Glass Mold Innovation Through Collaborative Research

By Gayle Matthias and Tavs Jorgensen

Collaborations between practitioners with different skills and knowledge bases can be a great driver for innovation. Over the last 4 years we have been working together to combine our knowledge bases to develop a new approach in making glass casting molds. The process we have established means that molds can be created directly from 3D computer files without the need for a physical pattern - a process that potentially offers significant advantages compared with conventional glass molding techniques.

We both work at Falmouth University, but in different departments and roles. Tavs is a Research Fellow at the Academy of Innovation and Research (AIR) and has a background as a designer in the ceramic industry. Over the last ten years, he has increasingly focused his practice on academic research into new digital design and fabrication tools. Gayle is a Senior Lecturer in Contemporary Crafts and also an established glass artist who, over many years, has built up extensive experience in a wide variety of kiln-formed glass techniques. In particular, Gayle has explored the use of the ceramic shell molding technique for glass casting. Ceramic shell molding has long been an established process in the metal foundry sector, but unless modified, the process is unsuitable for glass casting. Through a PhD study, Aron McCartney pioneered the adaptation of this molding process for the glass sector. Gayle provided material for Aron's PhD in the shape of a case study, and it was Gayle's expertise with this process that informed much of the early experiments of our research project at Falmouth.

We started our research with a series of open-ended explorations of various 3D printing technologies applied within a glass practice. Initially, we tested plastic models (ABS type) produced on the university's Stratasys Rapid Prototyping (RP) machine. To explore other 3D printing technologies, we contacted the UK supplier of ZCorp powder based 3D Printers, who agreed to donate a number of models printed in a starch material for our early stage research. We ran a series of tests on both types of materials using an adapted ceramic shell recipe, treating the models as if they were standard wax patterns in a 'lost-wax/burn-out' approach. Both the plastic and the starch models provided somewhat mediocre results. The plastic patterns proved to expand slightly during the pattern burn-out stage, which would result in cracked molds. The starch models had poor surface quality and were also very fragile, making them tricky to mold.

The ZCorp retailer also supplied us with a sample made in a new printing powder (the ZP 150 powder) in the form of a small vase. We decided to test this material by casting glass into it. The resulting cast, though small, indicated good refractory possibilities and ability for the mold to dissolve easily in water. This changed the nature of our investigation, no longer using RP models as mold patterns, but directly printing the mold itself without the need for a physical pattern, this process is commonly known as 'Rapid Tooling' (RT). The ZCorp retailer continued to support our research by supplying a series of more complex printed molds. On firing, we found these thin walled molds to be structurally deficient, readily collapsing during the kiln casting process. It became apparent that the printed molds would need to be reinforced in some way. Consequently, we started to explore ways of strengthening the molds with layers of ceramic shell. However, on testing we found that the internal 3D printed mold layer would shrink considerably when fired, whereas the ceramic shell would not shrink at all. The resulting gap between the two surfaces resulted in cracks in the internal layer when glass was cast into the molds. Through extensive research we managed to reduce the shrinkage of the inner printed part of the mold by the addition of infiltrants. We also established an alternative refractory coating that provided a much better fit with the printed layer.

The method we have now established means that we can produce molds that are thin (6 - 12mm in total wall thickness), but still with very good structural integrity. Apart from eliminating the need for a physical mold pattern, the process has a number of other potential advantages compared with conventional molding approaches. In particular, lower firing temperatures and shorter firing cycles can be used, allowing for a wider range of glass types. Molds assembled from several parts have also successfully been tested, which makes the process extremely versatile.

One of the driving forces of our research was Gayle's desire to employ this new molding process in her own creative practice and to more widely explore the potential of new technology tools. Gayle's recent '*Anatomical Deconstruction'* series, based on low-tech assemblages combining sheet and cast glass with broken sanitary ware, made in pursuit of a 'willful amateurism', provided an artistic starting point. Gayle thought that it was important to maintain this ethos for making in the digital collaboration. The intention was to respond to two broken ceramic fragments, reuniting them in a new configuration using cast glass as a conduit. Conventional digital modeling was found to be counterproductive and unintuitive; as a consequence, a 3D scanning machine was used to digitally capture the ceramic edges. By repositioning the ceramic fragments on a grid base, the ceramic edges could be orientated using a digitizing arm. The data could then be aligned with the scanned data enabling the production of a digital model. 'Sinew', the resulting glass cast assembled with ceramic ready-made, possessed a degree of accuracy of fit and fluidity of form very difficult to achieve through conventional modeling and illustrated how other artists could possibly use the RT molding.

As well as employing the molding concept in a creative practice, we are also very keen to explore other applications, and continue to actively seek partners to collaborate with. We both recognize that the 'pooling' of our collective knowledge has been one of the key ingredients in successfully developing the research, and we consider that establishing further spheres of collaboration has the potential to develop the project much further.

Such an opportunity arose when contact was made with glass artist Matt Durran. He had for a while been working with the Royal Free Hospital in London on a project which investigated the use of glass molds to grow human replacement tissue for reconstructive surgery. Through this contact we have explored the employment of our molding process for this, entirely novel, application. The relationship with the Royal Free Hospital is still developing but so far we have successfully made ear, trachea and face glass molds. The molds for these parts have been created either through 3D modeling from diagrammatical drawings, or directly from 3D digital scan data.

While seeking external collaborations, we also continue to try to extend our collaborative engagement within our own institution. In particular we are very keen to involve the students in the research that we are undertaking. In February this year we took initiative to launch a pilot scheme with level three undergraduate students from design based courses at Falmouth University. We made a call for students to propose designs that could be interpreted through RT molding, with the aim of testing the boundaries of the molding process through the application of scale, texture, form and intricacy of patterns. Although not concluded, the project has so far provided a very useful 'testing ground' for the molding, driven by diverse, individual student design requirements.

When we started this research, the main target sector appeared to be creative studio glass practitioners, however the development and dissemination of the research has presented us with the potential for much wider applications. As 3D scanned objects and CAD files can be directly translated into RT molds without the need for physical models, easy transition from virtual files to RT molds could result in CAD files being shared and modified as part of the design process. As a consequence, glass casting could become more accessible and new creative opportunities and materials could be explored. The RT process can also eliminate many of the difficulties with the lost wax method of casting. Furthermore, the molds are made from safer materials and the casts are very easy to de-mold.

Combining and exchanging knowledge and skills can create exciting new hybrids and we intend to look to further our collaborative relationships to explore and utilize this molding process to its full potential.

Author Biographies:

Tavs Jorgensen

Tavs initially trained as a craft potter in his native Denmark before moving to the UK to establish a successful career as a designer in the ceramic industry. While he still maintains an active creative practice, his practice is now mainly focused on academic research into the use of new digital design and fabrication tools.
He has used glass in a number of recent research projects, and currently in the process of exploring new approaches in glass forming with a novel molding concept known as 'Reconfigurable Pin Tooling'.

Tavs is a regular visiting lecturer at the Ceramic and Glass Department at the Royal College of Art, London and also frequently guest lectures at a number of other leading international academic institutions.

Gayle Matthias

A practicing glass artist, having exhibited nationally and internationally, Gayle Matthias has work in the permanent collections of the V & A, Musee de Vianne, and Ebeltoft Museum of Glass amongst others. Gayle previously worked in the Gallery Education Department at the Crafts Council, UK. Over the years she has worked with Colin Reid, Diana Hobson and Peter Layton at the London Glassblowing workshop. Gayle has been an artist in residence in France and the US and examples of her work can be found in many glass publications.
Gayle has also been visiting lecturer at Wolverhampton University, Central St Martins and North East Wales Institute.

Gayle and Tavs are both members of The Autonomatic Research Group at Falmouth University, UK. This research group is widely recognized for pioneering research into the use of emerging digital design and fabrication technologies in craft and design practice. www.autonomatic.org.uk