Exercises in Plasticity: Retooling the Mold

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With the widespread availability of numerically controlled manufacture, design at all scales increasingly relies on countless, mass customized parts. These parts often respond to digital parameters more readily than to material parameters. Design is therefore increasingly responsive to technology rather than tradition. The following design research project attempts to combine tradition and technology in order to study the problem of seriality. The project combines craft traditions with digital techniques to explore a plasticity of parts and their impact on the conventions of material assembly or the making of larger wholes.

Despite the promise of rapid prototyping technologies, casting continues to produce three-dimensional copies more quickly, economically, and durably than rapid prototyping.[1] Beyond the known advantages of serial production, such as the interchangeability of standardized parts and the durability of continuous surfaces, casting, and its required tooling have received little academic attention despite their central roles in the production of seriality. Tooling refers to the mold used to produce copies of components or objects. When reconsidered in light of computation, the mold offers opportunities to rethink seriality through the introduction of plasticity.

The digital turn at the close of the twentieth century introduced two different models of part to whole. The first with its exploration of parametric design and scripting attempts to maintain visual coherence by preserving the dominant features of a part while changing its scale or orientation. This produces continuity with difference,

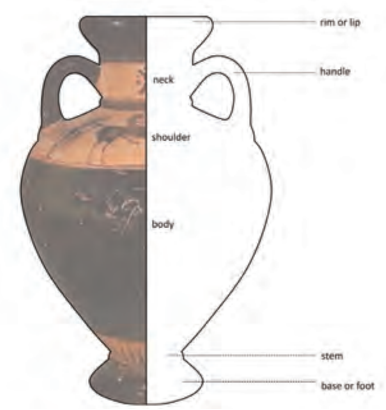

Figure 1: Greek Vessel Features

where continuity is primarily visual and difference characterizes the production, detailing, and resources associated with physical manufacture. The second attempts to recuperate some of the optimization lost in the former by mixing identically repeated parts with a smaller percentage of bespoke parts. This reintroduces uniformity of parts in order to manage the economic and technical constraints of difference. The following research project proposes a third model that combines the material and the numeric, allowing parts to vary in kind rather than degree without disregarding the impact on resources of unrestrained difference. This variation is managed logistically and technically in order to generate both a conceptual and procedural approach to seriality. The technical constraints of manufacturing are studied prior to the conceptual development of the project, allowing innovation of means to directly shape design ambition. The work proposes that non-unifrom seriality can spawn families of objects, allowing the study of variation to initiate new object lineages.

In the design seminar course after which this paper is named, graduate students in architecture and media arts at UCLA studied the relationship of cast vessel forms to their mold making logics. The course, co-taught with Noa P. Kaplan, asked students to reconsider the relationship of part to whole in the design of a vessel as both object and series. Central to this work was our shared interest in the formal, material, and technical parameters that configure vessels. Specifically, we were interested in understanding the influence of mold making on Western vessel forms.

We wondered if we might examine the problem of the mold as a way of bringing together tradition and technology. Here, the vessel is neither a high-volume, identically reproduced object nor a singular, handcrafted artifact. Instead, we approached the vessel with plasticity in mind. Plasticity refers to the capacity of a form to reflect the myriad of conditions under which it takes shape. These conditions may be material or abstract and are informed by historical and contemporary technologies. We wondered if plasticity might reinvigorate the status of the object as object series. By comparing one object to another in the same family, one discovers the ambitions of a given design proposal.

We studied casting processes and tooling constraints that influence the configurations of mass-produced vessels. *Tooling* refers to the manufacturing elements necessary for production. With casting processes, this includes one, two, or multiple part molds. A *mold* is defined as a fixed or restrictive pattern or form, but historically, the mold has been strongly associated with the first descriptor: the rigid, unchanging container. We asked students to consider the role of responsiveness in the design of tooling in order to exploit the potential of the restrictive, yet variable dimension of the mold. In *casting*, a liquid suspension is poured into a tool or mold and undergoes a chemical reaction. Typically, the mold determines the form of the resulting solid. The design of the mold reflects numerous production constraints, including part removal, mold fabrication, and mold durability and lifespan.[2] Students were encouraged to explore the opportunity for the liquid suspension and the mold container to inform one another, a collaboration of skin and substance. Students developed the design of the tool alongside proposals for a series of vessels. Static molds were reconceived as *responsive molds* capable of adaptation and variation due to the use of a flexible or reconfigurable mold material or through the rearrangement of components into multiple forms. The resulting cast objects explore plasticity, creatively circumnavigating the rigidity and identical repetition of the mold.

Students studied the historical development of hand-built, thrown, and slip-cast ceramic forms to understand their formal components and the impact of material behavior and production techniques on vessel silhouette, features, and serial production. The typical components of early Greek vessel forms—the rim, neck, shoulder,

Figure 2: Vessel Prototypes, 2:4:12

Figure 3: Vessel Prototypes, 2:4:12

Figure 4: Vessel 1 of 5, Dark Opulence

Figure 5: Vessel 3 of 5, Dark Opulence

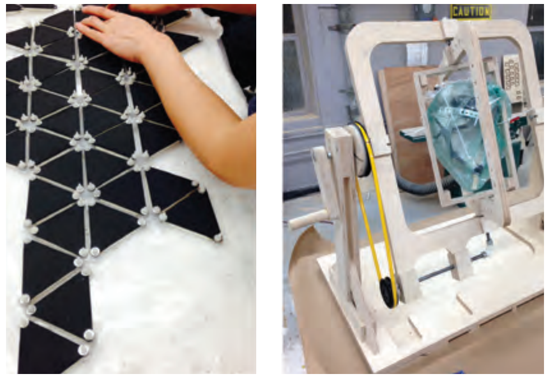

Figure 6: Developed Mold (L) and Rotational Casting Machine (R), Dark Opulence

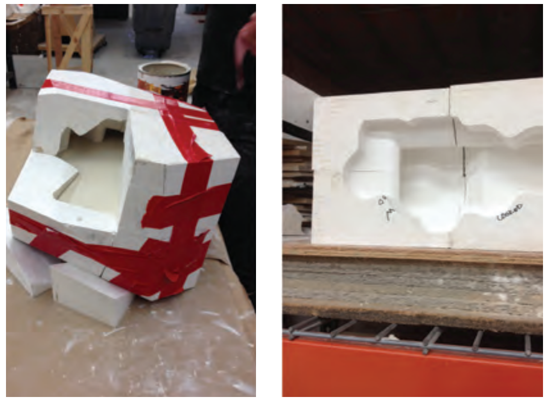

Figure 7: Eight-Part Tumbling Mold, Tumble

body, stem, and base—were studied to understand their morphological evolution in relation to function, ceremony, and classical aesthetics (fig. 1). A survey of contemporary vessels considered the relationship of morphology to material, craft, and industrial processes, and importantly, the technological mediation of material with mechanical and digital means.

Two lines of material exploration, slip cast ceramic materials and urethane resins, were explored to understand the relationship of mold to substance. The means and methods under investigation were the casting process and, specifically, the tooling necessary for production. Geometric constraints influence issues of part removal and mold fabrication. Following casting, the part must be removed from the mold. This requires each part of the mold to avoid undercuts or geometric features that will lock the part to the mold. Molds are fabricated by CNC machining, hand sculpted, or cast over solid patterns. These forms of fabrication exert their own geometric pressure on mold design, which is explored through the work. Responsiveness was produced using two- dimensional, developable molds or reconfigurable three-dimensional molds in order to introduce material behavior and technology to the abstract, formal expression of the vessel.

Each proposal is a series of cast vessels made using one innovative mold, designed as a responsive machine for serial production. The projects argue for design processes that encourage robust feedback between digital technology and material tradition. Through these exchanges, new vessel forms are conceived and produced in series. Identical reproduction is replaced with non-uniform seriality.

Two projects used a *developable mold* for the rotational casting of urethane vessels. A developable mold is a three-dimensional mold capable of unfolding or flattening to a two-dimensional surface and reconfiguring in three dimensions again. The project 2:4:12 critically engages the bilateral symmetry of vessel forms, producing asymmetrical sidedness while maintaining the bilateral part line associated with two-part casting. Four developable molds were designed as flat patterns using garment making techniques. Each pattern features a particular boundary condition and internal features to regulate surface area and distribution. The two-dimensional patterns were fabricated with darts to dynamically modify the mold's surface area and alter the silhouette of each half independently. These darts were activated manually using individual zippers in order to reuse each form without producing identical casts and facilitate mold removal from undercuts. The four molds were paired to produce 12 different primary vessels (fig. 3). Individual refinements to the molds produced further variations in each half, thus expanding the series into larger families of vessel forms. The primary part lines of the two-part molds register on the exterior as sharp lines in contrast to the curvilinear expression of the soft undulation produced by darting on either side (fig. 4). The project's use of a developable, two-part mold is an exercise in sidedness. Rather than conceiving of the object as a rotationally or bilaterally symmetrical form, each vessel has two distinct sides. When presented in elevation, the object reads as unified, while from other vantage points, the object's articulated part lines join two juxtaposed silhouettes.

The project Dark Opulence designed one developable mold of tessellated equilateral triangles that included four possible, three-dimensional configurations within it. The triangular cells of the unfolded pattern were identical, allowing any edge to be matched to every edge within the pattern. Depending on the folding instructions used, the mold configuration differs in volume and silhouette, and the resulting cast vessel changes in form, orientation, and relationship to the surface on which it rests (figs. 4 and 5). The matched edges were fastened together on the exterior, producing hard edges where folding closed the mold and leaving soft edges where the tessellated forms were continuous. Each reconfiguration of the mold produced a fully closed silicone bag into which urethane was rotationally cast (fig. 6). The mold was tied into an external skeleton to prevent collapse during rotation. Further, the developed mold was coated with powdered pigments that produced a gradient hue of black to burgundy. As in 2:4:12, the final cast is cut to define its rim and opening, revealing the variable wall thickness that results from its mechanical casting process. Rotational casting allows the vessel to depart decisively from the vertical axiality associated with thrown or cast vessels. The orientation of the vessel is not predetermined; rather, it emerges from the geometry and material distribution of each unique cast. A flat vessel base has been replaced by a series of sharp, distributed edges. These edges, a result of the reconfigurability of its mold, become the impossibly thin edges upon which the vessel delicately rests. Instead of determining an a priori vessel orientation, the vessel body settles into a relationship to the table that is dynamic, at once a factor of geometry and its specific center of gravity.

Figure 8: Vessel 2 of 5, Tumble

The next two projects explored the three-dimensional *reconfigurable mold*. In these projects, molds are produced in multiple parts that may be reoriented as individual parts or as an assembly. The first project, Tumble, explores orientation to both conform to, and undermine, production constraints. An eight-part mold is designed to tumble as an assembly, producing objects that refuse singular readings of orientation (fig. 7). Each mold part is machined from a different face such that when assembled, its tool paths and unique profiles purposefully misalign. While any given mold part complies with 3-axis machining limitations, the whole does not. These assembled rectangular molds are cut from the outside, producing a multifaceted polygonal whole. With the removal of one mold, porcelain slip is added to the remaining mold parts during casting. Reorientations of the mold are possible on each of its outside faces. The resulting series is similarly ungrounded (figs. 8 and 9). The artifacts of machining tumble around the vessel forms, making it difficult to relate these manufacturing side effects to a particular manufacturing process, or the vessel to a particular orientation.

Figure 9: Vessel 5 of 5, Tumble

The second project, Multibody, explores the mold as a kit of individual parts that may be assembled in numerous ways. The project challenges the unified expression associated with vessel bodies and the typical relationship of neck to vessel body. The vessel body is cut into quadrants. These quadrants receive a variety of mold parts and may stack up to three units high. The project treats the two resulting part lines as two independent faces that may or may not align. When the part line doubles and misaligns, the logic of mold assembly is directly expressed in the vessel. The stackable, reconfigurable parts challenge the dominance of the singular, rotationally symmetrical body of traditional vessel forms (fig. 10). The body of the vessel multiplies around its axis. As its parts are arrayed and reoriented, its silhouette is destabilized (fig. 11). Features start and stop abruptly, and the vessel's silhouette varies in the round. The body of each vessel bifurcates, multiplies, and separates, conflating body and neck and inside and out.

The last project, Static Variability, investigates fluid dynamics across a topographic surface with a specially designed one-part, open mold. The mold surface is

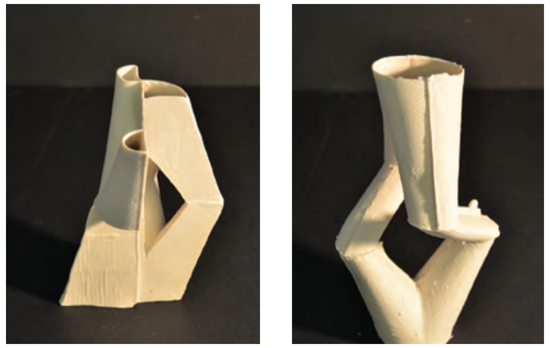

Figure 10: Vessel 2 of 8 and Vessel 1 of 8, Multibody

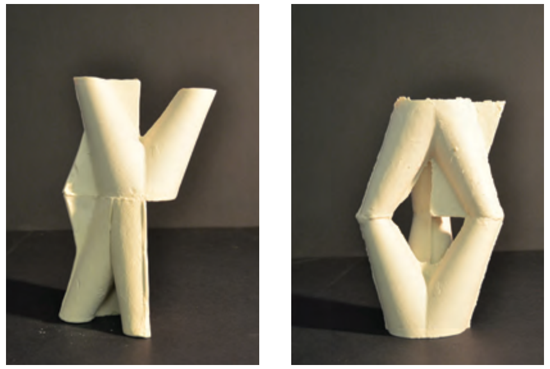

Figure 11: Vessel 6 of 8 and Vessel 3 of 8, Multibody

initially defined by a series of two-dimensional, closed contours that describe a field of nine concave chambers. These chambers are flexible units that produce a wide variety of vessel forms, featuring one or multiple aggregated units. The design ingenuity is in the relationship of these units, and the topographic surface in which they reside, to fluid dynamics. The design of the mold choreographs the flow of porcelain clip across the mold's surface, following multiple trajectories and originating at several fill origins (fig. 12). In slip casting, the flow of material may not stop during mold filling, or traces of this discontinuity remain in the vessel surface. Embracing this constraint, the mold was refined to channel fluids from unit to unit as the level of the slip rises. In addition, the contours are varied one above the next to produce flared rims at different levels of the mold. This allows vessels in the series to have a variety of depths, side wall inclinations, rim widths, and configurations (fig. 13). One-part, open molds typically result in simple vessel typologies such as platters, plates, bowls, or cups. By studying the geometric definitions of body and rim, this project incorporates the potential for many vessel forms in one ingenious mold. Nearly 30 vessels of varying size, shape, and configuration were made in order to argue for the mold as a site of design research.

This body of work attempts to make the case that high and low technologies, when carefully and thoughtfully combined, not only escape the aesthetic limitations of individual tools but also support robust material experiments. When adopting an agnostic rather than technophilic or positivist relationship to technology, one can visit problems of design with new sensibilities and more comprehensive expertise. As noted by Moma's Senior Curator of Architecture and Design Paola Antonelli in the exhibition catalog *Mutant Materials*, "Today, very high technology can coexist in peaceful synergy with very low technology."[3] Contemporary technology and the technologies of craft, taken together, afford a plasticity to objects that allows us to revisit the conventions of design, establishing new relationships between part and whole, one and many, and the object and ourselves.

ENDNOTES

1. Jim Lesko, *Industrial Design: Materials and Manufacturing Guide* (New York: John Wiley & Sons, 1999), 141–42

2. Ibid., 23–24.

3. Paola Antonelli, *Mutant Materials in Contemporary Design* (New York: Museum of Modern Art, 1995).

IMAGE CREDITS

All project images are credited to respective students (see below), except for Figure 1, credited to Roberge, Heather.

STUDENT WORK

2:4:12 by Ciro Dimson, Angel Gonzalez, and Camella DaEun Kim

Dark Opulence by Fuk Man (Fei) Mui, Kara Moore, and Alex Rickett

Tumble by Andrew Akins, Miguel Nobrega, and Emma Price

Multibody by John Brumley, Sarah Johnson, and Corliss Ng

Static Variability by Julieta Gil, Jazzy Lin, and Jeff Rauch

DESIGN SEMINAR CREDITS

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Figure 12: One-Part Topographic Mold, Static Variability

Figure 13: Vessel Prototypes, Static Variability