TECHNICAL PAPER

School of Fish, just click print

The process of enlarging sculpture with foundry ready advanced technologies and additive manufacturing methods.

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Introduction

In late 2018, the Royal Botanical Gardens in Burlington, Ontario wanted to create an artwork for their reflecting pond to extend the Dan Lawrie International Sculpture Collection on their grounds. Cobalt Connects, who organized the project, chose Artcast Inc. to complete the project knowing of our experience with enlarging smaller original works into large bronze public sculpture and monuments. The piece that was chosen to be enlarged was *School of Fish* by Kakkee Negeoseak, an Inuit stone carver.

Problem

In the case of *School of Fish,* we had to decide which method of enlargement would work best for the sculpture. At our foundry, we create sculptural enlargements using one of three methods: freehand enlargement, scan-assisted enlargement, and full-digital enlargement. Freehand enlargement is the more traditional method of enlarging a sculpture; however, it is a completely manual process involving potentially inaccurate calculations, human error, and has become more cost-prohibitive unless the artist can do it themselves. The most common technique for us to use is scan-assisted enlargement, which utilizes 3D scanning technology and multi-axis milling equipment. This method does not require a particularly high-resolution scan file as the details can be added with a sculpting medium that is applied to the surface of the milled Styrofoam, typically modelling wax. The manual addition of detail is a labour-intensive process.

Solution

For *School of Fish,* we chose full-digital enlargement. The full-digital method uses a high-resolution 3D scan. A pattern is produced directly from the 3D file. This method allows us to get an accurate wax without the use of rubber molds or additional wax labour. The 3D printed patterns also offer the ability to work with a uniform wall thickness throughout the sculpture, unlike handmade waxes.

Process

Important steps regarding this specific project

Note: The scan file in this case is supplied by the client otherwise it would have been sourced by Artcast Inc.

1. Pricing

   The information available from the 3D scan file allows us to accurately estimate the cost of production as well as plan the project more accurately regarding disassembly for casting and specifics for installation. 3D files offer information such as surface area and volume as well as estimate the final cast weight of the piece in C873 silicon bronze. The use of advanced technologies such as 3D scanning and printing allow the client to save the cost and the storage space required of a rubber mold.

2. Printing

   Material choice in a printed project is critical. For a piece this large and smooth the chosen material was PMMA. The printer used for this project offered a large build volume, modifiable patterns, and excellent burnout properties. Other technologies such as SLA investment casting patterns have excellent surface quality and burnout properties, however, they are not able to be modified to the

same extent as the PMMA patterns and special consideration must be made during shell making and dewax. SLA patterns are a thin shell of plastic with supports on the inside that allow the print to remain rigid until dewax. The thin shell does not allow much material to be removed for modifications and can cause shell cracking during dewax if the shell is not thick enough or if the print has not been punctured to allow pressure from the air tapped in the printed plastic part to escape.

3. Touch Up

Since PMMA is modifiable with standard wax tools we were able to easily add the artist's signature to the top of the piece by carving it into the surface. We also added extra wax around the eyes of the fish to smooth out some faceting that was present due to the original scan resolution.

4. Client Approval and First Looks

The client was able to see a section of the prints that had been tacked together with wax for inspection purposes. With the 3D printed patterns this assembly was not necessary however it was done for documentary purposes. For projects involving handmade waxes, we assemble the wax panels entirely as they are made to ensure that they will fit together properly in the assembly stage later in the process.

5. Gating

Not all printed materials adhere well to our pouring wax. Our pouring wax is the general-purpose wax we use for sprues and making waxes from rubber molds. The pouring wax is reclaimed after steam dewax. For pieces that do not adhere well we use sticky

wax. The PMMA prints do adhere quite easily and no extra care is needed when processing the pieces for gating.

6. Shell Building

School of Fish went through our standard aluminosilicate shell system without any special processing. The prints act exactly as a wax would opposed to other processes such as SLA foundry patterns. SLA patterns are hollow and tend to float during a dip cycle. If the patterns are not adhered well to the gating, then the pattern may detach and float in the slurry tank. Since we hand dip our shells this has not been an issue for us.

7. Dewax

The dewax cycle for our 3D printed patterns varies depending on the material. For instance, the PMMA prints can go through the autoclave with the other 100% wax clusters. The PMMA will not melt out of the shell; however, since it has a negative coefficient of thermal expansion it does not risk destruction of the shell. This allows us to remove any wax used for the gating system as well as the wax used to seal the prints without having to incinerate it. Our preheat/burnout furnaces will incinerate the remaining print material. The incineration of PMMA required higher than average amounts of oxygen in the burn. We remedy this with the addition of air lines directly into the gates and risers of our shells. This addition of air lines was not a new concept for us as it is how we burned out wood for other direct-cast projects.

8. Inspection

Since we had to take special care when dewaxing the printed pieces, we make sure to inspect all of the shells. Normally this means a blast

from the compressed air hose and a visual inspection for any ash or residue.

9. Casting & Chip-off

Pouring metal into shells that once contained 3D printed patterns was not out of the ordinary unless the burn did not successfully incinerate all the remaining PMMA material. If there was still carbon or ash remaining in the shell, we would have had to repair any non-form present on the castings. Otherwise, there is no need to treat these shells any differently.

10. Assembly

The assembly of printed patterns is simple and easy compared to some projects we have worked on where we must make the wax panels by brushing wax into a silicone mold. Handmade waxes often have varying thicknesses and could warp during either the solidification and cooling of the casting or while the piece was assembled for fit in the wax room earlier on in the process. The panels from a printed sculpture may still warp during some stages of the process; however, they are a much closer fit than handmade waxes.

11. Patina

The patina on *School of Fish* is intended to compliment the artist's original sculpture. Often, Inuit sculpture is carved in green or black stone. The patina that was chosen is a combination of a black basecoat with a hand stippled green over top of it. The stippling of the green will give an impression of stone while maintaining the elegant aesthetic of a bronze sculpture.

12. Installation

The cast sculpture itself weighed only 500 pounds. The concrete pedestal it stands on in the reflecting pool is 3000 pounds. The pedestal was lifted into place first, followed by the limestone base, and finally the bronze sculpture.

13. Unveiling

The veil came off the piece, its reflection, enhanced by the setting sun, casting an orange glow on the piece. The sculpture was extremely well-received, and the attendees had nothing but great things to say about the work. Those who were at the unveiling were impressed with how well the sculpture translated from a stone carving into a large bronze fine-art public sculpture. Everyone who was involved in the project, including the artist, was very happy with how the sculpture appears in its final resting place. Although the sculpture was enlarged using advanced technologies, it did not make the final piece any less artistically valid.

Observations

During our pricing process there are calculations we use to estimate how much time is necessary to complete the sculpture. We were impressed with how seamless the process was for *School of Fish* to be cast. The total time in our shop was around two months. The typical timeline for traditional enlargement can be close to six months or more due to the enlarging, texturing, and rubber mold steps necessary to cast the sculpture. This piece has been a proof of concept for ourselves and our clients. The experience of casting enlarged sculpture from printed patterns will play a large role in our planning of large projects in the future.