Additive Manufacturing for Use Constructing Glass Blow Molds

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Abstract

Optic molds are a useful tool for blowing and patterning glass. They have a cylindrical shape with an inward facing pattern used to leave an impression on glass blown inside. The creation of optic molds may be made more efficient by the use of additive manufacturing, not necessarily to create the mold itself, but to create patterns from which a mold may be cast. By using customized PLA patterns to form plaster molds, then casting aluminum into the plaster molds, optic molds may be produced quickly, economically and with a high degree of customization.

Introduction

Optic molds, also known as dip molds, are a common tool used in glass work. Patterns are impressed onto a piece of molten glass, which takes the shape of the cup shaped mold and is left with its inward facing pattern. The glass may be twisted as it is removed to produce a swirl pattern and may be shaped then into any sort of cup, vase, or other desired glass object. An example of a cup that has been manufactured using an optic blow mold can be seen below in Figure One.

Figure One: Optic Mold Glass Blowing Example

Examples of optic molds themselves can be seen in Figure Two. The hollow star shapes that can be seen are the cavity that the glass is blown into.

Figure Two: Assortment of Optic Blow Molds [1]

Fused filament fabrication provides an efficient means to create optic molds with a high degree of precision and at a low cost. By first creating a sacrificial PLA model for the desired mold to be based on, any pattern or size of optic mold may be manufactured with relative ease. This model is designed to look exactly as the desired finished product, only to create a plaster mold in which aluminum castings may be made. Using printed molds allows for any sort of complex patterns to be made and makes custom modifications simple. PLA and other polymers commonly used in additive manufacturing are not suitable for use with high temperature molten glass, and it is only used to produce a more robust metal casted mold of itself.

In order to create a usable optic mold, aluminum was chosen as a relatively cheap, easy to handle material that could hold up to glass blowing. In order to create aluminum mold, plaster was formed around the printed model to create a negative of the finished product, which aluminum may be cast from.

This was then baked and the PLA structure inside is burned away leaving only the casting mold.

Once the plaster casting was created, aluminum was poured in and allowed to cool, producing the final optic mold. This process allows for the production of detailed patterns that would ordinarily take much longer to produce.

Process

The final product we wished to create is an optical glass blowing mold. To do this several casting steps are required to transition from a printable material, to one that can withstand glassblowing temperatures. However, our method allows the original geometry to be modeled using software, skipping the precise and difficult step of sculpting the desired pattern by hand.

CAD Model and 3D Print

The first step in the creation of the blow mold, was modeling the mold in SolidWorks. This allowed for tight design control of the exterior pattern that would be on the final product. The model used can be seen in Figure Three.

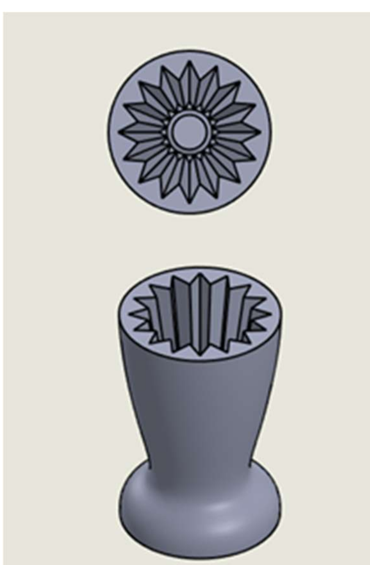

Figure Three: Blow Mold CAD Model

The CAD model was then sliced and printed in PLA through fused filament fabrication using transparent filament and low infill (5%). This print setting and material selection was made based on the next step of creating the mold. When firing the plaster around the PLA, it is desirable for the plastic mold to burn away completely leaving no residue, dyes, or melted plastic in the casting mold. The printed component was photographed before it was destroyed and can be seen in Figure Four.

Figure Four: PLA Printed Mold

First Casting

After manufacturing a suitable PLA model on which to base the casting mold, plaster was formed around it. The plaster covered PLA model was then baked and hardened as the PLA model was burned away. The foot of the model was left uncovered by plaster to create a sprue for the aluminum to be poured into.

Second Casting

After the plaster casting mold was created, the plaster mold is heated to 1000 degrees Fahrenheit so as to acclimate it to the temperature of the molten aluminum and prevent cracking. Before pouring the aluminum, a graphite crucible was heated in a furnace to approximately 1500 degrees Fahrenheit before aluminum scrap was placed inside. The aluminum was then melted and poured into the mold. The crucible can be seen before heating in Figure Five and heated to glowing in Figure Six.

Figure Five: Graphite Crucible

Figure Six: Heating of the Crucible

Figures Seven & Eight: Pouring the Molten Aluminum

The final aluminum optic mold, shown in figure nine, is essentially an exact replica of the printed model. The foot of the model forms an opening in the plaster that serves as a sprue for the aluminum, and some overflow can be seen in this final mold.

Figure Nine: Cast Aluminum Optic Mold

Glass Blowing

Once the optic mold is manufactured, it may be used for its purpose: glass blowing. To use the optic mold, a glass blower inserts a bubble of glass or a parison into the top of the mold and blows through a blowpipe to inflate the parison to fill the mold, which will take its shape as it cools. If desired, the glass may be twisted as it is removed to add a twist to the pattern, and the glass may then be further processed into any sort of glassware. Figure ten and eleven demonstrate the use of optic molds.

Figures Ten & Eleven: Using an Optic Mold [1] [2]

Materials

The printed model was made from undyed, transparent polylactic acid (PLA). PLA is a commonly used material for FDM and has a relatively low cost. The model was printed with an Ultimaker FDM printer using 5% infill and 0.1mm layer distance. Transparent filament was chosen specifically to eliminate the presence of dyes which may not burn off with the PLA, and It was printed at low infill to facilitate burn off yet have enough structure to produce a quality plaster cast.

Plaster was used to form the casting mold, as it is frequently used for casting metals and can stand up to the heat of molten aluminum. It was easily formed to the PLA model and retained its shape as it was hardened. Aluminum was chosen for the final mold as it has a low melting point (660.3 C) among metals and was thus easy to handle, and it is relatively inexpensive.

Conclusion

This process displays the efficacy of 3D printing as a template for casting optic molds, and potentially other cast molds or objects. Using additive manufacturing allows for the manufacture of molds with potentially complex geometries that would otherwise be difficult to construct. If a mold may be modeled and printed, then it may be simply cast in aluminum.

The use of PLA as a sacrificial template mold provides a simple method for producing intricate patterns in the final cast mold, with minimal cost and a relatively short lead time for production. This may be repeatable for many cases requiring metal casting of detailed or otherwise difficult to manufacture patterns.

References

[1] "Sonoran Glass School." https://sonoranglass.org/product/intermediate-glassblowing-using-color-bar-trails-and-optic-molds/

[2] "Messages From a Bottle" https://sites.google.com/site/glassbottleexhibit/manufacturing-techniques/mold-blown-bottles