Buffing with rubbing compound on a lambs wool disc.
There are several methods of securing pieces together after lay-up of the component parts. If possible, it is preferable to bond parts together, as metal fasteners call for the need to drill holes through the fiber glass. This concentrates stress at the point of fastening and may cause cracking.

The most versatile bonding agent is epoxy. It has low shrinkage and bonds to most materials. If you have need to bond metal, plastics, wood, or any combination of these, epoxy is the answer. When bonding polyester to polyester, polyester itself is the best adhesive. It also works fairly well in bonding metal to polyester. Resorcinol glue can be used as an adhesive for reinforced plastics, but is recommended as an alternative only.

When fastening something like a metal base to a fiber glass chair, metal fasteners become more applicable. This allows for removal of the base and for application of upholstery before the attachment of the base. Areas that are to be drilled through can be reinforced with extra layers of glass or with metal that has been thoroughly cleaned and roughed with a file or disc sander before laying into fiber glass. "T-nuts" are ideal fasteners because of the large contact area they give, the fact that they form spacers through the fiber glass, and they can be used blind. Other fasteners that can be used
with reinforced plastics are:

Bolts with spacers

Rivets

Self-tapping screws--preferably with fine threads

Metal inserts--self tapping, self threading, push in type

Fasteners that are screwed into the fiber glass itself have a tendency to de-laminate the entering surface of the plastic. This should be a consideration when selecting a fastener.
CHAPTER VIII

SUMMARY

Preparation is probably the key word when working with fiber glass. Prepare your ideas with drawings and a model in order to have a clear idea of what the finished product will look like. This will eliminate a lot of unnecessary work if the idea proves to be bad.

Produce a full scale model that is an absolute replica of the finished piece you plan to make. Keep in mind that waves, ripples, and pinholes will be transferred to the mold and the finished article.

When preparing for the fiber glassing, take special care in applying the release agent. Polyester is not known for its great adhesive powers until it comes to removing it from a mold.

Have all material on hand when you are ready to start a specific job. This is especially true when doing the actual fiber glass work. All materials should be right at your finger tips. Cleaning solvent (M. E. K.) and paper towels should be where they can be readily used. Fiber glass should be pre-cut to fit and placed conveniently. Mixing and measuring utensils, mixing sticks, and catalyst should be handy. The resin container should be easy to pour or dip from and placed on papers so that the resin is not dripped on the floor. Cleanliness is a must or you will think you have been tarred and feathered by the time you are through.

If the release agent has been applied to a waxed mold, it should adhere to the piece rather then the mold when they are parted. The release agent
is then easily washed off with water.

Finishing the inside of the work probably is easier when left in the mold. Care must be taken when rounding off edges, so as to not penetrate through the colored gel coat.

Areas through which fasteners are to go should be reinforced. Use bonding techniques where possible in assembly. When choosing fasteners, remember that self-tapping ones may loosen laminates.

Many fine and interesting things can be made of reinforced plastics. Things can be done with reinforced plastics that are not possible with other materials, but one must remember that they are not magical. They require hard work and patience just like woodworking, metalworking, ceramics, or any other craft. They are not short cuts to be used when something else will do the job better.
Fig. 30  Finished chair.
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