TECHNICAL BULLETIN 152

ACRYSTEEL® M FRP PRODUCTS

Small Marine Craft

Aristech Surfaces has been a leader in acrylic/fiberglass reinforced product ideas for over 25 years. Many O.E.M./ fabricators have discovered new possibilities in the use of Aristech Acrylic Sheet products. The advantages of Aristech Surfaces Continuous Cast acrylic sheet products are unlimited in the areas of design, configuration, colors, fabrication and superior surface appearance. Challenge your imagination —specify Aristech Surfaces Acrysteel® M Sheet for many of your marine parts. Acrysteel® M is an impact-resistant, partially-crosslinked acrylic sheet formulated specifically for demanding marine applications.

Introduction

This technical bulletin describes how small boat shells (Figure 1) up to 22 feet (6.7 m) long can be produced from Aristech Surfaces Acrysteel M Impact acrylic sheet and reinforced quickly and easily with a thin primer coat of polyester resin and chopped fiberglass.The general procedure follows with enough detail to enable an existing FRP boat manufacturer to convert from gel-coated polyester surfaced boats to attractive and durable Acrysteel M surfaced boats.

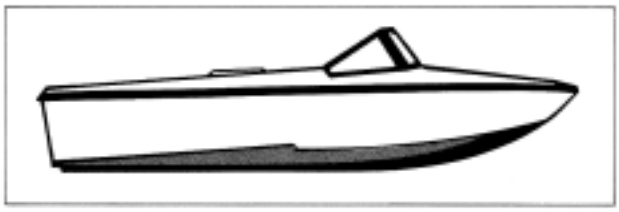

Figure 1. Small Boat

Plant Layout

Many plant layout variations accommodating numerous manufacturing throughputs are possible. Therefore, no attempt to define a specific flow diagram will be made in this bulletin. Perhaps the most important feature is to keep the material or product moving in a continuous, logical mode. Each operation will be discussed in process sequence beginning with Acrysteel M Sheet handling and storage and finishing with the primer coat FRP application. The major FRP and reinforcement application, final boat assembly and finishing will not be covered in this bulletin, but are virtually the same as for gelcoated surfaced boats.

Acrysteel M sheet handling and storage area

A typical sheet size for this process is 0.100” (2.5 mm) thick x 110” (280 cm) wide x 228” (580 cm) long for both the deck and the hull. Sizes and thicknesses will vary depending on product design, size and depth of vacuum forming draws. The sheet length and width are usually 6 to 8 inches (15 to 20 cm) greater than the finished product dimension to provide for clamping the sheet during thermoforming.

Acrysteel M can be supplied in sheet form on pallets or on reels in one continuous length. Reels are recommended for this application. In sheet form, the pallet will contain 15 to 20 sheets and weigh approximately 2000 lbs.(900 kg). On reels, the material length will be about 700 feet (215 m) and the package weight about 4000 lbs.(1,800 kg). Pallets are usually stored as received while reels must be placed on A-Frames or comparable stands for unwinding asnd sheet cutting. Each pallet or reel will contain one color and adequate space should be left between and around each item to allow for easy movement of a fork lift truck or the unwinding of reels. Space will have tobe allowed to cut sheet, or remove it from the pallet, or move the reel to the vacuum forming machine.Storage should always be inside and arranged with the product mix and production schedules in mind. It is highly recommended that a first-in first-out sheet inventory procedure be utilized. This involves always using the oldest sheet available. Each package should be plainly marked with the color and identification number so the proper material is selected and so vacuum forming machine operators can easily record any problems in the production log by color and package tag numbers. No special pallet equipment is needed in the sheet storage area other than a fork lift truck with tine extensions capable of handling the oversized pallets. If reels are used, see Aristech Surfaces Technical Bulletin #133 for handling and storage instructions.

Vacuum Forming Area

It is best to have the vacuum forming area enclosed and relatively free of drafts and airborne dirt. The area should be kept clean at all times. The entrance from the sheet storage and cutting area can be an overhead garage-type door that is only open when sheet material is being delivered to the vacuum forming machine. The exit to the finishing area will generally be open. Positive pressure may be needed in this area to minimize dirt from the finishing area.

Sheet Cleaning Devices

As sheets are individually removed from the pallet and loaded into the clamping frame of the vacuum forming machine, they should be cleaned to remove any dust, dirt or particles that might adhere to them. The sheet usually contains some static electricity, especially if the relative humidity is less than 50%. Cleaning is best accomplished by using an antistatic device attached to an air hose. These devices can be obtained from either the 3M Company or the Simco Company. (See sources of supply in Technical Bulletin #159 for complete address, etc.) The device is attached to a standard OSHA approved air hose and is activated by a push button on the air nozzle. Air is simply blown across both sides of the sheet to remove the adhered particles and static electricity.

It is important to remove the static electricity to prevent the dirt and dust particles from “jumping” immediately back on the sheet. If a sheet is extremely dirty, it should be wiped with a tack cloth such as those supplied by the Detron Manufacturing Company.

Vacuum Forming Machines

The recommended vacuum forming machine (see Figure 2) is an automatic single station type equipped with top and bottom moving platens. The sheet clamping frame should be activated with air cylinders and move horizontally into an electric infrared-type oven with heaters on both top and bottom. At the start of the heating cycle, the top heaters are usually 10 inches (25 cm) from the sheet and the bottom heaters 20 inches (50 cm) from the sheet. The heaters should be controlled with 15-second percentage timers. The automatic vacuum forming machines used in this process should have adjustable clamp frames that can be set to clamp exact sheet sizes.

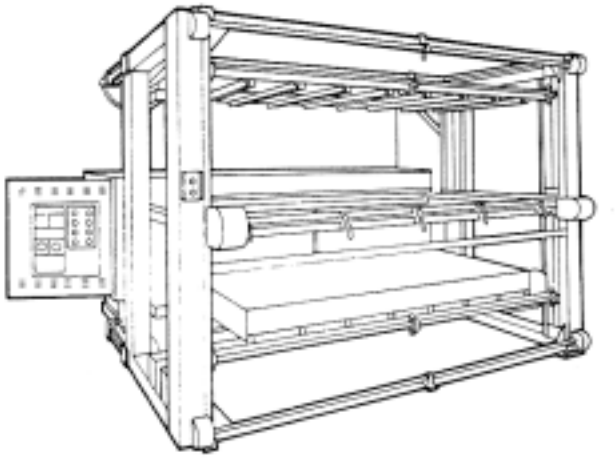

Figure 2. Vacuum Forming Machine

The clamping frames should be designed to move out from the machine horizontally for easy loading of the sheet and unloading of the formed part. The clamp frame should load from the bottom which will allow a sheet to be automatically loaded into the frame with a simple air operated vertically moving platform. The formed part can be unloaded similarly directly onto support jigs. See Figure 3 for a simple schematic of the vacuum forming area.

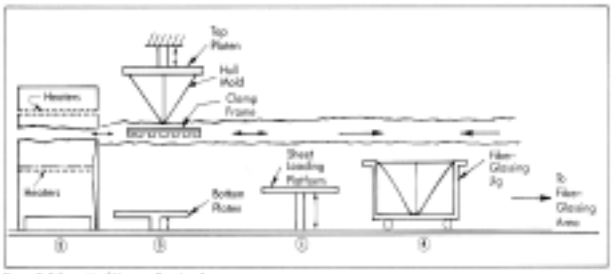

Figure 3. Vacuum Forming Area

Many other types of equipment design can be used to produce these parts (i.e. a simple sign making vacuum forming machine). Manufacturers of vacuum forming equipment are generally prepared to offer considerable technical advice and assistance. They sometimes will have machines set up for a potential customer to observe in actual operation. Some of the manufacturers will vacuum form some shape or part to demonstrate the equipment.

Tooling or Molds

The recommended tooling for this type operation is made from glass reinforced tooling grade polyester or glass reinforced epoxy. Typical boat hull mold configuration is illustrated in Figure 4.

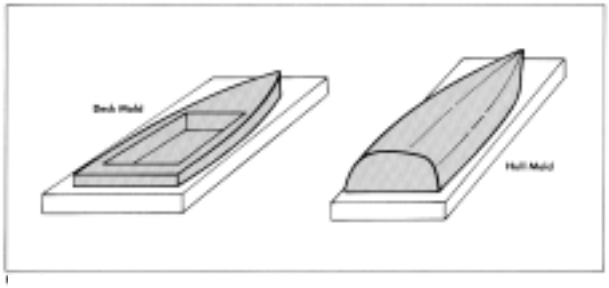

Figure 4. Vacuum Forming Molds

Usually, FRP boat manufacturers using polyester gel-coating techniques will have mold making technology and capability. If this is the case, then the conversion from gel-coat molds to vacuum forming molds is not very difficult. If mold making technology is not in-house, there are many experienced mold manufacturers. See Technical Bulletin # 159 for sources of supply for a listing of several. Mold prices will vary widely, ranging from $20,000 to $50,000 per tool. A general procedure for producing these molds is:

a. Engineering drawings of the deck and hull are used to fabricate wood patterns which are nearly exact replicas of the finished vacuum formed Acrysteel M parts.
b. The wood patterns are used to produce polyester or epoxy female, or reverse “Master” molds.

c. The master molds are used to produce vacuum forming tools or molds which again are nearly exact replicas of the finished vacuum formed Acrysteel M parts. (Note: A finished vacuum forming mold is slightly smaller than the finished part to allow for the Acrysteel M sheet thickness.

A mold can yield as many as 2000-3000 finished Acrysteel M parts if properly cared for and maintained. In the vacuum forming molds, vacuum holes are drilled every 1" (2.5 cm) in the heart of recessed mold radii. These holes can be as large as 1/16” (1.6 mm) in diameter. Several larger holes up to 1/4” (6.4 mm) in diameter may be strategically placed to allow for rapid evacuation of the air during the vacuum forming step. However, care in hole placement must be taken to prevent mold mark-off in the finished part.

Fiberglassing Area

Established FRP boat manufacturers will have an existing fiberglassing/manufacturing area and will probably not need to change anything. For those who will be adding a new fiberglassing manufacturing area, the following is offered: The fiberglassing area should be separated from the other manufacturing areas because of the nature of this process. Polyester resins contain styrene monomer which is flammable and must be handled in a way to limit worker exposure to its vapors. The exact procedures and precautions vary geographically depending on building codes and specific company internal safety regulations. Your local building code agency, OSHA and EPA, should be contacted when setting up a fiberglassing operation. The fiberglassing area must have adequate exhaust fans and/or spray booths. The total area can be a large "spray booth" provided adequate exhaust fans are used and ventilation is accomplished. Styrene vapors are heavier than air, therefore floor exhausts will be necessary. As in FRP operations, respirators and eye protection will be required for the personnel working in this area. The reinforcing process is a combination of chopper gun and hand layup operations.

Chopper Guns

There are several manufacturers of chopper gun equipment. Equipment costs vary and there is a range of models. The more expensive equipment (Figure 5) which uses an airless dual spray polyester stream that has an external catalyst mix seems to work best. The fiberglass is chopped separately, usually in 1" (2.5 cm) lengths, and blown into the spray pattern about 3" to 5" (8 to 13 cm) in front of the dual spray nozzles. The dual spray does the best job of wetting the glass fibers. No recommendations are made as to specific manufacturers. Most have comparable equipment ranging from economy models to the more deluxe models; and as a group, the chopper gun manufacturers have been found to be very cooperative. They usually have application labs where the equipment can be demonstrated or they will bring equipment to the potential buyer's facility for a demonstration.

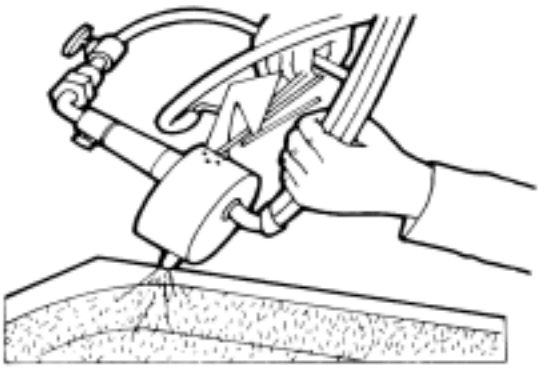

Figure 5. Chopper Gun

Rollers

Although this operation is as important as the chopper-gun spray application, there is not much to say about rollers. The rollers are aluminum consisting of a series of small discs about 3/8" (9.5 mm) wide. These discs are arranged in various configurations ranging from 7" to 9" (18 to 23 cm) rollers, that look like the rollers used to paint walls, to small 1/2" to 1" (12 to 25 mm) wide rollers for rolling out tight inside radii (Figure 6). Rollers are available through chopper gun manufacturers and FRP supply houses.

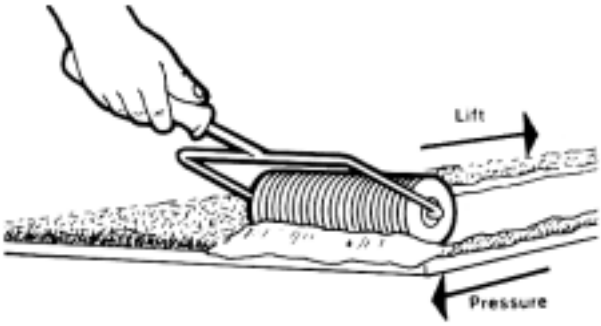

Figure 6. Roller

Resin Tank Mixing And Central Resin Supply

If the manufacturing operation is high volume, it is advisable to set up a central resin supply system. This type of operation usually consists of a series of central supply tanks where the polyester resin, and any fillers or additives used are mixed. Constant agitation, if required, should be available. One tank is usually in use while mixing is occurring in the other(s). Tanks of one thousand gallon (3,800 liter) capacity are often used. Suppliers of polyester resins often offer technical assistance in setting up resin supply systems.

Fiberglassing Support Jigs

It will be necessary to build jigs to support the vacuum formed Acrysteel M shells during the fiberglassing operation. The jigs should be made from polyester resin and fiberglass and will be the reverse (female) shape to the formed Acrysteel M part(s). They are often made by taking a well formed Acrysteel M part (deck or hull); and taking care to retain its true shape, apply a light FRP layer via a chopper gun to what would normally be the finished exposed side of the part. Let the FRP layer cure and then apply more FRP until enough structural integrity is achieved to allow a second FRP jig buildup on the opposite Acrysteel M side. Then liberally apply a good releasing wax to the Acrysteel M side of the part. This is much the same as gel-coat molds are prepared prior to making a gel coat part. Next layup a part using tooling grade polyester and a combination of chopped and hand layup plies until enough thickness (about 1/4" (6.4 mm)) is obtained to support formed parts. Mount the jig on a platform "wagon" (Figure 7). Enough jigs to satisfy production throughputs will be needed.

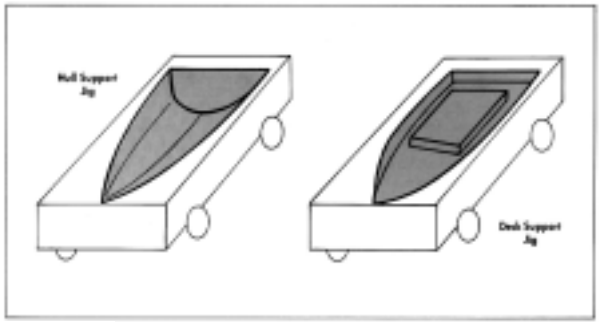

Figure 7. Support Jigs

Materials And Quantities Used (Deck And Hull)

A. Acrysteel M Sheet

Size 0.100" (2.5 mm) thick by 110" (280 cm) wide by 228" (580 cm) long. Two sheets are required, one each for the deck and the hull. Each sheet contains 174.2 ft^2 (16.2 m^2) and weighs 107.8 lbs.(49 kg). The completed deck and hull after trimming will contain about 142 lbs.(64 kg) of Acrysteel M. It is often possible to use some of waste area to form auxiliary parts, such as bait well lids, to more efficiently utilize the materials. Contact the Aristech Surfaces Technical Group for ideas and suggestions.

B. Polyester Resin

General purpose type polyesters designed for bonding to continuous cast acrylic sheet are recommended. Complete testing and evaluation studies should be made with the FRP System selected to insure bonding and product integrity. Several suppliers of polyester resin are listed in Technical Bulletin #159.

C. Glass Roving

Sixty (60) strand (no tracer) continuous clear, silane coated fiberglass is recommended. This material is usually supplied in wound balls containing 33 lbs.(15 kg) each. However, larger balls are available from some suppliers. Several suppliers of glass roving are listed in Technical Bulletin #159.

D. The Resin Mix

A typical mix for the resin system is 70% Polyester Resin and 30% chopped glass. The boat hull will require about 99 lbs.(45 kg) of this mix, with approximately 74 lbs.(34 kg) remaining after trimming. The boat deck will require about 65 lbs.(29 kg) of mix, approximately 48 lbs.(22 kg) of which will remain after trimming.

E. Weight

Based on the weights given above, the FRP primed boat hull shell will weigh approximately 144 lbs.(65 kg), while the FRP primed boat deck shell will weigh nearly 119 lbs.(54 kg)

F. Raw Material Cost

With the information given above and using current prices of the various raw materials, raw material costs can be calculated (see Table 1). Of course, raw material costs will increase based on material usage efficiencies and scrap rates. A well run operation will have a material usage efficiency of 90 to 95% and finished goods scrap rate under 5%.

Table 1

Material	Quantity Used Hull	Deck
.100" (2.5 mm)Acrylic Sheet	174 ft.^{2} (16.2 m^2)	174 ft.^{2} (16.2 m^2)
Polyester Resin	72 lbs.(33 kg)	47 lbs.(21 kg)
Catalyst	.72 lbs.(.33 kg)	.47 lbs.(.21 kg)
Fiberglass Roving	24 lbs.(11 kg)	16 lbs.(7.3 kg)

Process Operation and Direct Labor Consumed

A. Vacuum Forming

Based on the production schedule, the Acrysteel M sheet is cut from the reel and placed on a staging pallet and moved to the vacuum forming machine. At the staging area, the operator(s) will record the package numbers, color, and number and type of parts to be run in the log or daily work sheet. The Acrysteel M sheets will be stacked on the staging pallet accordingly. Four (4) minutes per boat shell (deck and hull) will be required using two (2) operators. The vacuum forming ovens are preheated and percentage timers set. An Acrysteel M sheet is loaded in the clamp frame (20 seconds) and the automatic vacuum forming machine started. The sheet should be heated for 2.5 to 3.0 minutes to a temperature of about 360°F (182°C). Percentage timers must be adjusted to arrive at these conditions. After the sheet is heated, it will automatically exit the oven, vacuum form (40 sec.) and cool (3 min.). If mold release is a problem, use air pressure through the vacuum holes only to facilitate part removal. Do not use mold release materials as they will adversely affect FRP bonding. The part is removed and placed on an FRP jig (40 sec.). Two machine operators will be required in this area. It is usually desirable to keep several formed parts as a buffer between vacuum forming and fiberglassing. This total operation will consume approximately 8 man-minutes per part produced or 16 man-minutes per boat shell (deck and hull).

B. Fiberglassing Primer Coat

One team of fiberglassing operators will be required in this area. This team will consist of a chopper gun operator and three roll-out operators. First, it is advisable to lightly sand the entire surface to be fiberglassed with 100-200 grit sandpaper to provide a better surface for bonding to the FRP layer. The team should apply about 1/16" (1.6 mm) FRP over the entire back surface as uniformly as possible. It is very important to carefully roll out this layer to insure a good bond between the Acrysteel M and the FRP layer and to provide a good base for the remaining fiberglassing. This operation will consume about 60 man-minutes per each boat (deck and hull) produced.

For cautions and other information relating to handling of an exposure to this product, please see the applicable material safety data sheet published by Aristech Surfaces.

These instructions are based upon experience with Aristech Surfaces products only. Experience with products of other manufacturers is specifically disclaimed. For most uses, check for local code approval and test for application suitability. These procedures, techniques and suggested materials should only be used by personnel who are properly trained in the safe handling of the chemicals and the equipment with which they are working. Acrylic sheet is a versatile thermoplastic, however, it is combustible. Avoid exposure to heat and aromatic solvents, clean with mild soap and water, avoid abrasives. These suggestions are based on information believed to be reliable, however, Aristech Surfaces makes no warranty, guarantee, or representation as to the absolute correctness or sufficiency of any of the foregoing, or that additional or other measures may not be required under particular conditions or circumstances.

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