Application Brief

Silicone Part Production with 3D Printed Eggshell Molds

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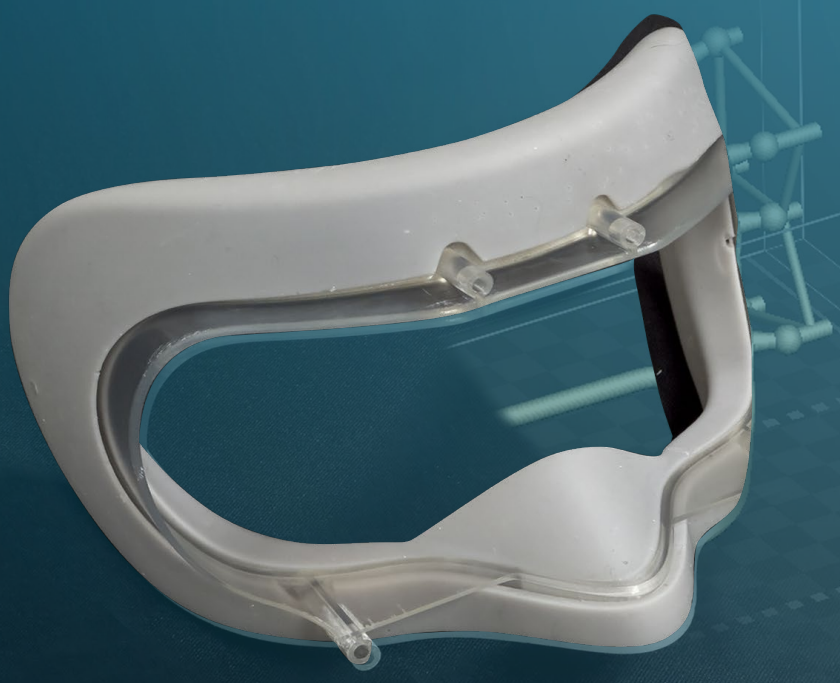
Advanced Applications Engineer



3D SYSTEMS
Additive Manufacturing Solutions

Introduction

Eggshell molding is a sacrificial manufacturing technique that uses 3D printing to produce a thin, single-use mold that is injected with the final production material and then broken away. Also known as digital silicone tooling, this technique enables the production of true silicone and rubber parts without expensive metal tooling and with faster product development times. Our 3D printing solutions produce resin-based eggshell molds with high accuracy and speed. They enable the quick turnaround of a variety of silicone parts, including geometries that are traditionally impossible to make with tooling.

Key challenges

CONSISTENT QUALITY FOR ALL DESIGNS

3D printed eggshell molds resolve common limitations to deliver part performance and perfect surfaces in any silicone. This process reduces material usage relative to other injection molding techniques that use 3D printing while also alleviating the challenges of direct 3D printing with elastomeric materials, such as support scarring.

FLEXIBILITY

Budget constraints often restrict the ability of design teams to effectively iterate complex designs with metal tooling. The material efficiency of eggshell molding makes it possible to 3D print multiple molds that you can inject different materials into, to test more designs, more cost-effectively.

TIME-TO-MARKET

Producing functional silicone parts with a fast turnaround increases development speed.

Silicones are the most commonly used materials for commercial and medical applications.

Uses and examples

- Wearable technology
- Sporting goods
- Footwear
- Bath/kitchen appliances
- Medical simulation models

The quality, flexibility and speed of 3D Systems' plastic 3D printing solutions

Traditionally making silicone parts is an expensive and time-intensive process. Although metal or plastic tooling can deliver excellent results, it often requires longer lead times and more material, without allowing for flexible iteration during product development.

Modern part design with digital tools and 3D printing completely disrupts the tooling status quo. The ability to easily produce elastomeric parts with additive manufacturing pushes the limits of design creativity and enables all-new levels of responsiveness, with uncompromised quality.

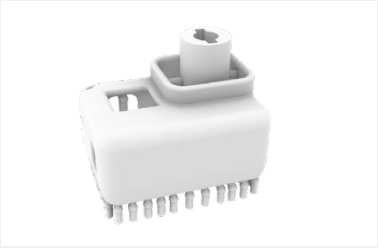
3D Systems' plastic 3D printing solutions for eggshell molding, including the ProJet® MJP 2500 Plus, Figure 4® and SLA systems, can produce functional end-use silicone parts that allow your company to be more effective with its product development schedule, to enable:

- Same-day 100% silicone parts production to accelerate design iteration and end-use validation
- Molding of extremely challenging details, like anatomy, texture and fine features
- Cost-effective iteration and production of all elastomeric parts
- Improved final product fit and performance

Digital silicone tooling - workflow solution and best practices

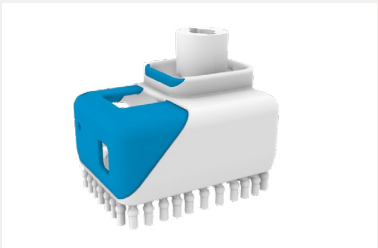
1. DIGITAL 3D PART DESIGN

2. EGGSHELL MOLD CREATION

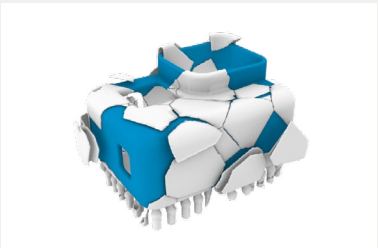


3. EGGSHELL MOLD 3D PRINTING

4. SILICONE INJECTION



5. EGGSHELL MOLD BREAKOUT



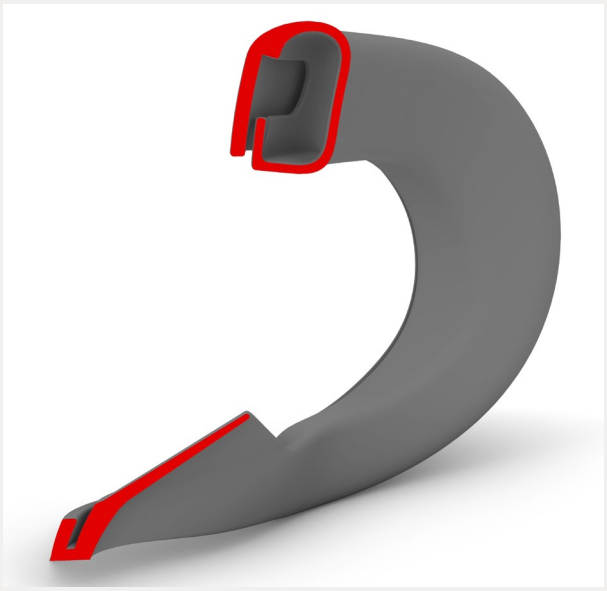
6. FINAL FINISHING AND VALIDATION

DIGITAL PART DESIGN

As you design your part, consider which technology will be most suitable for producing the eggshell mold. Does your part have large undercuts, trapped volumes or internal cavities?

For SLA and Figure 4 3D printing solutions, consider how to best orient the part on the build platform. The ideal orientation allows for easy draining of trapped material during printing or post-processing. If the part doesn't drain during printing on Figure 4, the suction force can cause the part walls to cave in and lead to undesirable part defects.

When using MultiJet Printing (MJP) technology for eggshell molds, consider how to drain the internally-trapped wax once melted. Make sure to have drain holes and vent holes to allow for airflow.



EGGSHELL MOLD CREATION

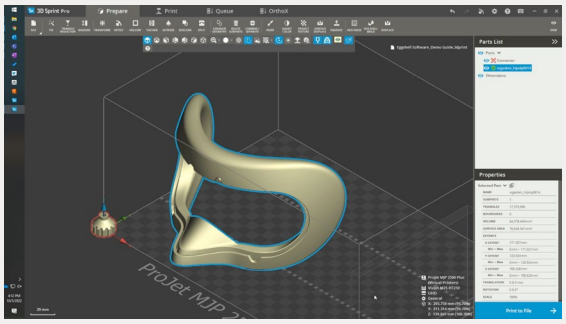
Mesh Import Settings

Surface tolerance: 0.01mm

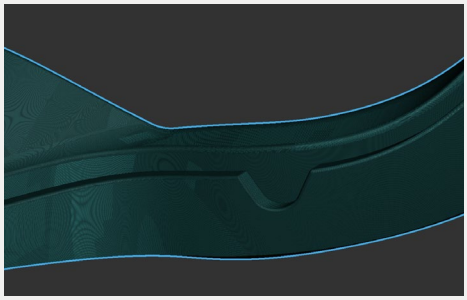
Maximum edge length: 0.2mm

Stitch: 0.1mm

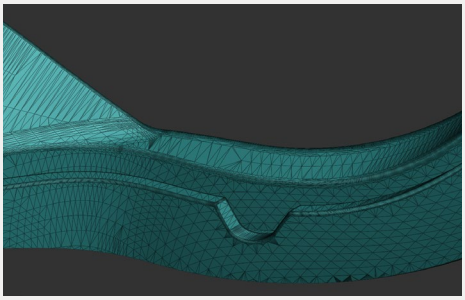
1. IMPORT PART AND CONNECTOR



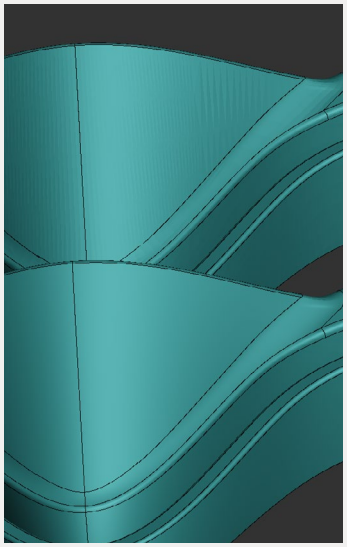
Use the high resolution import settings to preserve small and thin features and avoid features becoming faceted or over-simplified. This is ideal for parts with any kind of curvature, whether simple or compound.



High resolution

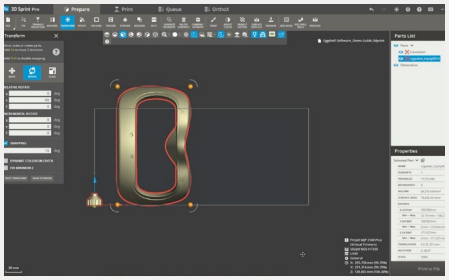


Standard resolution



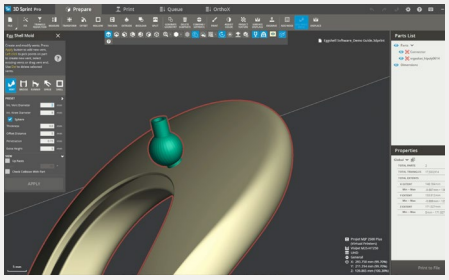
Standard resolution (top) versus high resolution (bottom)

2. PART ORIENTATION



Once the part is imported, consider the orientation for draining out the support wax when 3D printing using MJP technology.

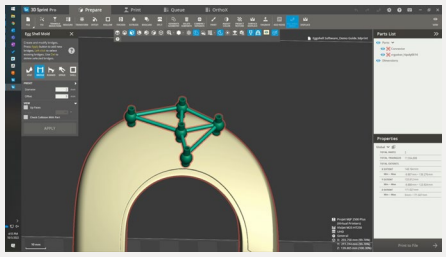
3. VENTS, BRIDGES AND RUNNER PLACEMENT



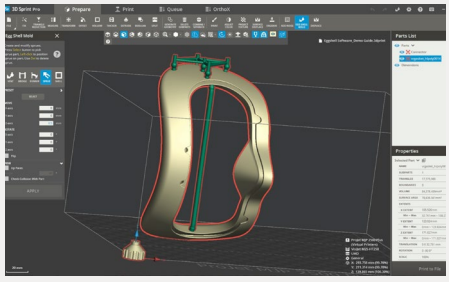
When placing vents and runners, be aware of critical surfaces and take into consideration that the mold will be placed inverted during the cleaning process.

Place vents where air will naturally become trapped. Consider thin and long features, as well as cantilevered features.

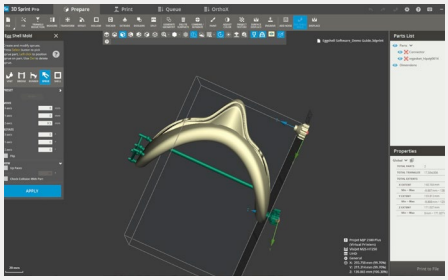
Once the vents are placed, you can generate the bridges.



Place the runner between the two inside faces of the part to allow for the silicone to reach the inside of the other side of the part more easily.

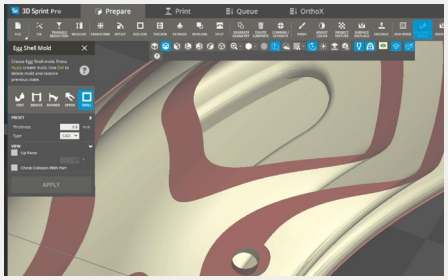


4. SPRUE PLACEMENT



Position injection sprue in areas that are easy to access and hold. This placement should also allow for fluids to drain easily.

5. EGGSHELL MOLD GENERATION AND INSPECTION



The 3D printing technology you select impacts part offsetting. For SLA and Figure 4, you can print eggshell molds with a wall thickness down to 0.3mm. For MJP, we recommend printing the part with at least a 0.8mm wall thickness. Using additional reinforcement like structural ribbing or lattice supports is useful for parts with internal cavities or large surfaces that are flat or undulating.

Use the Z clipping point tool to inspect the vents and the eggshell to ensure it has been generated properly.

EGGSHELL MOLD 3D PRINTING

Our SLA, Figure 4 and MJP eggshell molding solutions can scale and print as many or as few eggshell molds as needed for development or limited production.

For parts with limited geometric complexity, we suggest SLA or Figure 4. The speed and material efficiency of these systems enable part production within 24 hours.

For parts with greater complexity, with features like grooves, undercuts and internal cavities, we suggest our MJP platform, which prints with a wax support that can be melted and drained away.

POST-PROCESSING

SLA and Figure 4 3D printed eggshell molds can be post-processed with isopropyl alcohol and air drying. Avoid exposing printed molds to isopropyl alcohol for more than five minutes. This can over-dry the mold and lead to cracking. Any resulting hairline cracks will be noticeable in molded parts. Use a squeeze or spray bottle with isopropyl alcohol to flush out residual resin in the mold and air dry any trapped residual solvent. Your mold is fully clean when there are no spots of shiny residue or trapped fluids.

Post-process MJP 3D printed eggshell molds with a lab oven set to 70°C. Make sure to use a temperature-controlled oven as the wax may begin to smoke at higher temperatures. Melting supports in a vat of already molten wax can help speed up the melting process, but take care to not overfill the container. During the draining process, after the initial bulk drainage, you may need to roll the part around to drain trapped volumes. To fully drain trapped wax from vents in the eggshell mold, invert the mold on top of some paper towels in the oven.

SILICONE INJECTION

Any off-the-shelf silicone products can be used for injection. After manual mixing and vacuum degassing, backfill the silicone into a syringe or a preloaded injectable cartridge with the mixing canula. If you are using a custom connector, you can 3D print adapters to modify your injection tools. Alternatively, print your injection sprue using a pre-existing connector to establish a secure and stable seal for easy injection of the material. Most silicones can be hand injected; only firmer shores (above 60A) will require assisted mechanical force.

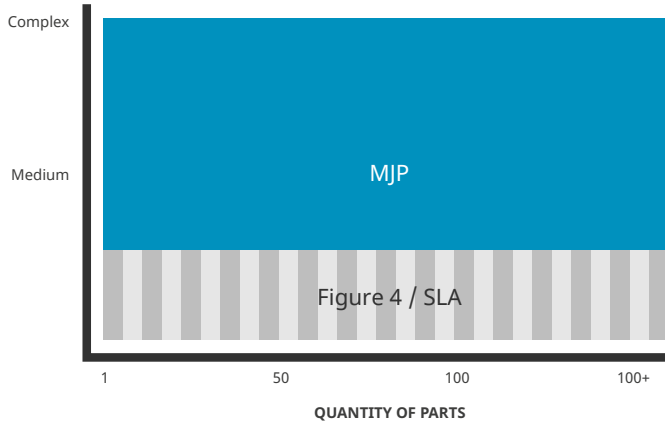
EGGSHELL MOLD BREAKOUT

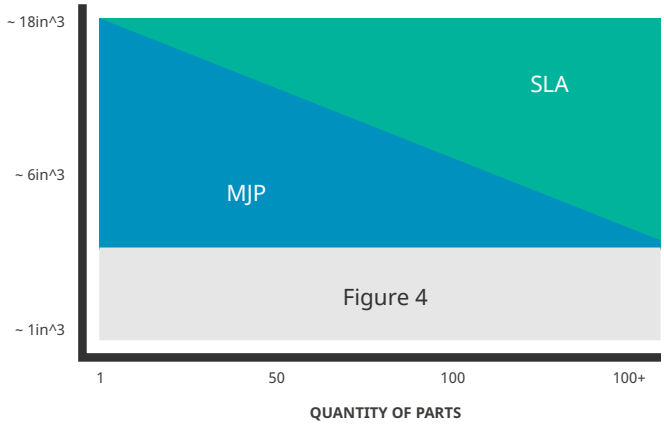
Demolding an eggshell mold is exactly like removing the shell from a hardboiled egg. Removing the mold under running water helps peel the mold shards away from the part surface. Place a strainer in your sink or remove the mold into a bucket to prevent plastic debris from flowing into your plumbing. Once the eggshell mold has been removed, you can use a razor blade or flat trim cutter to remove the sprue and vent spots.

Solutions

Printers	Materials	Software	Appliances and accessories
ProJet® MJP 2500 Plus ProJet® 6000 HD, ProJet 7000 HD SLA printers Figure 4® Standalone, Modular and Production	VisiJet® M2S-HT250 (MJP) VisiJet® M2S-HT90 (MJP) Accura® 60 (SLA) Figure 4® HI TEMP 300-AMB (Figure 4) Figure 4® EGGSHELL-AMB 10 (Figure 4)	3D Sprint® is an advanced, single-interface software for intuitive file preparation, editing, printing and management. It also includes a set of tools to easily create eggshell molds.	Vacuum chamber Caulking gun Syringe Lab oven with temperature control (for MJP parts) UV curing unit for SLA and Figure 4 parts Plastic tubs Mixing auger

Solutions Comparison





What's Next?

Learn more about 3D Systems' silicone part production with 3D printed eggshell molds

Talk to our experts.

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