



WELCOME TO A 3D WORLD

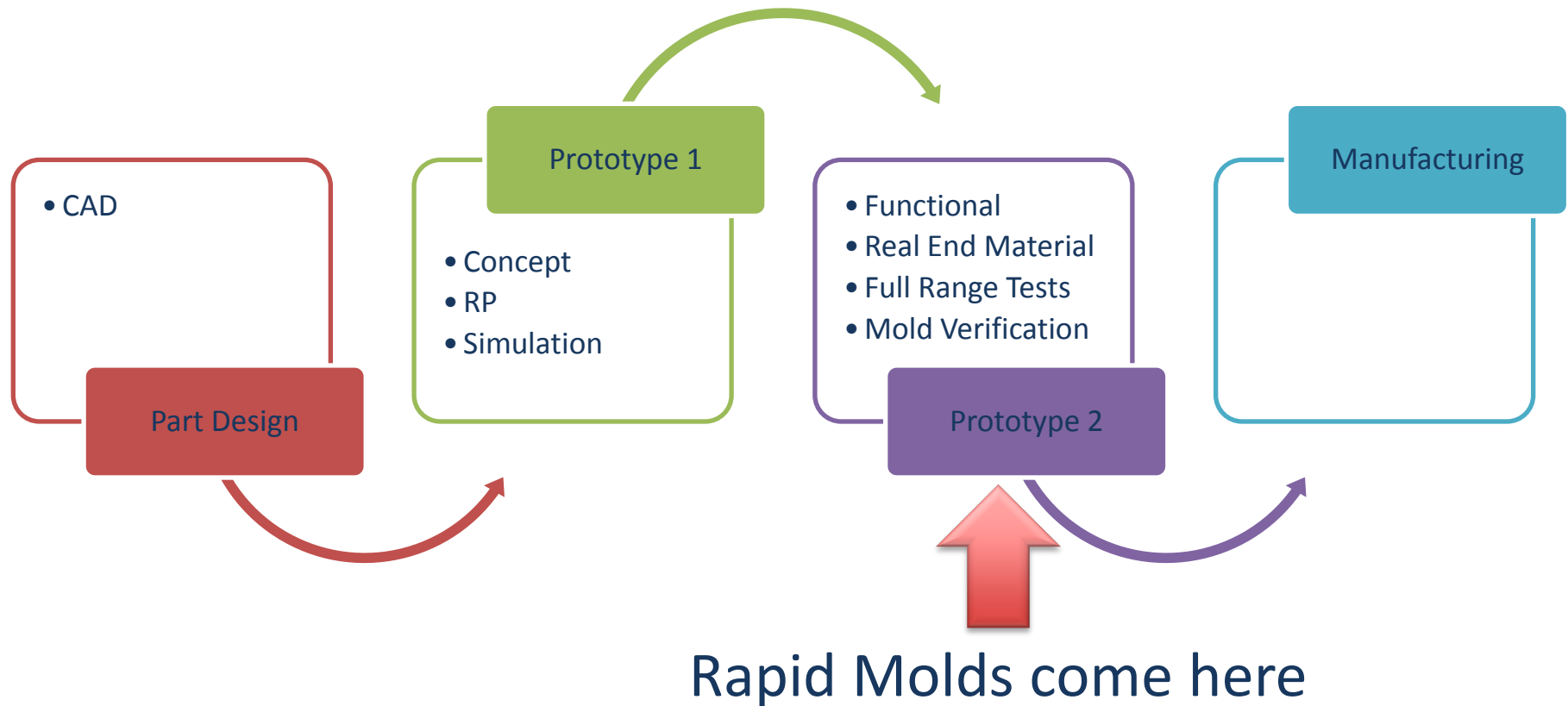
3D Printed Rapid Tools for Injection Molding Applications

Shanghai Dec2014

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- 3DPIM – what is it good for?
- 3DPIM - Best fit
- 3DPIM – Growth engine - Wins
- Available resources for success
- Injected Parts examples
- Technical Tips and Tricks for success
- Q&A

PIMT – What is it good for?

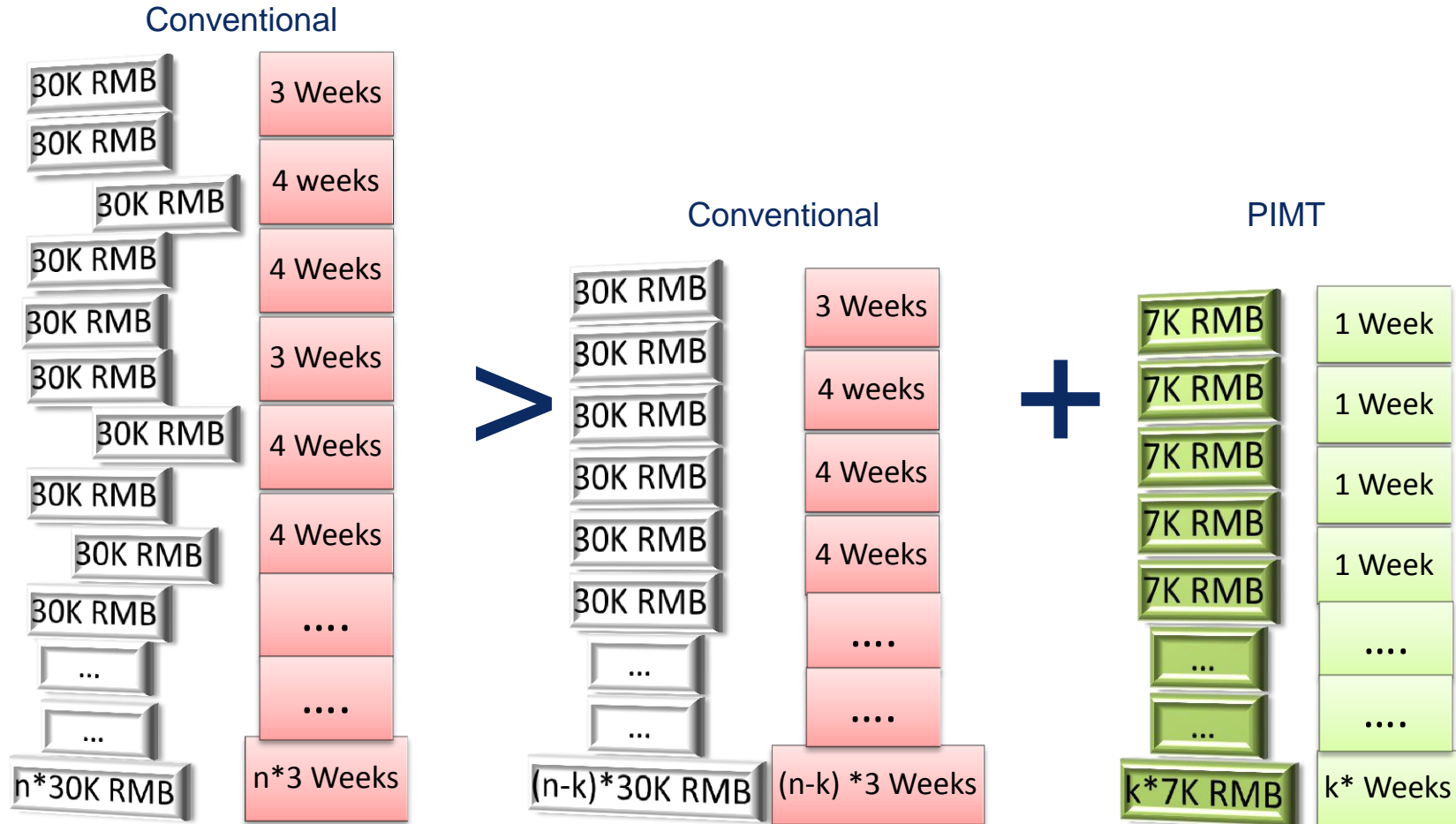


- Watch this video to see an example: [video](#)

PIMT – What is it good for?

Yearly expense on tools

Yearly expense on tools



- Some projects can be moved to 3DPIM use – **saving both time and money** in the bottom line

3DPIM – Best fit

Thermoplastics with:

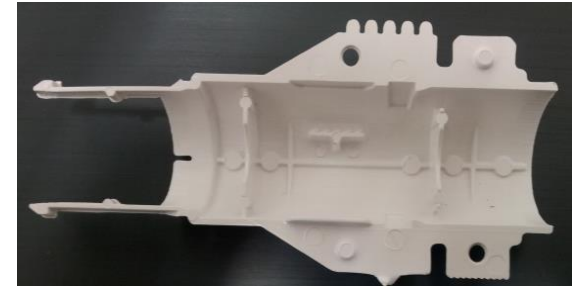
- Molding temperatures $< 300\text{ }^{\circ}\text{C}$ ($570\text{ }^{\circ}\text{F}$)
- Good flow ability
- Candidates: PE, PP, PS, ABS, TPE, PA, POM, PC-ABS
- Glass filled resins

Low quantities (5 to 100 Parts)

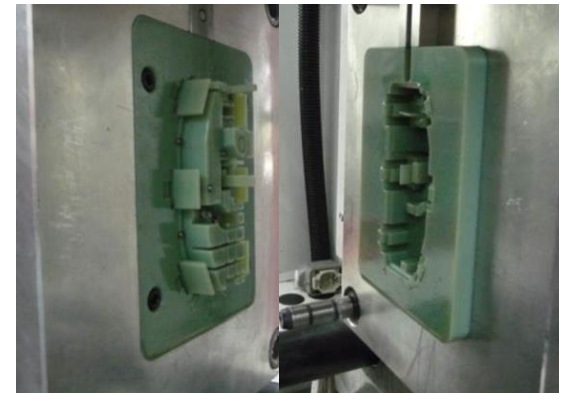
Mid-sized parts ($< 165\text{ ccm}$, [10 cu. in.]

Machine type:

- Bench Plastic Injection Molding Machines
- 50- to 100-ton molding machines



Use resins with reasonable melt and viscosity



PolyJet inserts in a mold base

Growth Engine - wins

- Printer: **Eden260V**
- Industry: CG – Manufacturing ladders
- Need for IM: Safety tests must be done with end product material (Usually PP)



- Printer: **Connex500** (Already owned and used a Desktop for IM)
- Industry: CG – a leading manufacturer in the plastics processing industry
- Need for IM:
 - Create prototypes from end product material
 - Same design testing with different plastics



Growth Engine - wins



- Printer: **Connex500**
 - Industry: Medical
 - Need for IM: Speeding time to market in medical device product development for their customers
 - [Yahoo News!](#)
-
- Printer: **Connex260**
 - Industry: CE – certified manufacturer of high quality, build-to-print cables and harnesses for commercial and military applications.
 - Need for IM:
 - Create prototypes from end product material
 - Same design testing with different plastics



Growth Engine - wins



- Printer: **Connex260**
 - Industry: Plastic
 - Need for IM: Low volume production
 - [Diversified Plastics.mp4](#)
-
- Printer: **Connex500**
 - Industry: CG (Multi-Billion International Company)
 - Need for IM:
 - Create prototypes from end product material
 - Functional tests- living hinges



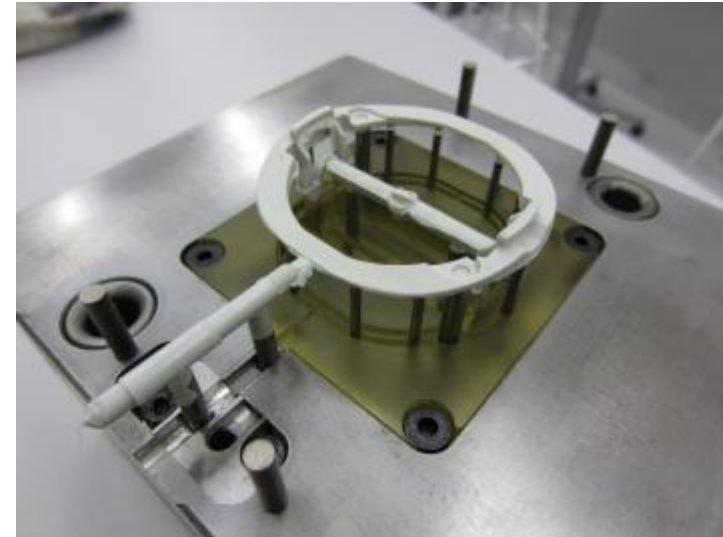
Growth Engine - wins

- Printer: **Connex500** (2nd Printer purchased for IM only)
- Industry: Pumps Manufacturer
- Country: UK
- Need for IM: Low volume production and services
- [Video : Whale](#)



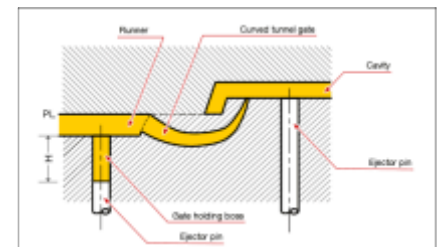
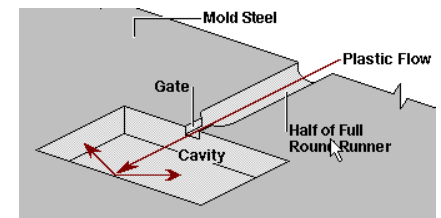
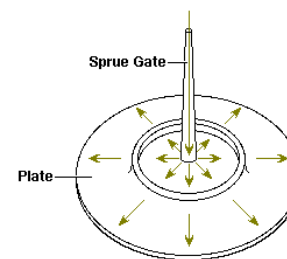
Growth Engine - wins

- Printer: **Connex500** , **O30Pro**
- Industry: Consumer Electronics
- Country: Germany
- Need for IM: Low volume production and services



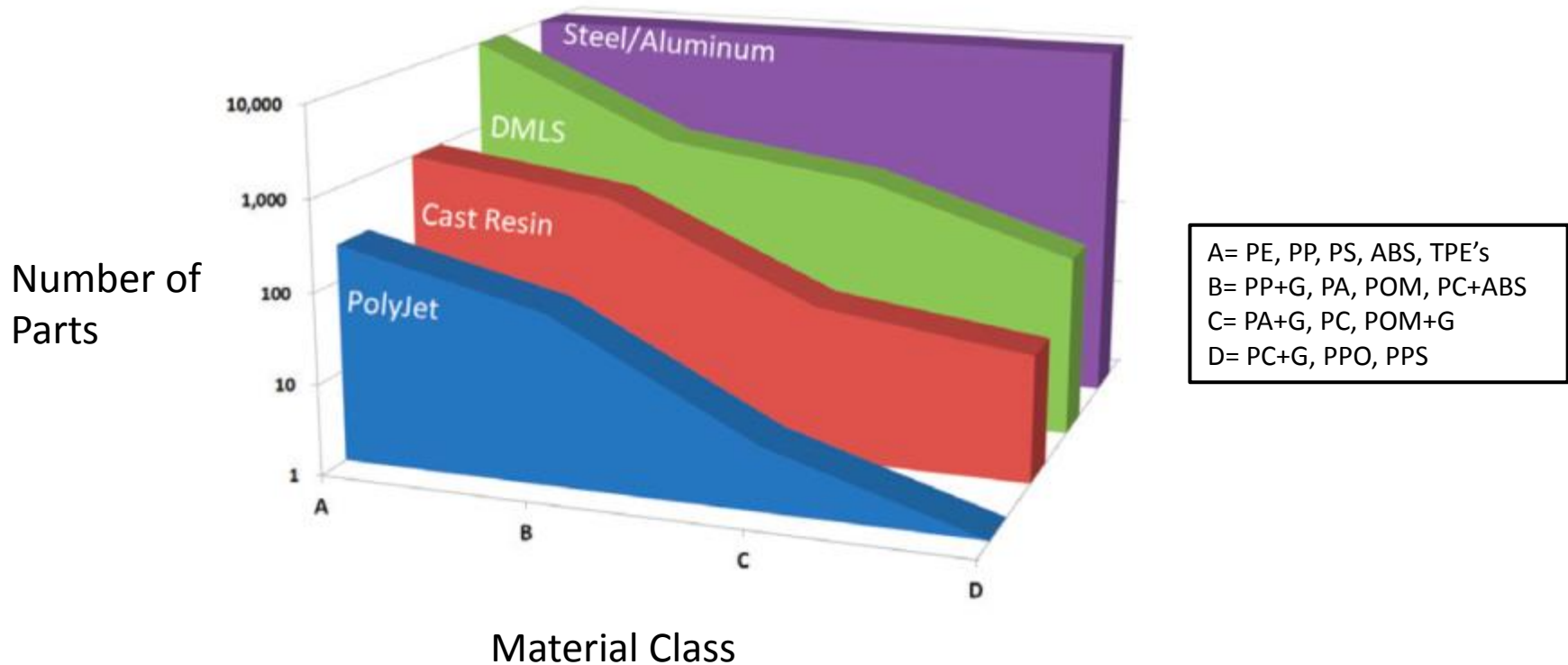
Available resources for success

- Available resources on line:
 - [Case Study – Budapest University](#)
 - [Whitepaper](#)
 - [Application notes and expert advice](#)
- Technical support
 - AE out of SSYS Shanghai office
 - “Tool Trial Service” from Stratasys China



PIMT – Flexibility in Prototype Manufacturing

- What can we offer? (Remember the plastic world...☺)



Part 1

Industry	Consumer goods
Part description	Screw Cap, Gas filter
Material injected	Acetal, PP+GF, EPDM
Special features	Threads, 3 part mold



Acetal



PP+20% GF



EPDM



PA 66 + 20% GF

Part 1 – Injection parameters

Material	PP+GF	PA+GF	POM
Nozzle Temp [C]	195	285	195
Inj. Pressure [bar]	200	200	200
Hold Pressure [bar]	200-400	200-400	200-400
cycle time [s]	110	110	110
Clamping force [kN]	400	400	400



Part 2

Industry	Consumer goods
Part description	Ice cream spoons
Material injected	PP
Special features	6 cavity mold
comments	Injected in different colors

	Cost (US\$)	Turnaround (days)	comments
P20 Steel	3200	30	
Aluminum	1400	30	
ABS-like	785	7 hr. (1 day)	Connex 260 Consumption: 400gr RGD535 480gr RGD515 100gr support

Time saving: 3000%

Cost savings:

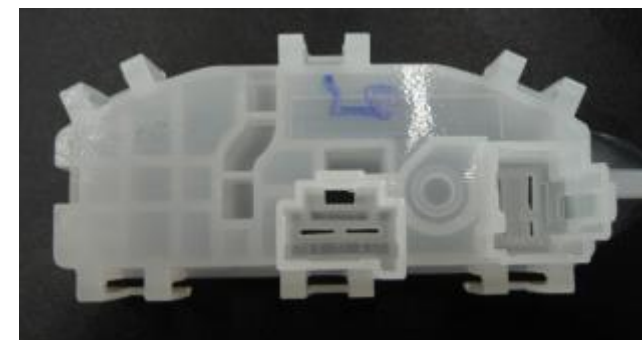
- 44% over aluminum
- 75% over steel



Part 3

Industry	Automotive
Part description	Steering wheel connector
Material injected	Wax, HDPE
Special features	Highly complex. Thin walls
comments	10 parts molded, long cycle time

Material	HDPE
Nozzle Temp [C]	185
Inj. Pressure [bar]	600
Hold Pressure [bar]	300
cycle time [s]	360
Clamping force [kN]	300



Part 4

Part description	Test part
Material injected	PP, ABS
Special features	Ribs, bosses, shut offs
comments	<ul style="list-style-type: none">Deep draw in the ejection direction



Material	ABS
Nozzle Temp [C]	210
Inj. Pressure [bar]	450
Hold Pressure [bar]	150
Holding time [s]	5
Cooling time [s]	140
Comments	Vortex air separator blow time for 60 seconds after ejection

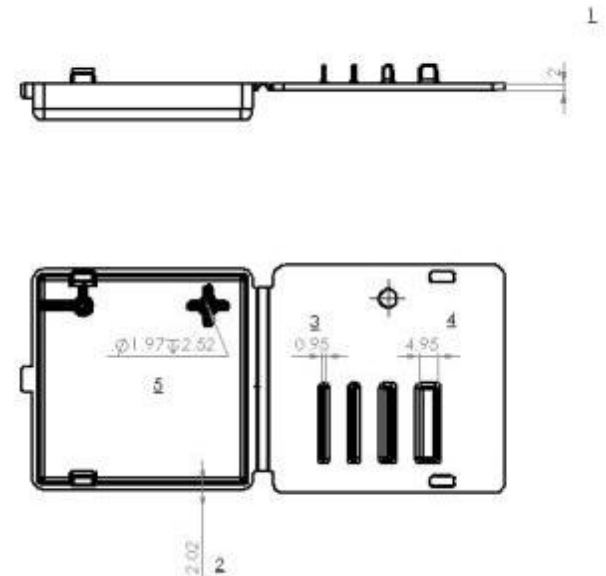


Part 5

Part description	Test part
Material injected	PP
Special features	Living hinge, bosses, press fit
comments	<ul style="list-style-type: none"> • 100 parts out of 2 tools • Low pressure developed • Tools did not fail



Material	PP
Nozzle Temp [C]	220
Inj. Pressure [bar]	600
Hold Pressure [bar]	200
Holding time [s]	8
cycle time [s]	180
Comments	Cooling with air pressure



Part 6

	Cost (US\$)	Turnaround (days)	comments
P20 Steel	3400	18	IL estimation
Aluminum	1670	7	IL estimation
ABS-like	960	22 Hr. (1 day)	Connex 500 Consumption: 810gr RGD535 1408gr RGD515 150gr support



Time saving: 700-1800%
Cost savings:

- 43% over aluminum
- 72% over steel



Part 6

• Industry	• Automotive
• Part description	• Propeller
• Material injected	• POM (Acetal)
• Special features	• 3 part tool
• Barrel temp:	• 190-210C
• Pinj (limit)	• 300 bar
• Phold	• 100-50 bar (linear decrease)
• Holding time	• 8 sec
• Clamp force	• 150kN
• Vinj	• 10 cc/cm
• Switch over position	• 25cc
• Shot size	• 65 cc
• Cooling time	• 30 sec



Part 7

Industry	Automotive seals
Part description	TPE seals
Material injected	TPE
Special features	3 part tool
comments	From customer: “Compared to silicon molding, 50% in time and cost are saved as well as <u>real</u> material prototypes made..”



- 20 parts molded



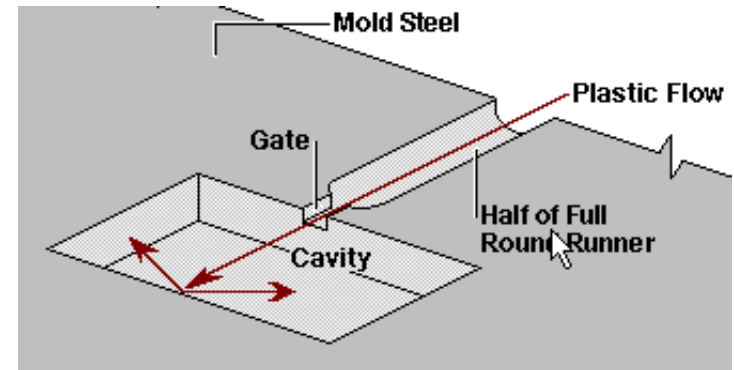
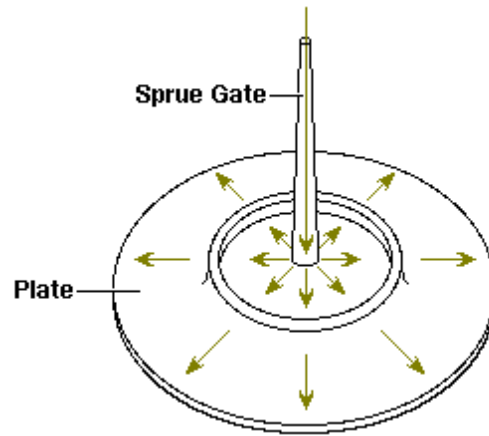
- 5 parts molded



Mold Design – Gate Design

Prefer

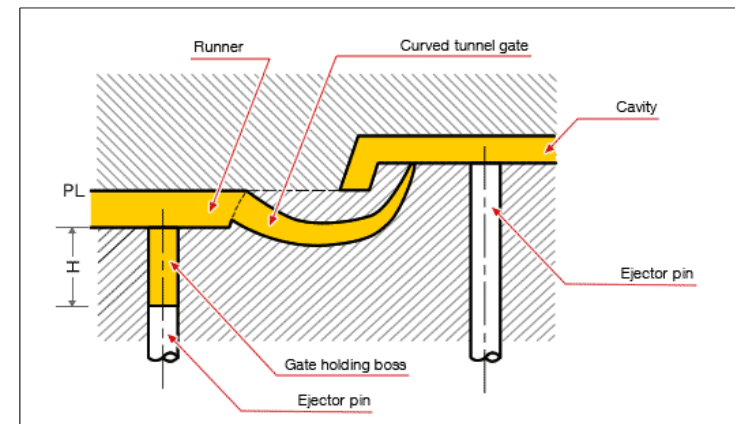
- Sprue gate
- Edge Gate



Increase gate size over traditional to minimize stress

Not recommended

- Tunnel, Cashew, Banana and point gate



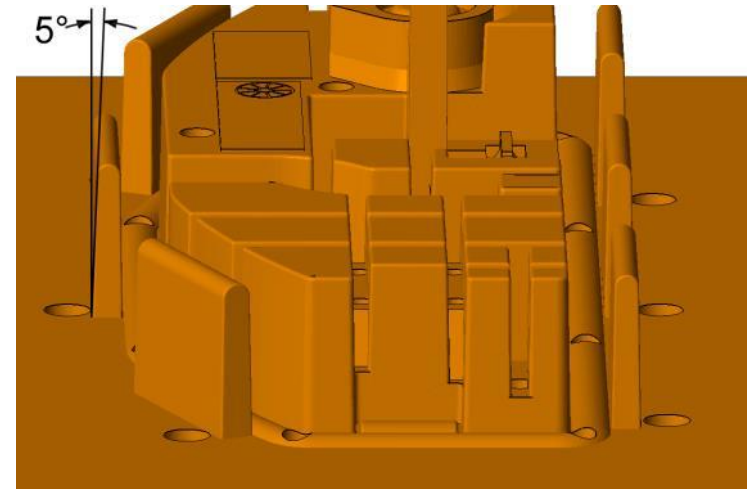
Mold Design – Draft and Shutoff

Increase draft angle (5°)

- To facilitate ejection
- To reduce stress

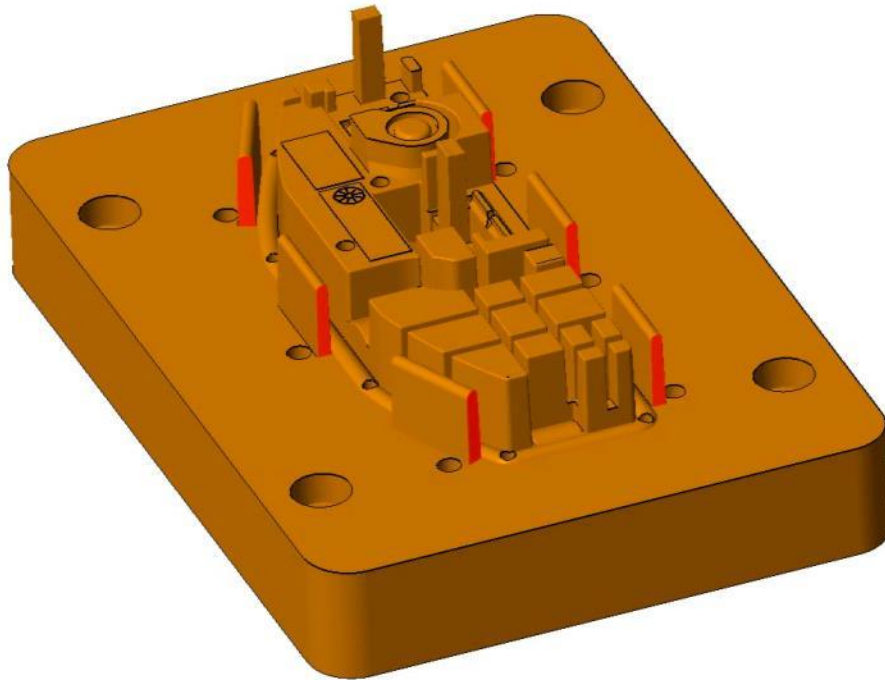
Inset shut-off faces

- Due to printer tolerance
- 0.05 to 0.1 mm
- For > 6 mm faces parallel to mold pull

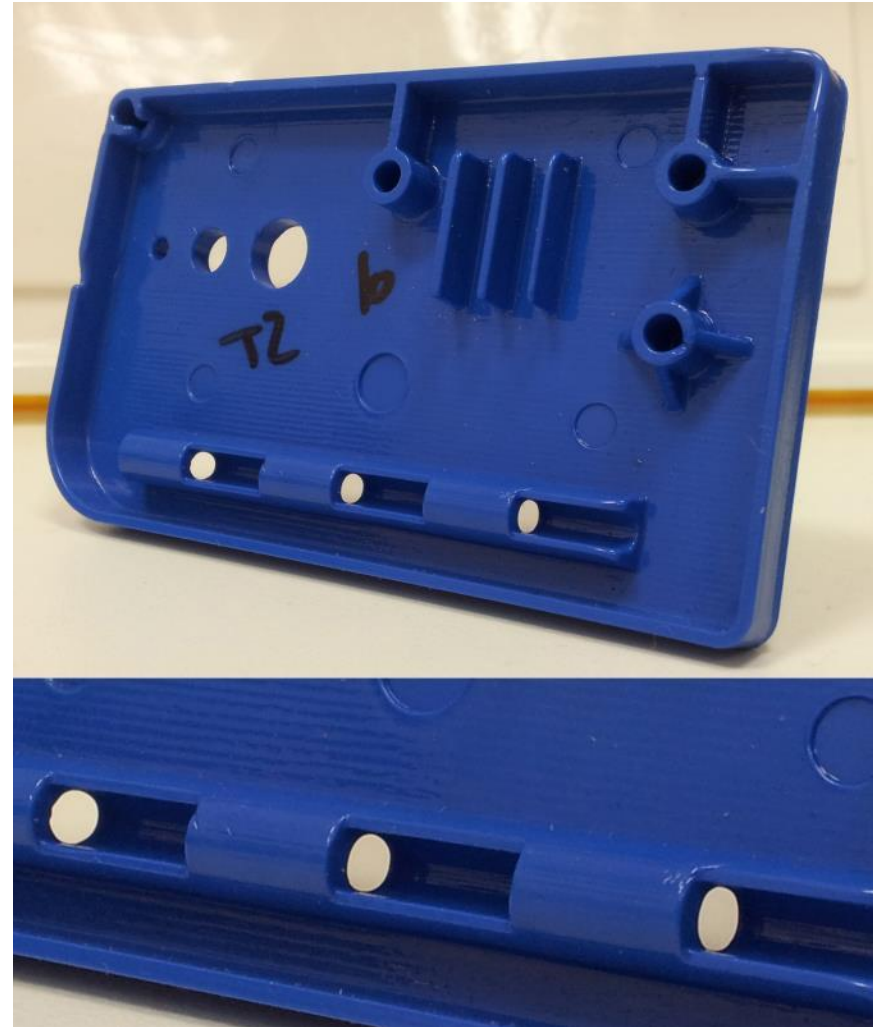


Increase draft angle – 5° recommended

Mold Design – Draft and Shutoff



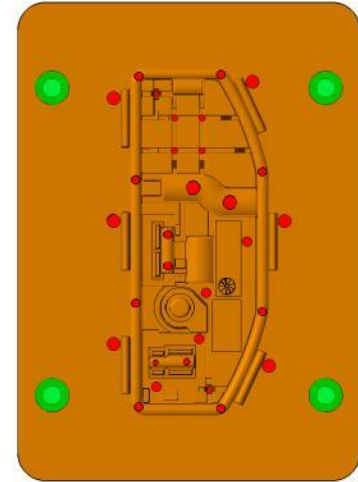
Inset shut-of surfaces (red)



Shut-offs on hinge required no inset

Mold components

- Ejection system
 - Add round holes for ejector pins
 - Undersize by 0.2 – 0.3 mm
 - Ream to perfect fit
- Cooling system
 - If used, locate 8 – 10 mm below cavity surface

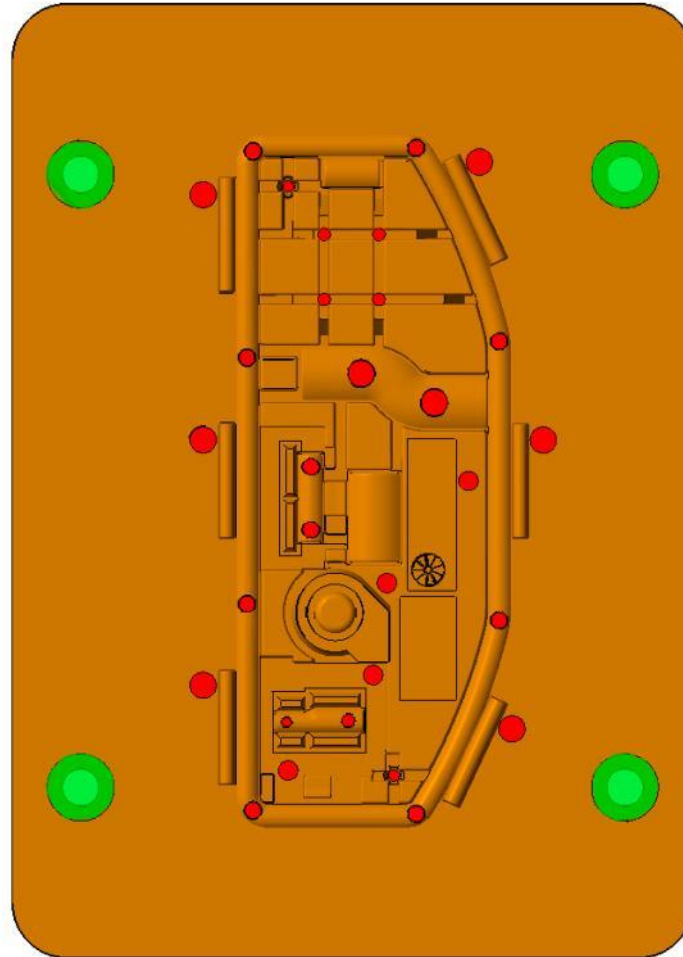


Add holes for ejector pins (red)



Cooling system is not recommended

Mold Design



Add holes for ejector pins (red). Bolt holes also shown (green)

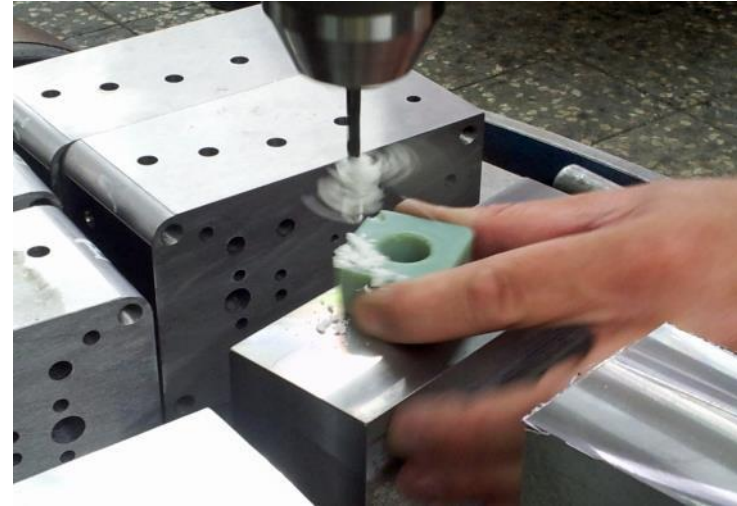
Mold Fitting and Finishing

Fit ejection system

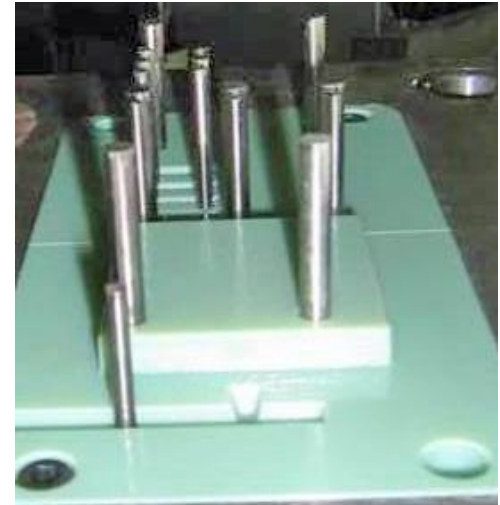
- Ream holes
- Confirm snug but smooth movement

Mold base option

- Face mill stock from side walls
- Seat inserts in mold base pockets
- Confirm 0.2 mm (0.008 in.) beyond mold base
- Mill or add shims to adjust



Ream holes for core and ejector pins



Fit ejection system

Mold Fitting and Finishing

Remove support material

Smooth surfaces

- For extraction (optional)
 - Light sanding (180/220 grit)
 - Surfaces that rise in pull direction
- For appearance (optional)
 - All surfaces
 - 180/220 grit followed by 320/400 grit



Sand vertical surfaces (red) for extraction



Sand cosmetic surfaces (green) for appearance

Mounting

Mounting options:

Mold base (recommended)

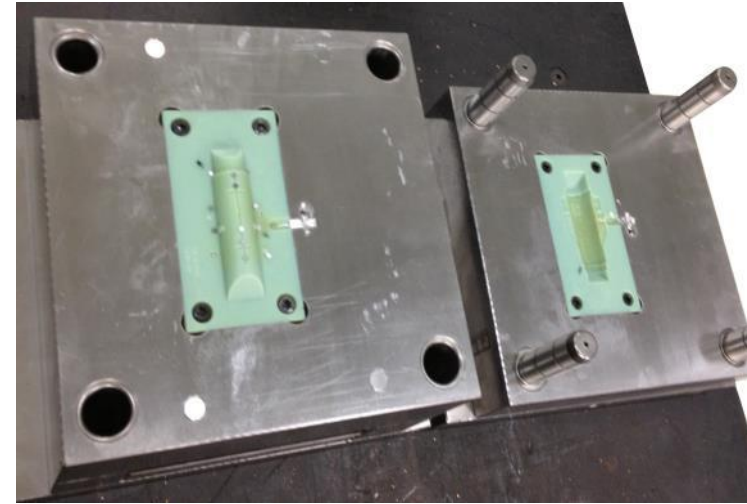
- Largest investment
- Increased part complexity
- Improved part quality

Steel plate with ejection

- Mid-range investment
- Increased part complexity

Steel plate without ejection

- Smallest investment
- Fastest



Mold base (recommended)



Plate mount with ejection (left)

Process Development

Goal: Conservative settings to maximize tool life

Process

- Start with very low pressures and temperatures
- Test runs

Inspect results

Adjust as needed



Test shots to dial in parameters

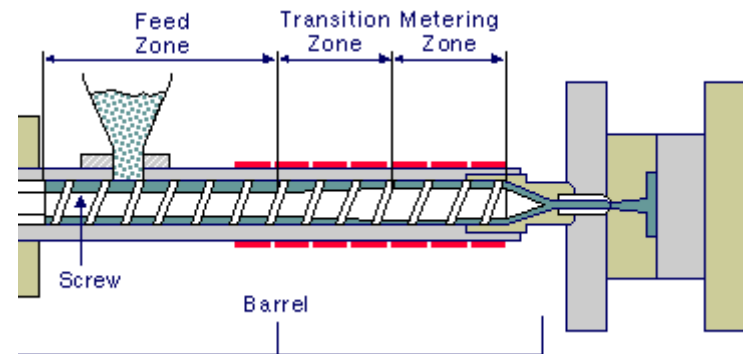
Process Development #1

Initial settings:

- Injection molding time limit
20 seconds
- Pack & hold phase
0 kPa (0 psi) and 0 seconds
- Shot size
75% of standard volume
- Barrel temperatures:
Low end of resin recommendation



Conservative settings for first shot



Use lowest recommended settings for barrel temperature and screw speed

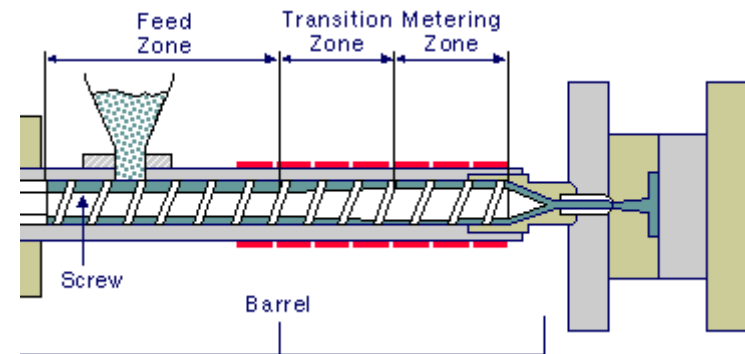
Process Development #2

Initial settings

- Injection speed:
 - Low end of resin recommendation
 - 10% to 20% of the machine's maximum screw speed
- Cooling cycle:
 - Small, thin parts: 40 seconds
 - Larger parts or thicker features: 90 seconds



Conservative settings for first shot



Use lowest recommended settings for barrel temperature and screw speed

IM: Molding Adjustments

Trial shots:

- Increase shot size- Target – 90% of volume
- Adjust packing pressure-30–50% of injection pressure
- Increase hold time

If sink marks are present:

- Adjust barrel temperature
- Adjust injection speed
- Do not over cool part
- Will cause part to shrink and grab tool



Threaded cap from mold: Left – 20% GF PP, Right- 20% GF PA 6/6

Process Development

Mold temperature:

- Will rise with continuous operation (undesirable)
- Allow to cool between shots -Target: 50 °C

Either:

- Use extended dwell between cycles
- Accelerate with compressed air during dwell



Compressed air cools mold to 50 °C (120 °F)



Thank you!

- For more information please contact me at – Alan.Yu@stratasys.com