Procedures for Making Plastic Vacuum-Forming Tools

Vacuum forming is considered an intermediate high-temperature tooling application. Usually the working temperatures of these tools do not get above 250 F., even though the temperatures of the thermoplastic sheet materials being formed are often higher. Many vacuum formers use cast or N© machined aluminum tools, which have excellent heat transfer rates and are best for long production runs and fast cycle times.

For prototype and short or medium production runs, the long lead times, handwork, and cost of aluminum tools is often prohibitive. These are applications where urethane and epoxy tooling can make sense. Keep in mind that plastic tools do not have the high heat-transfer rates of aluminum, so they are best used in single-stage machines where the tools have a chance to cool down between pulls.

There are a number of procedures for making plastic vacuum-forming tools. This is a listing of some that are commonly used. Please refer to the individual product data sheets for mix ratios and processing parameters.

Cast Tools

Urethane

Fast-cast urethanes, such as Replicast 609 and 612 work well for prototype applications or where the tools experience low heat, such as for forming blister packs. Replicast 609 is a non-settling, 1:1 mix ratio, fast-setting, easy machining system that is best for small tools. Replicast 612 is used for larger castings where more working time is needed. It needs to be premixed on a paint shaker and is more abrasive on cutters.

Release the pattern with PA0801 non-silicone paste wax, apply three or more coats, buffing between coats. Premix either Replicast system on a paint shaker, if available. If not, use a spatula or Jiffy Mixer to make sure parts A & B are completely suspended before continuing. Blend parts A & B at a 1:1 ratio (by weight or volume) and pour into the pattern cavity. Pour at one spot and allow the material to flow out from that point. The tool can be demolded from the pattern after two hours. Drill the vacuum holes. Allow four hours of cure time at 75 F. before placing the tool into service.

Epoxy

Cast epoxies can be used for any size tool, but are best for small and medium sizes. Epoxies have much higher heat resistance than urethanes, so they can be used for higher production rate tools. Please refer to "Procedures for Casting Resins" detailed instructions on how use these materials. Here is a list of materials that can be used:

- **PT1554 A/B Aluminum-Filled Heat Resistant Epoxy Surface Coat**
- **PT4935 A/B (fast) or B1 (slow) Aluminum-Filled High-temp Casting Resin**
- **PT4925 A/B (fast), B1 (slow) or B2 (very slow) Aluminum-Filled High-Temp Casting Resin (this system has our highest aluminum content, but is thicker than PT4935 and harder to use)**
- **PA0703 Aluminum Needles**

Small Cast Tools

Use either PT4935 A/B or PT4925 A/B to make solid castings. Mix at the proper ratio, pour into another container and remix. Pour at one spot into a properly prepared pattern and let the material flow out to fill the cavity. If a bubble-free surface is required, brush a thin coat of the mixed material on the mold surface before casting. Do not pour any thickness greater than 1½-inches thick with the B hardener.

Allow the casting to cure overnight at 75 F. If possible, it is best to give the tool a short post-cure for 2-4 hours at 120-150 F. In most cases, the final cure will take place at the temperatures involved during the actual vacuum-forming process.

The final steps are to mount the casting on a backing plate and drill out the vacuum holes.

Medium Cast Tools

Method 1: Use either PT4935 A/B1 or PT4925 A/B1 and use the same procedure as described for small cast tools. Keep casting thickness to 4-inches or less.

Method 2: The use of PA0703 aluminum needles as filler has the advantages of controlling shrinkage, since it displaces resin; and increasing heat-transfer rates, because it raises the aluminum content of the casting. Keep castings to 8" thick or less.

Brush the prepared pattern with a coating of PT1554 A/B surface coat that has been mixed at the proper ratio and remixed in another container. Allow this coating to gel to the point where you can leave a fingerprint but it will not transfer to your finger. Do not let this coat cure to a hard glazed surface.

Mix PT4935 A/B at the proper ratio and brush coat the back of the rubbery surface coat with this mixture. Blend the remaining batch of this casting resin with PA0703 needles at a ratio of 50:50 by weight. Keep adding needles to the mix until you get a concrete slurry-like consistency and pour into the cavity. As the needles settle, keep adding more until needles are resting upon needles. Use a vibratory table, if available, to help pack the needles.

Allow this casting to cure overnight at 75 F. Demold from the pattern and post cure, if possible, for 4-6 hours at 120-150 F. Mount to a backing plate and drill out the vacuum holes. Be careful when using long thin drills because they break easily when they contact a needle.

Large Cast Tools

Large cast tools are heavy, easy to crack, and use large amounts of materials, so it is usually recommended to laminate large tools.

On large cast tools, it is possible to integrate copper cooling lines into the casting. Wax the exterior of the copper line so that the epoxy will not bond to it. Position the lines approximately ¼-½ inches away from the face of the pattern before casting. This can be used with either of the two following methods.

Method 1: If the large tool is to be cast solid, use the same procedure as outlined for Medium Cast Tools but use PT4925 A/B2 (very slow hardener). This system will keep exotherm and shrinkage to a minimum on large castings, but will require the following cure cycle: Overnight at 75 F. plus 4-6 hours at 120 F. Demold from pattern and starting at 150 F., cure at 50 F. increments for a minimum of two hours each. The final cure should be 25 F. above the expected use temperature. Turn off the oven and allow the tool to cool to room temperature.

Method 2: Use the same method as outlined for Medium Cast Tools Method 2, but substitute PT4935 A/B1 (slow hardener) for mixing with the aluminum needles. Cure overnight at 75 F., followed by 6-8 hours at 120-150 F. before placing into service.

Laminated Epoxy Tools

Laminated epoxy methods of making vacuum-forming tools are usually reserved for medium or large tools. Small tools are easier to cast than laminate. The advantages of laminated tools, lightweight, low shrinkage, and high strength only make sense for larger tools.

The following materials are required for making laminated epoxy tools:

- **PT1554 A/B Aluminum-Filled Heat-Resistant Epoxy Surface Coat**
- **PT2620 A/B Filled High-Temp Epoxy Laminating Resin**
- **PA0703 Aluminum Needles**
- **Style 7500 (10-Ounce) Fiberglass Tooling Fabric**

Medium Laminated Tools

There are three methods for making medium size laminated vacuum-forming tools. Method 1 is lower cost and a faster build, but for shorter production cycles. Method 2 takes more labor, but is stronger for higher production cycles. Method 3 takes the most time and effort, but results in a tool that can be used at higher temperatures and shorter cycle times.

Method 1: On a properly prepared pattern, brush on a coating of PT1554 A/B that has been mixed at the correct ratio and remixed in another container. Keep the coating to .030-inches thick or less. Allow this coat to reach the "fingerprint stage" and apply either a second coat of PT1554 A/B (some people like a thicker surface coat to provide material for sanding), or a brush coat of PT2620 A/B laminating resin. Immediately laminate a ply of Style 7500 fiberglass fabric into the second surface coat or the laminating resin. Using PT2620 continue laminating until you reach a minimum of three plies.

At this point, mix another batch of PT2620 A/B and use it to wet-out PA0703 aluminum needles. Use just enough resin to coat the needles so they will bond together, but not so much that resin fills the voids between the needles. Brush-coat the back of the laminate with freshly mixed PT2620 A/B and proceed to pack the freshly-coated needles onto the back of the laminate, filling the cavity. Allow to the tool to cure overnight at 75 F. Remove from the pattern and, if possible, cure the tool for an additional 4-6 hours at 120-150 F.

Mount to a backing plate and drill vacuum holes through the thin laminate only. The needles should be bonded together to form a honeycomb-like backup structure, which will allow air to pass through it.

Method 2: Make a full-thickness laminate (¼-½ inches thick depending upon the size and shape of the tool) using PT1554 A/B surface coat and PT2620 A/B (use B1 hardener if longer working times are required) laminating resin. Use the procedure outlined in Method 1, but continue laminating until you have the full desired thickness. Do not use aluminum needles for backup.

If additional support is required, make an eggcrate structure using laminated flat stock. Space this structure ¼ inch away from the back of the laminate and attach by using fiberglass cloth and PT2620 A/B. Circulation holes should be cut into the structure to allow air to freely flow through the eggcrating. Cure the tool as in Method 1. Drill vacuum holes through the laminate into the eggcrate area.

Method 3: Refer to "Fiberglass-Epoxy Wet Layup Tooling Procedure Room-Temperature Set, High-Temperature Usage". This procedure describes making a higher temperature service tool using vacuum-bagging techniques and higher temperature resin systems. Use this method to make vacuum-forming tools for the most demanding applications.

Copper tubing can be made into manifolds and bonded to the back of the laminates for cooling purposes.

PTM&W Industries, Inc.
10640 S. Painter Avenue Santa Fe Springs, CA 90670-4092
562-946-4511 800-421-1518 FAX: 562-941-4773
Visit Us At: www.ptm-w.com Send Questions To: info@ptm-w.com