Alternative Methods of Prototyping Liquid Silicone Parts

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Silicone Prototyping

- What are we trying to achieve?
  - Concept Pitch
  - Feasibility
  - Design testing fit, form, and function
  - Clinical trials
- What scale – 1, 10, 1000, 10000, etc parts?
- What time frame – 1 to 5 days, a few weeks, months?
- What materials are you considering?
- What is the budget?
Materials and Prototyping: LSR

- LSR – Liquid Silicone Rubber is Injection and compression friendly
- Applications
  - Strain reliefs, gaskets, seals, diaphragms.
  - Thermal/electrical insulators
- Viscosity is low but properties are middle range.
Materials and Prototyping: HCR

- HCR - High Consistency Rubber
- Highest viscosity
- High Mechanical Properties
  - High tear strength
    - Low elongation.
  - High modulus
  - Good compression set
- Applications
  - Valves, strain reliefs, Gaskets, and seals
Materials and Prototyping: RTV

- RTV – Room Temperature Vulcanization
- Low temperature cure, some as low as room temperature.
- Low viscosity and many are pourable.
- Wide range of mechanical properties
  - Can have high optical clarity
- Applications
  - Coating/encapsulating heat sensitive electronics
  - Pourable molding and casting
Compression Molding

- Material is displaced and compressed to create the geometry.
- Cycle time 2-15 minutes depending on complexity of mold and material cure characteristics.
- Rapid material changes and cleaning.
- Simpler construction that can be easier to modify.
- Operator intensive.
Transfer Molding

- Slug is compressed by mold action and transferred into cavity
- Shot size control by weight or fluid dispenser
- Most practical for HCR or thicker LSRs
Prototyping Comparison
3D Printing

- Print layer by layer a mold or part using 3D plastic printer
- Applications
  - Conceptualizing
  - Visual Aids
  - Fixtures
  - Castings
3D Printing Advantages

- Fast
- Inexpensive to build
- Undercuts can be build directly in
- Perform a basic fit and present 3D concepts
3D Printing Disadvantages

- Material may not represent end material. Limited to RTV and LSR materials.
- Dimensional accuracy +/- 0.01 inches or more.
- Excessive flash
- Surface quality is limited by the printer resolution 0.003-0.015 inches.
- Short tool life (1-10 parts)
- Long cycle time (>15min)
  - General purpose 40 durometer LSR at 240 for 30 minutes.
Compression Mold Aluminum

- Tool is machined from aluminum. Shut offs are fit. Dimensions are consistent with design intent.
Compression Molding: Advantages

• Advantages
  – Rapid turnaround (building, setting up, and processing)
  – Part can be made of design materials that represent the end product
  – Rapid material changes
  – Rapid changes to mold such as surface finish.
  – Cost beneficial.

Finish:
- No Cutter Marks
- Sand Blast
Compression Molding Disadvantages

- Disadvantages
  - Cycle time (2-15min) depending on material
  - Part cost
  - Limited number of cycles (1-5,000+).
  - May not represent production process.
  - Flash may be harder to control then injection molding

Magnified edge
Compression Steel vs. Aluminum Mold

- Advantages of steel vs. Aluminum
  - Steel has greater wear resistance.
  - Greater resistance to damage.
  - More overall cycles
  - Often preferred for Implantable

- Advantages of Aluminum vs. Steel
  - Weight decreased.
  - Faster machining and finishing of mold.
  - Cost
Injection Molding

- Faster production rate (10-60 seconds)
- Machine cycle controls can be automated.
- Molds are more complex.
- Significant time required to change materials, clean, and process in.
- Can cut cavity inserts to use in a shoe or MUD frame

- Steel vs. Aluminum – production quantity, strength, durability, and cost.
- Steel is preferred because silicone is very abrasive.
Prototype Injection Mold: Advantages

• Greater tool life.
  – (1000s-10,000s-100,000s)

• Increase production rate
  – (10-60 sec)

• Test part parting line, injection location, and handling processes.

• Develop manufacturing processes and procedures for operators.

• Build quantities of parts to transition into production line startup
Prototype Injection Mold: Disadvantages

- Greater complexity and cost to build tool compared to compression molding for lower quantities of parts.
- Over-molding and complex cores require actions or provisions for operators.
- More time to setup – die setting and processing.
- Slower material changes
  - Purge
  - Clean barrel, screw, and switch lines
Prototype Production Tool

- Tool represents final process with gating or cold deck and part removal such as robot, sweeper or compressed air.

- Advantages
  - Greater production rate
  - Validate production process

- Disadvantages
  - Greatest initial cost
  - Requires greater lead times

Valve Gated
Questions