Computational Slip Casting: Navigating Clay Practices within Digital Fabrication

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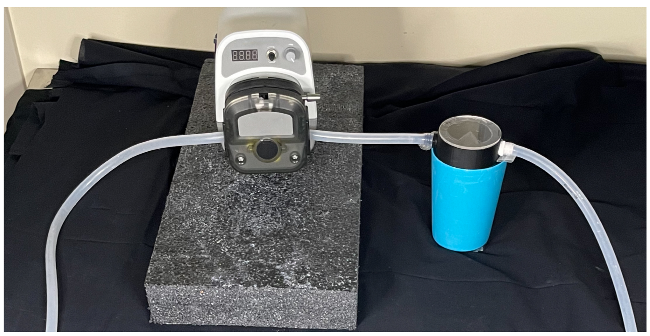

Figure 1: Computational Slip Casting System that includes the peristaltic pump and low pulsation dampener.

Introduction

Working with clay in makerspaces is an exciting new frontier, especially for supporting the aesthetic and functional forms found within ceramics. Despite advancements in clay 3D printing, the adoption of clay-based practices within makerspaces remains problematic. In this poster, we introduce a novel computational slip casting technique using peristaltic pumps and describe our method for developing the technique for adapting craft practices. We describe the challenges in navigating slip composition, adjusting for pump pulsation, facilitating slip dispensation and drainage. We demonstrate a set of computational routines for controlling the thickness of shell geometries. Our work adds to efforts to understand relationships between traditional skills and digital fabrication and discusses principles for designing makerspace-friendly clay fabrication techniques.

Background

The field of digital ceramics fabrication is in a constant state of evolution, with innovative methods such as clay 3D printing [2], robotic ceramic manufacturing [3], and clay extrusion systems [2] being developed by researchers. These methodologies automate the ceramic production process, resulting in intricate designs and details achieved through the hand coil technique. While numerous strategies are being explored to improve the efficiency, accuracy, and versatility of ceramic fabrication, the steps of preparing, drying, and post-processing clay for fabrication present substantial hurdles in a makerspace. Slip casting, in contrast, is a technique used to mass produce ceramic forms.Working with clay slip offers favorable advantages for the makerspace community due to its low maintenance, ease of cleaning, and straightforward preparation process within the makerspace.

Computational Slip Casting System

Slip casting involves dispensing a liquid-like clay known as slip into a plaster mold. The plaster mold's porousness triggers a capillary effect which eliminates the liquid from the slip, leaving behind a perfectly formed cake [1]. When timed correctly, the slip is then poured out from the mold to leave behind a shell geometry common to ceramic forms.

Method

Our work explores how to port over slip casting as a traditional ceramics technique to function within a digital fabrication workflow. As a precondition of our method, we make the assumption that the plaster mold has already been designed using traditional mold methods or leveraging computationally designed molds. Our system (Fig 1) incorporates an automated casting method that uses a peristaltic pump to dispense and drain slip into a pre-fabricated mold. This pump was chosen for its gentle and precise pumping action, adjustable pumping rates, and its ability to pump material with zero contact with material and electronic components. However, several challenges and insights in navigating traditional slip casting shaped the design of our functional slip casting system.

Navigating Slip Composition

The composition of the slip strongly influences the rate of material flow within the system. Slip is prepared through a specific blend of dry clay, water, and deflocculants. Deflocculants, like sodium silicate, aid in minimizing the suspension of clay particles (which form the 'cake'), subsequently decreasing the clay's viscosity. This process is critical to the system's operation as excessively high viscosity will prevent the dispensation and drainage of the slip. To ensure the ideal slip composition, it is reasonable to maintain a ratio of 40 parts water, 60 parts dry clay, and 0.25 part deflocculant [4]. We offer a clear and accessible guide to ensure precise slip preparation.

Reducing Pump Pulsation

The pulsation of the peristaltic pump causes an interval fluid flow, which is not ideal for slip casting. As a contribution, we have created a low pulsation dampener that creates a trapped air pocket in the tubing from the peak of the dampener(Fig. 2), resulting in a smoother fluid flow. This makes the peristaltic pump more compatible with the digital fabrication of slip casting.

Figure 2: Low Pulsation Dampener for peristaltic pump to produce smoother fluid flow to the system

Facilitating Slip Drainage

In the process of draining slip, we encountered a difficulty when the vacuum from the pump tubing began to distort the base of the cast if attention was not maintained during draining. As a resolution for this challenge, we developed a unique drainage nozzle adapter using OpenSCAD. The adapter(Fig. 3) is designed with a flat tip, allowing the tubing to firmly fit into the mold. We incorporated holes on the side of the adaptor to further enhance the drainage process. This design facilitates the extraction of slip from the mold without causing any deformation.

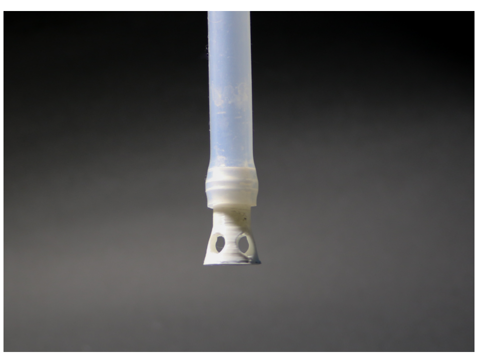

Figure 3: Drainage Tube Adaptor to prevent artifact deformation

Computational Slip casting

To demonstrate dimensions of computational design enabled with our system, we report results from two computational slip casting routines(Fig. 4).

- **Phased Outflow Slip Casting (POC)**. In this routine, a plaster mold was fully filled and then different volumes of slip were drained over time. This resulted in wall geometries that were thicker at the base versus the lip of the form, however this introduce drip artifacts in the final forms.
- **Phased Inflow Slip Casting (PIC).** In this routine, different volumes of slip were dispensed into a plaster mold over time, and then fully drained at once. This resulted in similar geometries as POC, but mitigated the drip artifacts.

Our experiments indicate POC is a useful technique for color slip casting to achieve unique aesthetic forms, while PIC is more appropriate for controlling wall thickness.

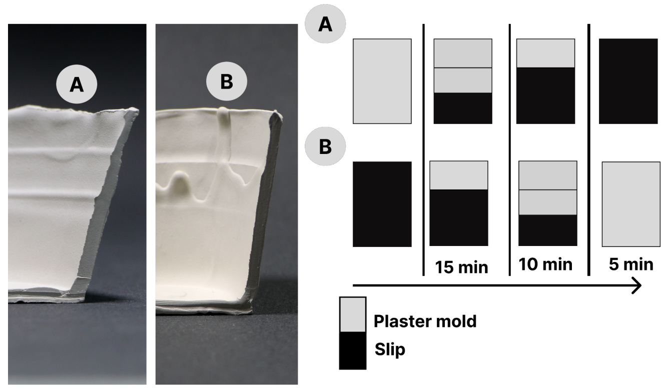

Figure 4: Additive manufacturing featuring various levels of dispensing markers within an artifact (A) using phased outflow casting (B)and phased inflow casting.

Discussion

Working with clay necessitates comprehensive considerations encompassing material preparation, maintenance, and storage or reclaiming processes. Our study demonstrated that clay practices go beyond mere physical interactions with solid clay, and can be harnessed in more flexible forms. Utilizing slip, we could employ liquid handling techniques for easier preparation and reclaiming. The technique presented introduces a new category of fabrication techniques – batch production. Despite makerspaces being well-suited for bespoke solutions, supporting manufacturing-oriented thinking remains critical. Slip casting not only offers insights into design decisions for scalability but also provides a fresh perspective on batch production in personal fabrication workflows.

Conclusion

Our research highlights that clay practices extend beyond engagements with solid clay and can be explored in more adaptable forms. We presented two computational slip casting techniques that demonstrate fine-grain control of wall thickness. By using slip, liquid handling techniques can simplify preparation and improvement. Slip casting provides not just insights into scalable design decisions, but also reimagines batch production within individual fabrication workflows within maker spaces. This necessitates systems that support makers' material literacy, fostering their ability to work seamlessly and creatively with various materials.

Acknowledgements

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