Molds with no witness lines made from multi-part pressure forming templates

This user story was written by one of our customers,
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Design Innovation, Inc. is an engineering design and prototype fabrication company working with tech startups, university labs, and US government labs. We employ CNC milling, 3D printing, and other fabrication techniques to make whatever is needed. We also create sculptural items in glass, metal, and wood, including one-of-a-kind art lamps. For some art lamps, stained glass sheets are formed into complex 3D shapes and precision cut and ground to final dimensions.

Above left: The final stained glass art lamp fitted into a metal frame

Above right: The refractory form in the kiln with a sheet of formed glass

> Have you used the Multiplier for a project that you would like to share with the world? We'd love to hear from you!
>
> Email ben@mayku.me to let us know what you have been making.

The challenge

This glass shaping is done in an electric kiln over custom refractory forms made from plaster reinforced with additives including silica fibers. Developing and fabricating the refractory forms has been one of many steps in the process. The refractory forms are cast in molds, and creating these molds has been one of the most time-consuming and difficult steps.

In the past, the molds were CNC milled from large blocks of aluminum. Any glitch or error in the milling process would likely result in an expensive chunk of scrap metal, and a perfectly machined mold would still require significant labor to smooth the milling marks out of the cavity. This led to very long moldmaking cycle times and a "do it once" mindset that opposed flexibility and experimentation.

The solution, and a new challenge

The Mayku Multiplier has enabled us to quickly make durable, lightweight molds, with a much greater sense of flexibility for trying out new designs. We print our templates in Formlabs High Temp resin, which has ideal working properties. One new challenge has been when the templates are too large to print in one piece and have to be assembled after printing. What appears to be a perfect seam after gluing and sanding will still leave a substantial witness mark in the pressure formed sheet, and thus would leave an unwanted mark in the cast refractory form and the eventual glass pieces. Re-sanding after pressure forming doesn't reduce the witness mark sufficiently.

The rest of the solution

We developed a hybrid gluing and filling process that sufficiently reduces or completely eliminates the witness mark from pressure forming templates assembled from multiple pieces. This process uses an engineering epoxy to form the primary bond between the parts of the template, and a hand application of Formlabs High Temp resin with UV curing to fill the exposed part of the seam.

The process

We print our templates as hollow shells with a reinforcing structure underneath, generally a grid with walls ranging from 4mm to 6mm in thickness. These have consistently been strong enough for the pressure forming process. Cleanup in the recesses of the grid can be minimal since it has no effect on the rest of the process.
Figure 1

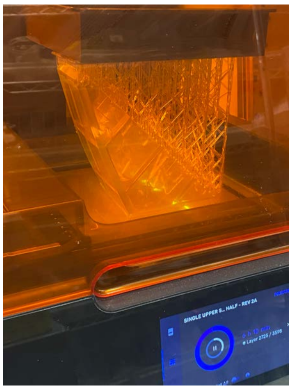

Figure 1

Ideally, the template pieces are as symmetrical as possible and have keying features between them for precision alignment.
Figure 2

Figure 2

A recessed pocket about 1/2mm deep should be provided between the mating surfaces for the epoxy, both to allow some thickness of epoxy and to form a barrier against the epoxy leaking up to the critical surfaces. This pocket is ideally split between the two mating surfaces.

Prior to using the epoxy, only enough cleanup is done to ensure precise mating of the template pieces. The epoxy is applied, and the pieces are clamped together. Using a dark epoxy makes it easier to see where it has gone.
Figure 3, Figure 4

Figure 3

Figure 4

After the epoxy has cured, the bottom of the template is sanded flat, generally with 80 grit sandpaper. All the sandpaper mentioned here is preferably silicon carbide wet or dry paper. Of course, wear an appropriate particulates respirator when doing any sanding of cured resin!
Figure 5

Figure 5

Depending on the condition of the critical seam, there are two ways to proceed. In the first method, the seam can be directly filled with High Temp resin using a syringe and narrow needle and/or a small paintbrush. The resin needs to end up higher than the seam so that it can be sanded down after curing, otherwise multiple cycles of resin and curing will be required. Getting resin a couple of millimeters to either side of the seam is pretty unavoidable, but more resin also means more cleanup is needed.

The second method starts with intentionally opening up the seam to allow deeper application of resin. This is best done with a Dremel or Flex Shaft type rotary tool and a small abrasive disk. This method gives even better results in terms of having zero witness mark, but adds the risk of scarring up the critical surfaces and requiring more resin fill and cleanup. If this method is followed, all abrasive grit must be cleaned away before adding the resin per the first method.

Since the resulting template is too big to fit in the Formlabs UV curing oven, a UV curing chamber can be made with an inexpensive UV curing lamp, a corrugated cardboard box, and a lining of aluminium foil. The template with wet resin is placed in the box and cured for 4-6 hours.

Assuming that the resin seam is completely above the surface of the template, the seam can be sanded down and the template can be finished. Initial lowering of the filled seam is done with curved files and 150 grit sandpaper wrapped around a cylinder. Sand this close to flush, but it doesn't have to be perfect.
Figure 6

This is followed by sanding of the critical surfaces with 220 grit sandpaper, which we do with a sanding block faced with a thin layer of high-density neoprene foam. Use more 150 grit at this stage only if 220 grit isn't getting anywhere. Keep the sanding block moving uniformly over the template and don't sand any more than absolutely necessary to achieve a smooth and even surface. Use cylinders wrapped with sandpaper where necessary. If there are any imperfections too deep to sand out, clean the form thoroughly and fill with more UV resin and repeat the curing process. Non-critical surfaces can be sanded smooth with 150 grit paper, followed by 220 grit. Be careful not to sand near the edges in any way that would interfere with the release draft on the template. Also, try to keep the marks from the final sanding passes parallel to the direction of pull for releasing the template from the formed sheet.

Once the entire template (except for the bottom) is sanded smooth to 220 grit, wash it off, dry it, and inspect it carefully. If it all looks good, do a final sanding with 400 grit. After washing and drying from that sanding, you may find some areas that need more sanding. Repeat as needed. If your application needs an even finer surface finish, proceed as necessary.
Figure 7

The template is now ready for pressure forming. We've had good results with the 1mm PETG sheets.
Figure 8

After pressure forming, we make a plywood frame and trim the PETG mold to fit. We scuff the underside of the formed sheet for better epoxy adhesion.
Figure 9

Masking tape is all that's needed to hold the mold to the frame. The underside of the mold and the adjacent portions of the frame are then coated with thickened epoxy. We use a bulk marine grade epoxy thickened with silica or sawdust, whatever is at hand that can make it thick enough to not sag. A layer about 6mm thick will suffice. This stiffens the mold and joins it to the frame. Ideally, wet the surfaces with a thin layer of non-thickened epoxy first in order to enhance adhesion.
Figure 10, Figure 11


Figure 6


Figure 7


Figure 8


Figure 9


Figure 10


Figure 11

Results

As shown here, the mold was used with an additional sheet aluminium dike (held together and secured with packing tape) to provide a riser for the refractory form. In most cases this isn't needed.
Figure 12

The finished refractory form.
Figure 13

The refractory form in the kiln with a sheet of formed glass.
Figure 14

A sheet of formed glass that has been cut and precision ground to final shape and then wrapped with copper foil, shown here test fitted into a metal frame.
Figure 15

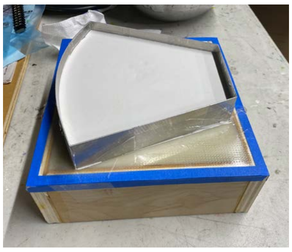
Figure 12


Figure 13


Figure 14


Figure 15

Revolutionizing design: The Mayku Multiplier advantage

The Mayku Multiplier revolutionizes the mold-making process, allowing for greater flexibility and experimentation in design. It enables quick production of durable molds, reducing the cycle time significantly compared to traditional methods like CNC milling from large aluminum blocks.

If you're interested in incorporating the Mayku Multiplier into your mold production workflow, get in touch with a Mayku Expert today.

Talk to a Mayku Expert