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Real Parts. Really Fast.™

How to Effectively Move from 3D Printing to Injection Molding

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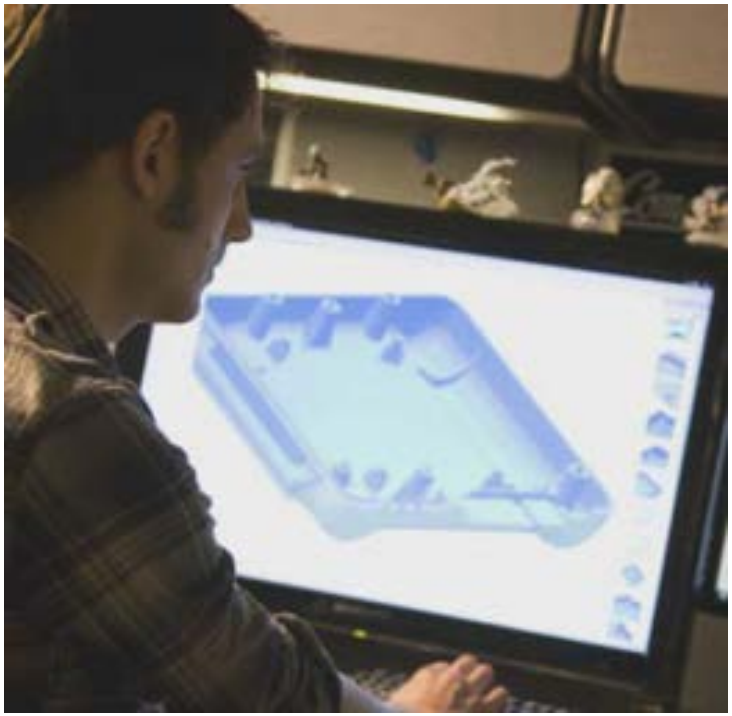
Overview

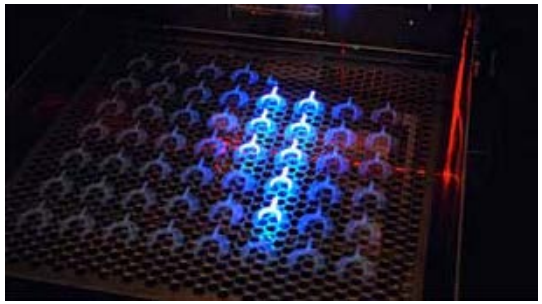
- 3D Printing
- CNC Machining
- Injection Molding
- Design Considerations for Injection Molding
  - Uniform Wall Thickness
  - Draft
  - Resin Characteristics
- Rapid Manufacturing at Proto Labs



What types of 3D printing do you utilize?

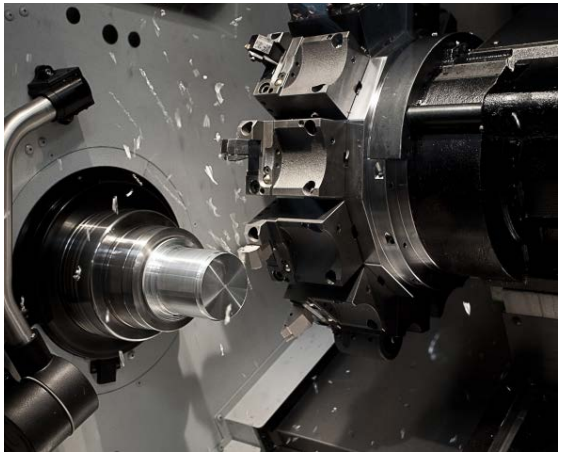
3D Printing

- **Fused Deposition Modeling (FDM)**
  - ABS, nylon, PEI (Ultem®)-like materials
  - Feature size down to 0.014 in.
- **Stereolithography (SL)**
  - UV-cured to solidify the material
  - Feature size down to 0.002 in.
  - ABS-, PC- and PP-like materials
  - Material can be clear and even mimic metal
- **Selective Laser Sintering (SLS)**
  - Feature size down to 0.022 in.
  - Nylon-like materials
  - Strong, impact resistant and high temperature
- **Direct Metal Laser Sintering (DMLS)**
  - Heat-treat cycle may be required
  - Exceed 98 percent density
  - Feature size down to 0.006 in.
  - Stainless steel, titanium and aluminum

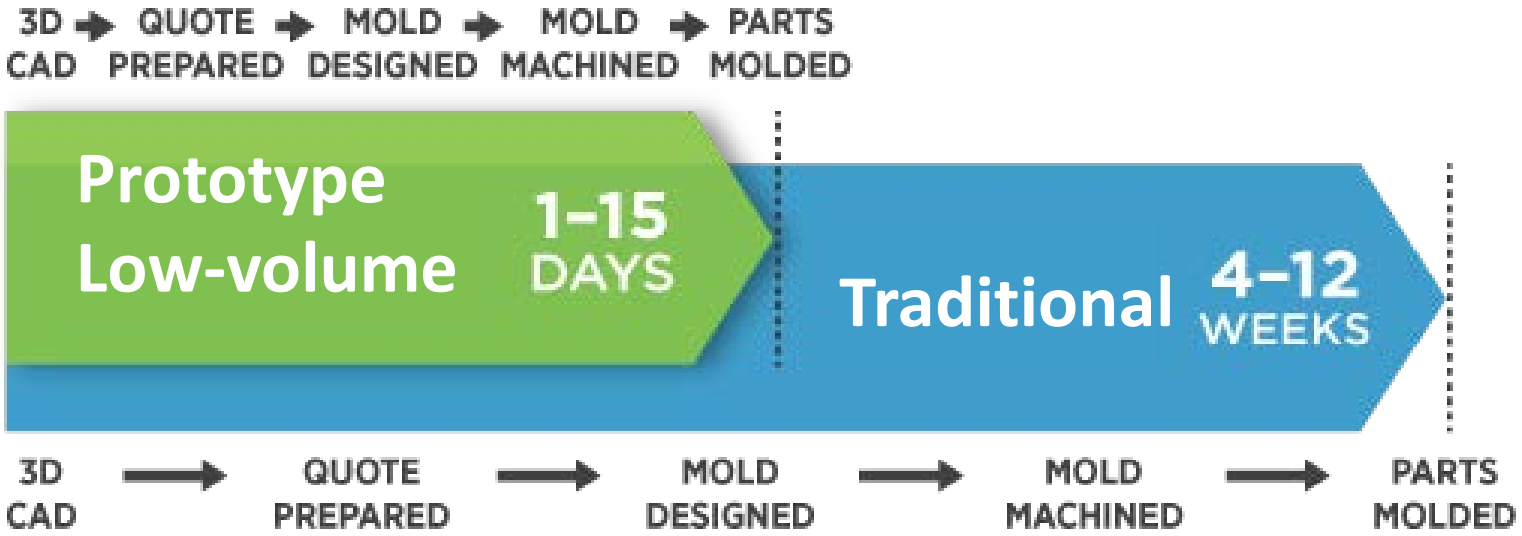


CNC Machining

- **Milling and Turning**
  - Three-axis milling
  - Lathe with live tooling
- **Improved material selection**
  - Engineering-grade thermoplastics
  - Hard and soft metals
- **Improved part functionality**
- **Improved tolerances**
- **Near molded quality**
- **Great for form, fit and function of prototypes**
- **Jigs and fixtures**
- **One-off parts**
- **Functional, end-use production parts**



How many people utilize prototype or low-volume injection molds vs traditional molds?



Injection Molding

- **Thermoplastic Injection Molding**
  - Materials are endless
  - Complex geometry can be achieved but limited to capabilities

- **Thermoset Liquid Silicone Rubber (LSR) Molding**
  - Extremely stable and flexible materials available
  - Complex parts can be produced
  - Improved optical properties, impact resistance, chemical resistance, electrical and temperature exposure over traditional rubber

- **Metal Injection Molding (MIM)**
  - 97 percent dense metal
  - Requires debinding and sintering process
  - Steel and stainless steel is available
  - Used widely in the medical and firearm industry where small parts are required for high production of parts

- **Magnesium Thixomolding**
  - Strong yet extremely lightweight compared to other metals
  - Used widely in computers and aerospace where weight is a concern

Designing for 3D Printing and Injection Molding

3D Printing

- Part design considerations can be endless
- No draft considerations
- Little undercut concern
- Thick and thin parts have few concerns
- Wall thickness considerations based on resolution
- Minimal materials, may sacrifice qualifications or functional requirements
- Surface finish can be compromised without secondary process

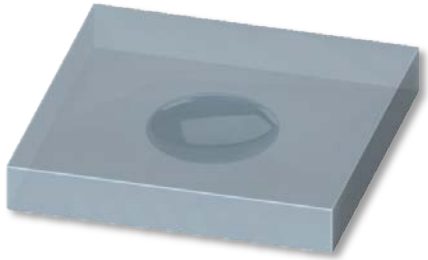
Injection Molding

- Manufacturing needs to be involved
- Draft is required to be molded
- Undercuts need to be considered
- Thick and thin parts can be concerns
- Wall thickness considerations based on material and geometry
- Limitless materials, can obtain actual material intended for qualifying material
- Parts are high quality with little to no secondary processes required

Uniform Wall Thickness

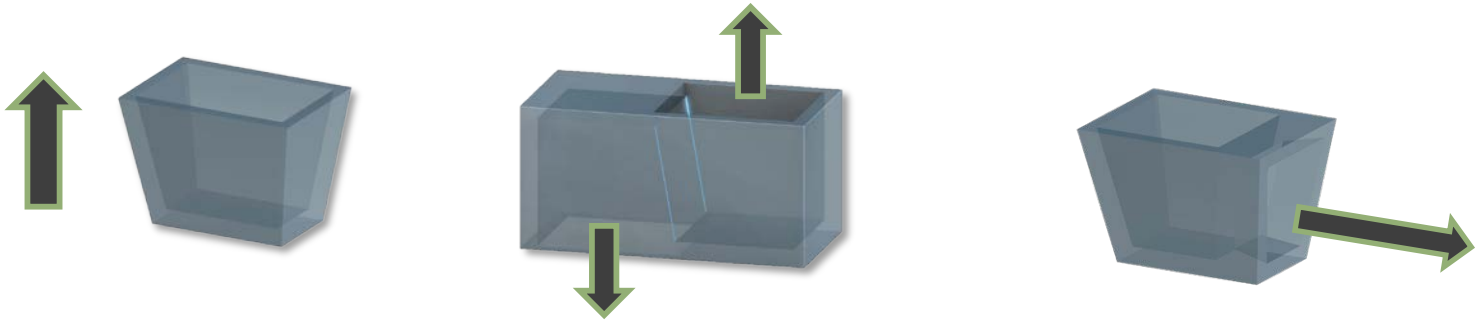
- **Know material properties before molding**
- **Design uniform wall thickness and use 50 to 60 percent wall thickness on perpendicular walls**
- **Avoid thin and thick areas**
- **Use adequate coring and ribbing**
- **These are great ways to remove:**

  - Sink
  - Warp
  - Flow or splay lines
  - Weak knit lines
  - High molding pressure
  - Voids
  - Shadowing
  - Incomplete fill
  - Venting concerns
  - Difficult gating



Draft

- **Proper draft ensures that the part surface and mold surface will draw apart instead of being dragged across one another during ejection**



- **The required degree of draft needed to avoid damage depends on a variety of factors including height, location and surface texture of the feature**
- **Draft is almost always required for surfaces that are in the direction of mold opening**
- **In parts with cam-driven side-actions, draft is also required for surfaces in the direction of cam action**
- **Shutoffs that are in the direction of mold or cam opening require draft as well**

Resin Characteristics

- **Important characteristics to consider when selecting a material:**
  - Strength
  - Stiffness
  - Impact resistance
  - Chemical resistance
  - Temperature
- **Characteristics to consider in design process:**
  - Warp
  - Sink
  - Void
  - Distorted shapes
  - Part thickness
  - Part complexity

Resin Characteristics

		Mechanical properties			Moldability characteristics						
Resin generic name	Some brand names	Strength	Impact resistance	High temp. strength	Warp and dimen-sional accuracy, molded	Fills small features	Voids in thick sections	Sink in thick sections	Flash	High temp. hard on mold & ejectors	Relative cost
Acetal	Delrin, Celcon	Medium	Medium	Medium-Low	Fair	Fair	Poor	Good	Good	Fair	Medium
Nylon 6/6	Zytel	Medium	High	Low	Fair	Excellent	Good	Fair	Poor	Fair	Medium
Nylon 6/6, glass filled	Zytel	High	Medium	High	Poor	Good	Excellent	Good	Fair	Fair	Medium
Polypropylene	Maxxam, Profax	Low	High	Low	Fair	Excellent	Poor	Poor	Poor	Good	Low
High Density Polyethylene (HDPE)	Dow HDPE, Chevron HDPE	Low	High	Low	Fair	Excellent	Unknown	Poor	Poor	Good	Low
Polycarbonate	Lexan, Makrolon	Medium	High	Medium High	Good	Fair	Fair to Good	Fair	Good	Good	Medium High
Acrylonitrile Butadiene Styrene (ABS)	Lustran, Cycolac	Medium-Low	High	Low	Good	Fair	Good	Fair	Good	Good	Low
Polycarbonate / ABS Alloy	Cycoloy, Bayblend	Medium	High	Medium	Good-Excellent	Fair	Good	Fair	Good	Good	Medium
Polybutylene Terephthalate	Valox, Crastin	Medium	High	Low	Fair	Fair	Unknown	Fair	Fair	Good	Medium High
Polybutylene and Polyethylene Terephthalate, glass-filled	Valox, Crastin, Rynite	High	Medium	Medium	Poor	Fair	Good	Good	Fair	Fair	Medium High
Polystyrene	Styron	Medium-Low	Low	Low	Good	Good	Unknown	Fair	Fair	Good	Low
Thermoplastic Elastomer	Isoplast, Santoprene	Low	High	Low	Poor	Excellent	Excellent	Good	Poor	Excellent	Medium-Low
Acrylic	Plexiglas, Acrylite	Medium	Low	Low	Good	Fair	Excellent	Good	Good	Good	Medium

http://www.protolabs.com/resources/molding-materials

Resin Characteristics

Resin	Inches
ABS	0.045 - 0.140
Acetal	0.030 - 0.120
Acrylic	0.025 - 0.500
Liquid crystal polymer	0.030 - 0.120
Long-fiber reinforced plastics	0.075 - 1.000
Nylon	0.030 - 0.115
Polycarbonate	0.040 - 0.150
Polyester	0.025 - 0.125
Polyethylene	0.030 - 0.200
Polyphenylene sulfide	0.020 - 0.180
Polypropylene	0.025 - 0.150
Polystyrene	0.035 - 0.150
Polyurethane	0.080 - 0.750

The table* shows wall thicknesses that Protomold recommends according to resin. Please note that thin walls only work on small parts and thicker walls are required where the resin has a long way to flow. Protomold makes parts with dimensions of about 0.25 in. to 29.6 in. (6.3 mm. to 752 mm.).

http://www.protolabs.com/injection-molding/design-guidelines

How Proto Labs Can Help

- **Additive Manufacturing:** 1 to 50 parts in 1 to 7 business days
  - Stereolithography (SL)
  - Selective Laser Sintering (SLS)
  - Direct Metal Laser Sintering (DMLS)

- **CNC Machining:** 1 to 200 parts in 1 to 3 business days
  - CNC Milled Parts
  - CNC Turned Parts

- **Injection Molding:** 25 to 10,000+ parts in 1 to 15 business days
  - Hundreds of thermoplastics
  - Silicone thermosets (LSR)
  - Metal injection molding (MIM)
  - Magnesium thixomolding

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Questions?

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