Part Design for Cycle Time Reduction

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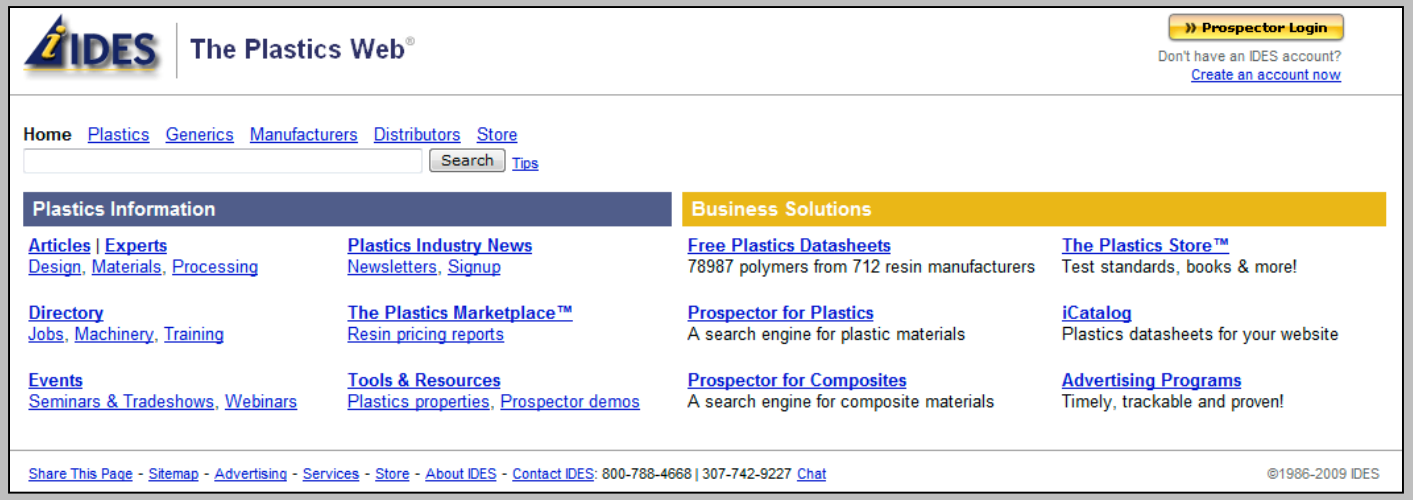

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Best Molding Practices

April 29, 2009

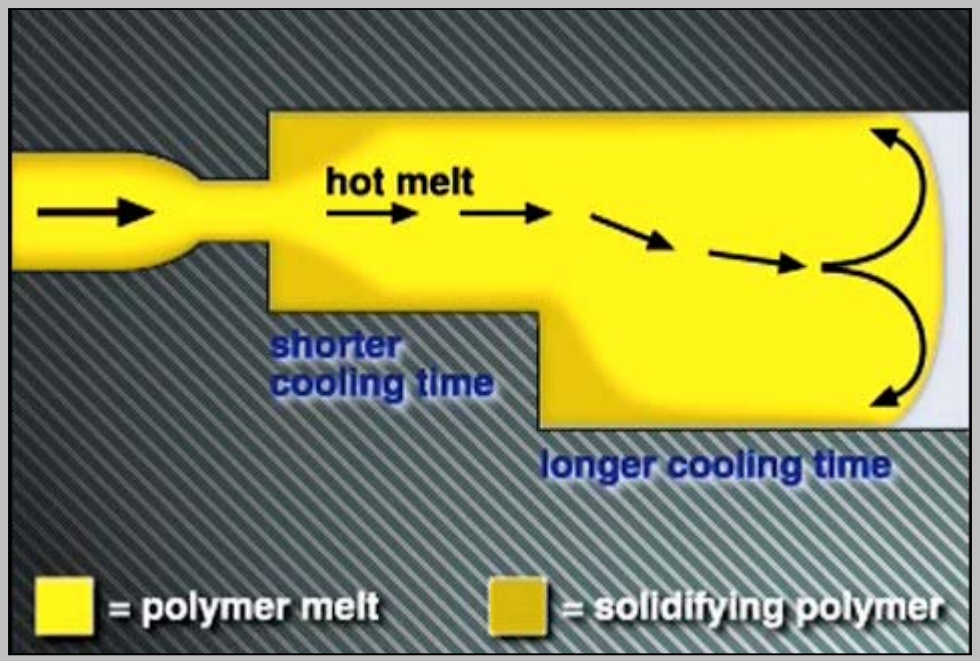
Part Design for Cycle Time Reduction

- Wall Thickness
- Part Removal
- Cooling
- Multi-Material
- Multi-Cavity

Wall Thickness

Due to poor heat transfer...

- outer layers insulate
- plastics cool slowly



Wall Thickness

Cooling time is exponential:

- Cooling Time ~ $\frac{(\text{Thickness})^2}{(\text{Themal Diffusivity})}$

$$\text{Minimum Cooling Time} = t_c = \frac{h^2}{\alpha \pi^2} \ln \left| \frac{4}{\pi} \left(\frac{T_M - T_W}{T_E - T_W} \right) \right|$$

For Example: with

α = thermal diffusivity ~ 10^{-7} m^2/s

h = plate thickness ~ 3×10^{-3} m

T_W = mold wall temperature ~ 50°C

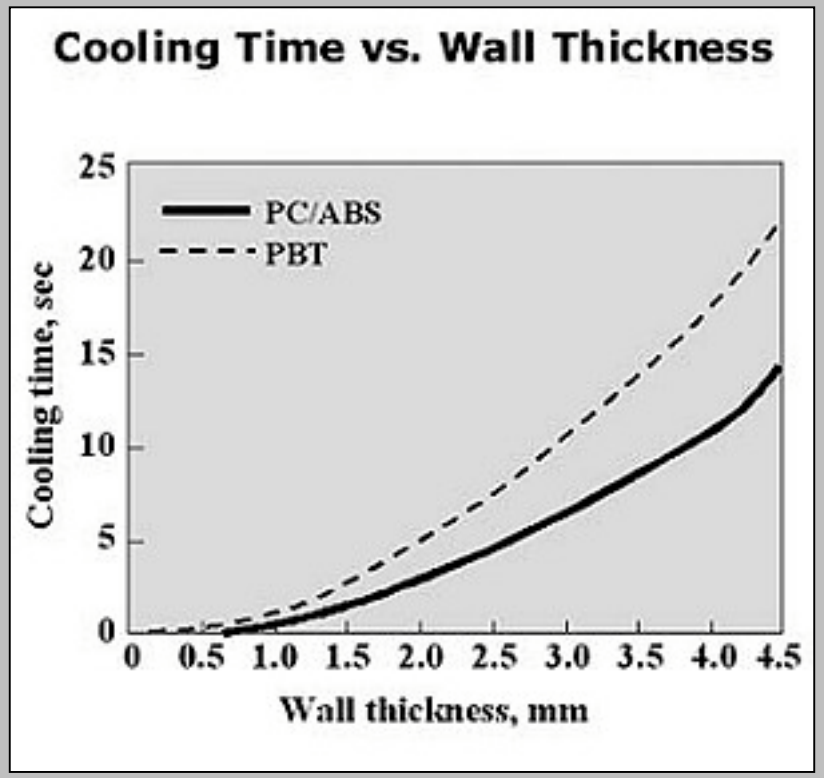
T_M = melt temperature ~ 250°C

T_E = ejection temperature ~ 100°C

Minimum cooling time for centerline to reach T_E is T_C ~ 23 sec.

Wall Thickness

Cooling time is exponential:



Wall Thickness

Every doubling in thickness
is a four-fold increase in
theoretical cooling time

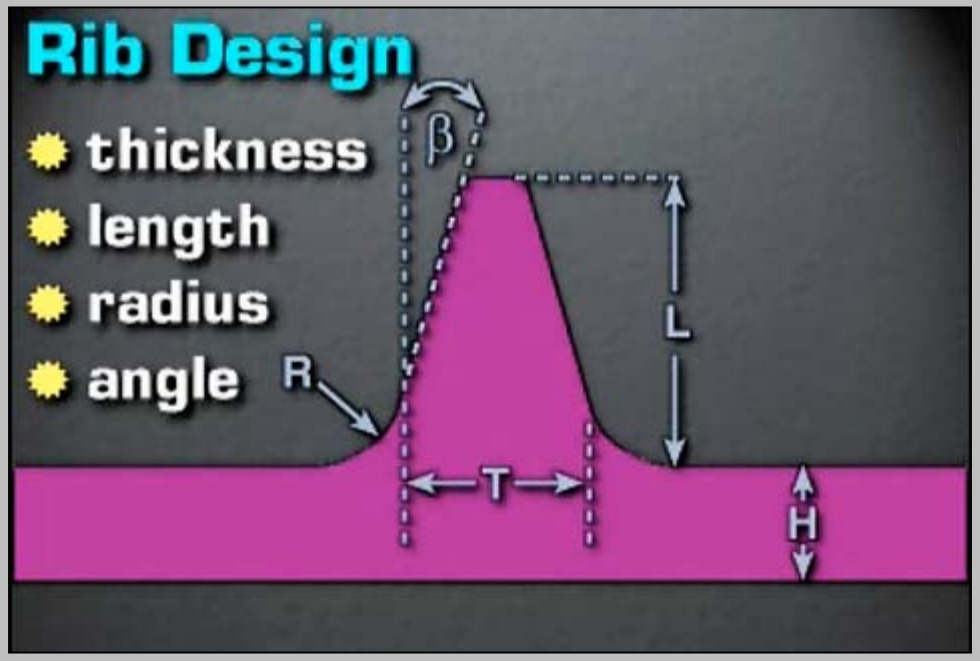
Wall Thickness

Adversely... Less than 30% thickness reduction cuts theoretical cooling time in half

Wall Thickness

Rib intersections…

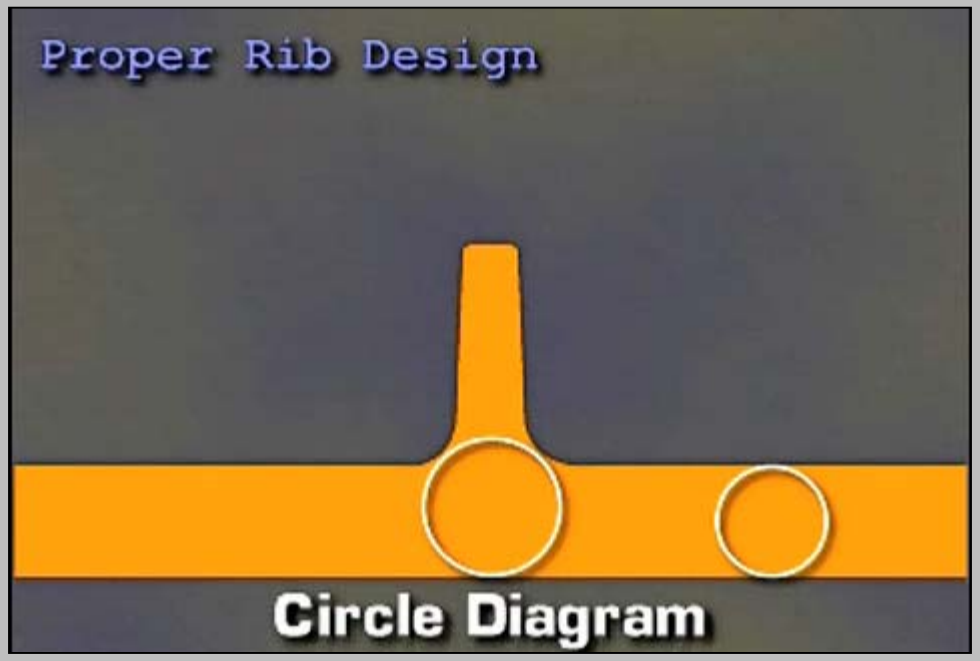
- create inherent thick sections
- typically have poor cooling



Wall Thickness

Circle Diagram Method...

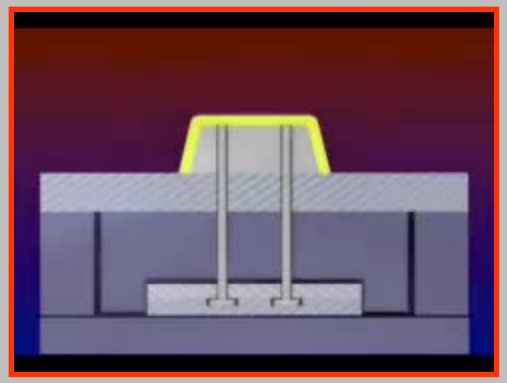
- diameter approximates thickness



Part Removal

In production...

- part removal is most common limiting factor on cooling time



Part Removal

Poor part and mold design...

- warpage
- distortion
- deformation
- marks

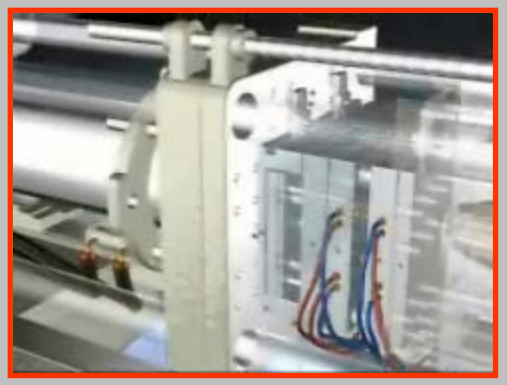
Part Removal

No mold design can compensate for a poor part design

Part Removal

Ejection system design...

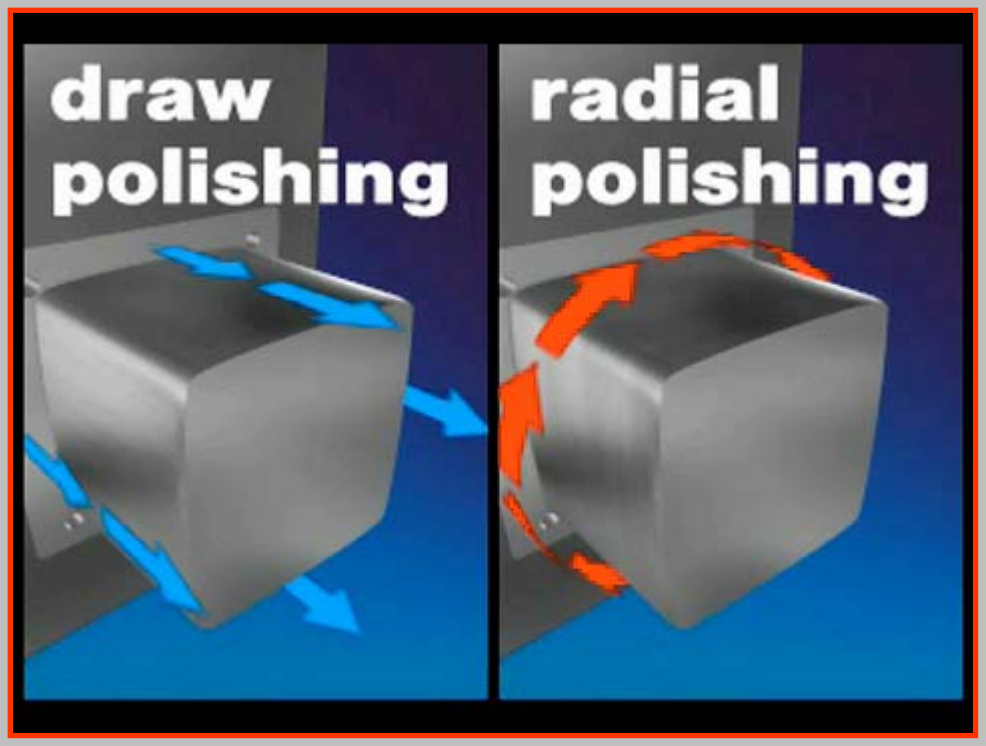
- even distrbution of force
- provide push points
- easily removed undercuts
- accomodate actions



Part Removal

Reduce stresses and vacuum forces...

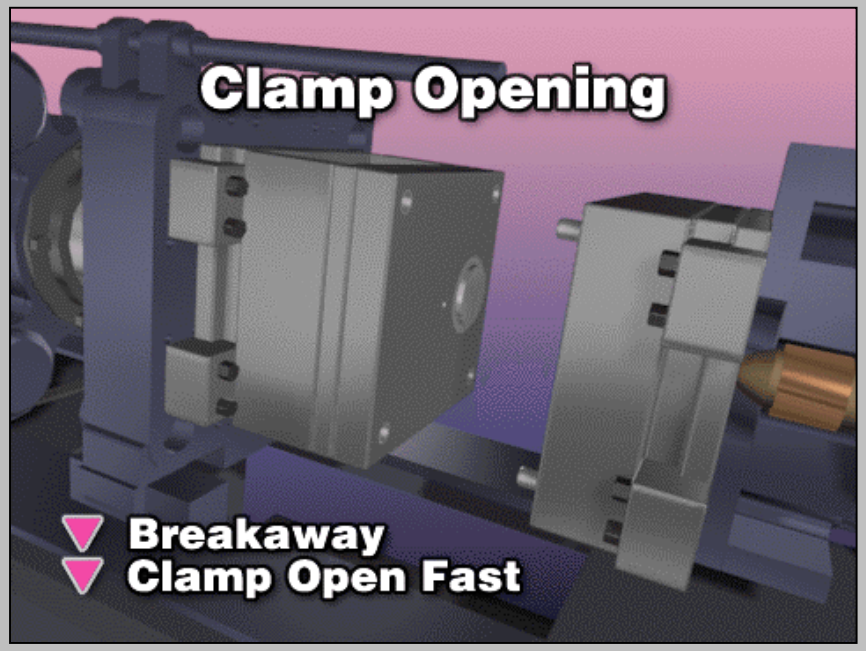
- draft angles
- draw polishing
- radii
- fillets
- ribs



Part Removal

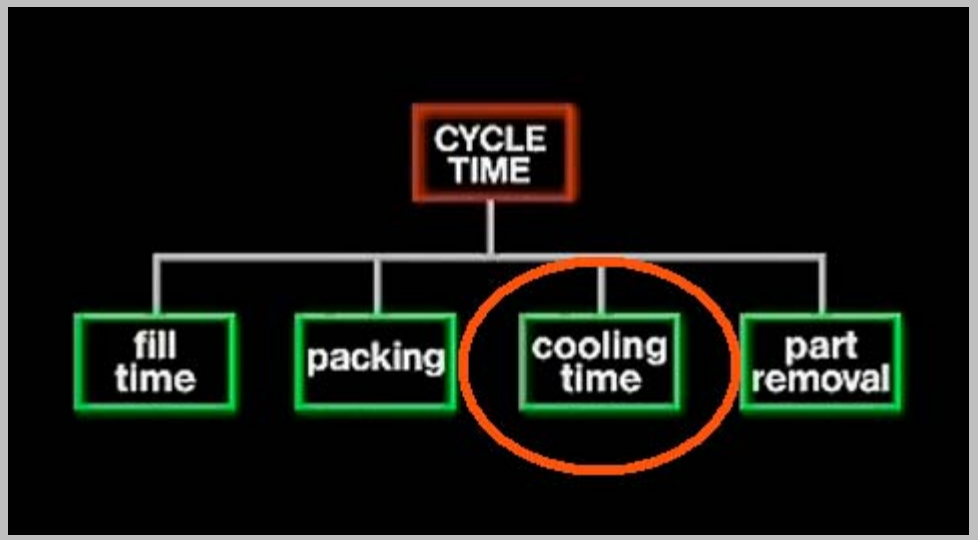
Lastly...

- ensure design accomodates mold opening



Cooling

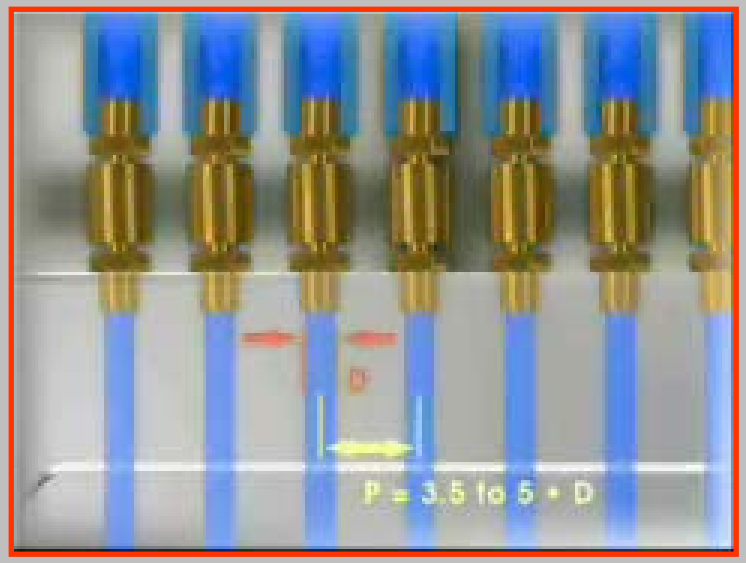
- Cooling Line Layout
- Differential Cooling
- Simplify Complex Cooling



Cooling Line Layout

Ideal cooling lines...

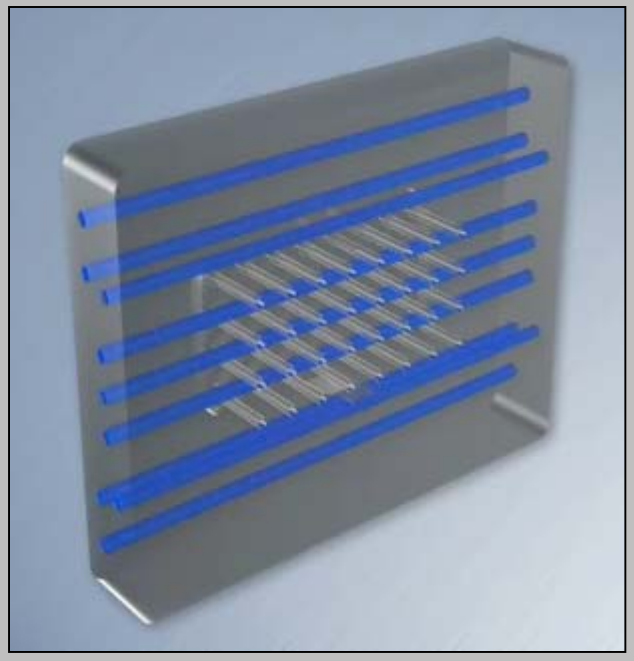
- Distance (P) = 3.5 -> 5 * D
- Depth (H) = D * 2



Cooling Line Layout

The best design balances…

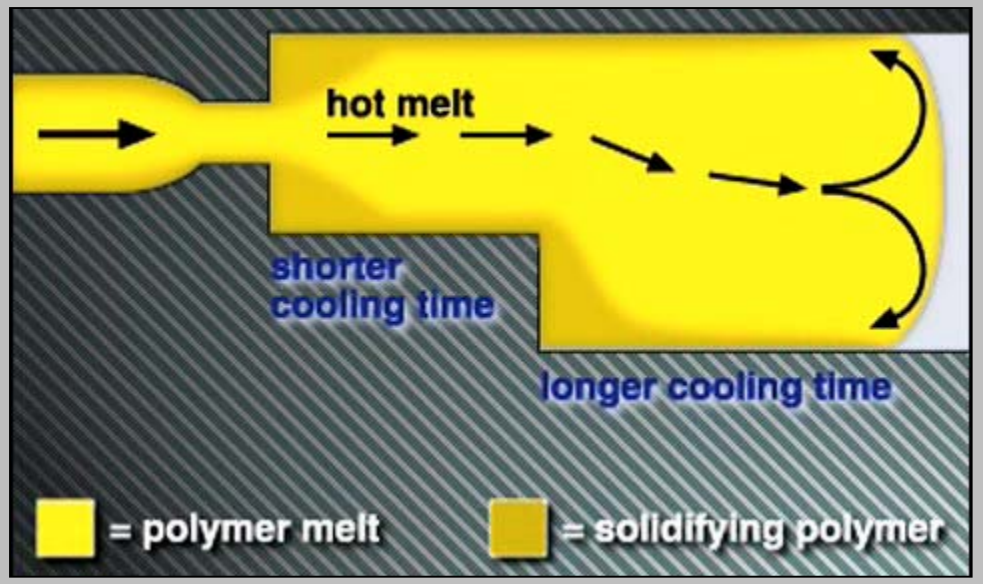
- cooling line layout
- ejection system layout



Differential Cooling

Variable Part Thickness Causes...

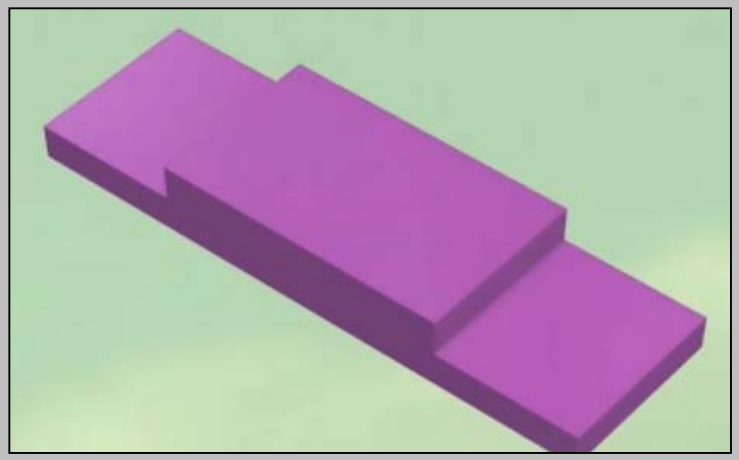
- inconsistent shrinkage
- increased warpage
- longer cooling time

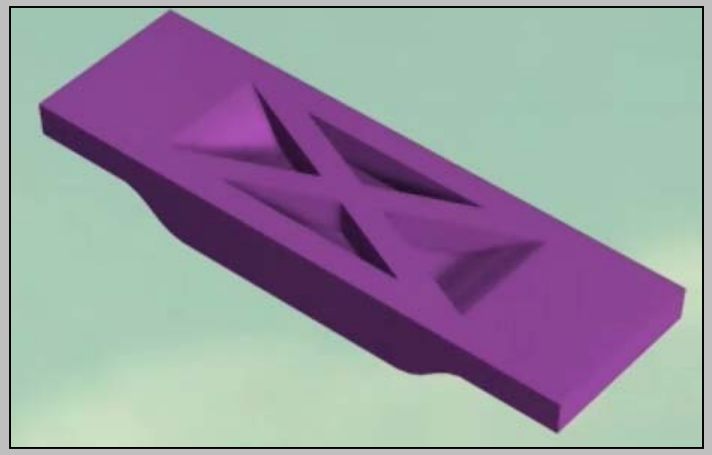


Differential Cooling

When Possible…

- smooth out thickness transitions
- avoid sharp corners
- maintain a consistent wall thickness
- use ribbing or gussets if necessary

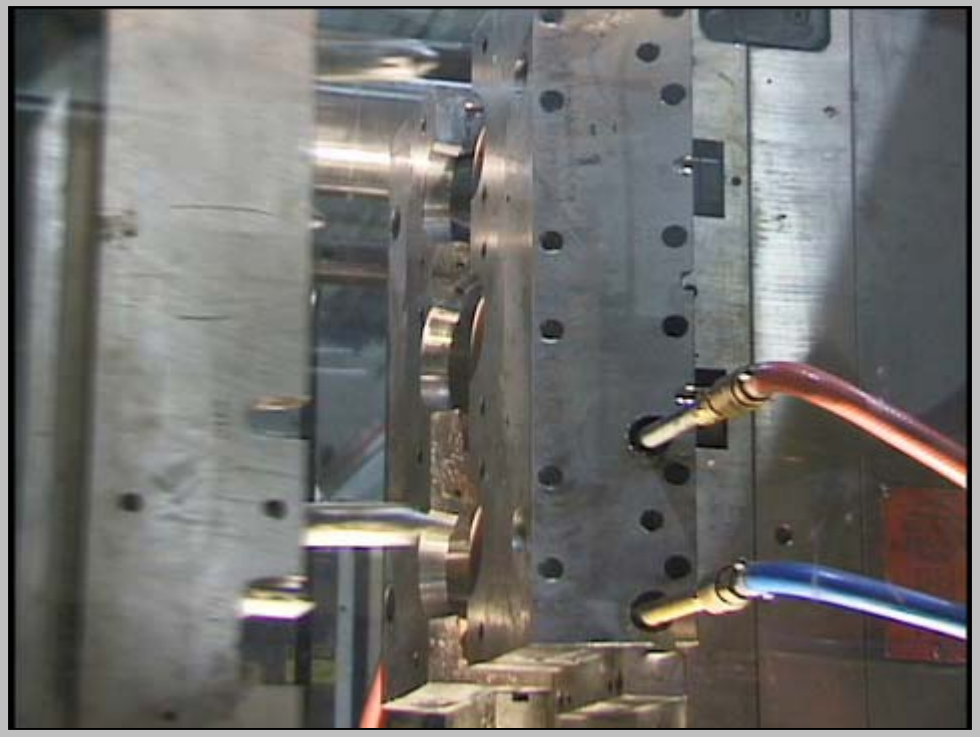




Simplify Complex Cooling

Design Considerations:

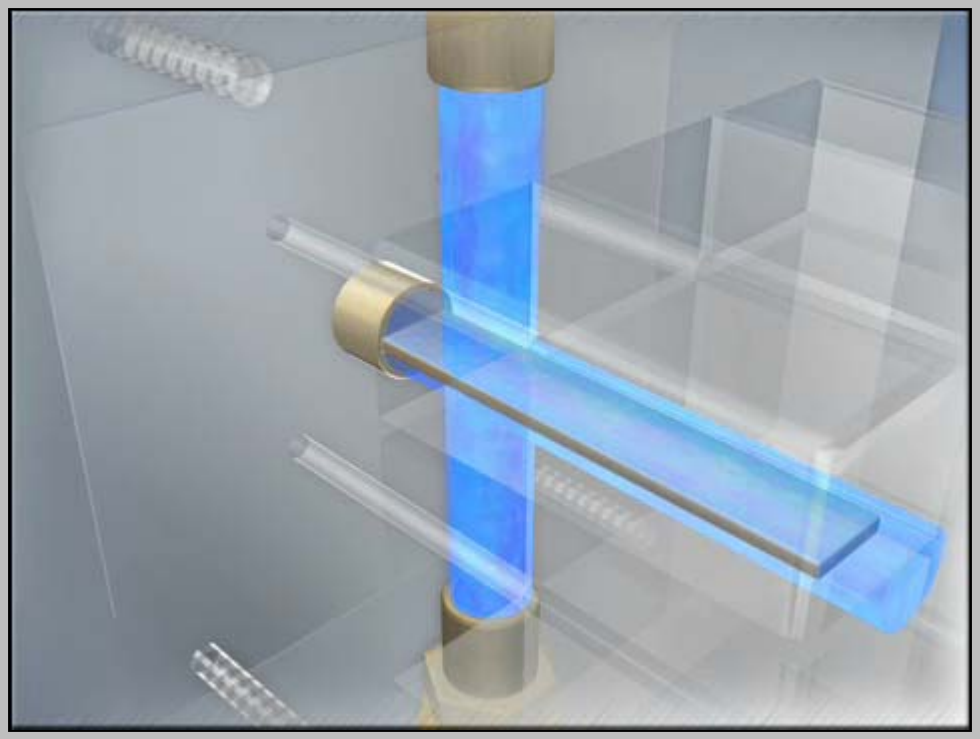
- large slides are easier to cool



Simplify Complex Cooling

Design Considerations:

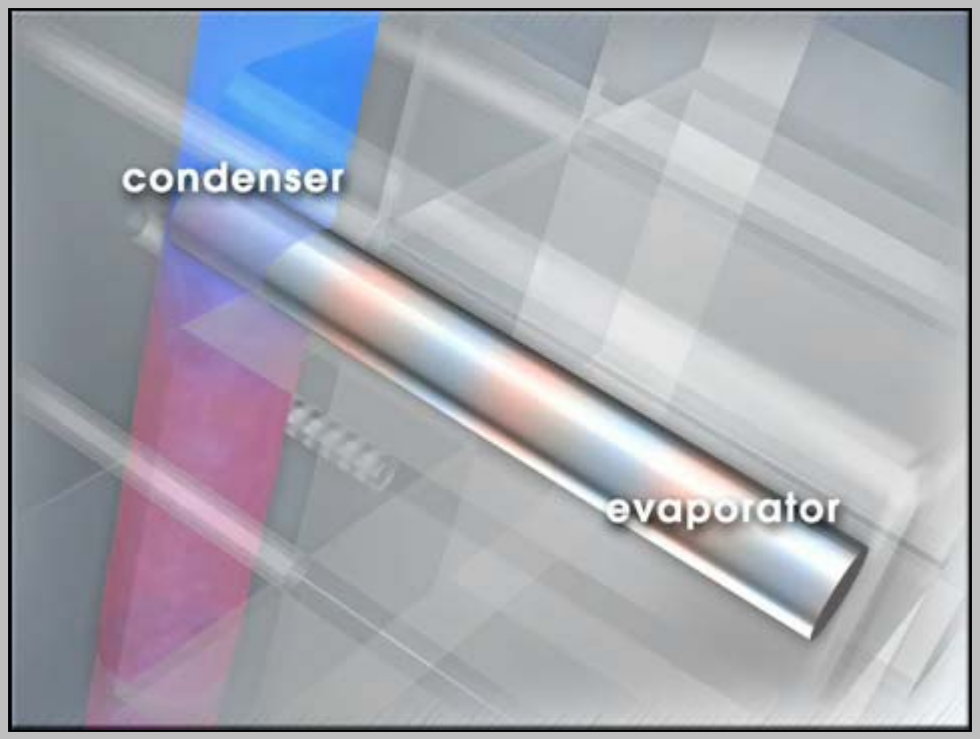
- accomodate water baffles or bubblers



Simplify Complex Cooling

Design Considerations:

- thermal pins are also great solutions



Simplify Complex Cooling

Design Considerations:

- incorporate stripper plates when possible

Simplify Complex Cooling

Design Considerations:

- incorporate mold designer when possible

Multi-Material

Many applications require different performance and appearance properties from the same part.

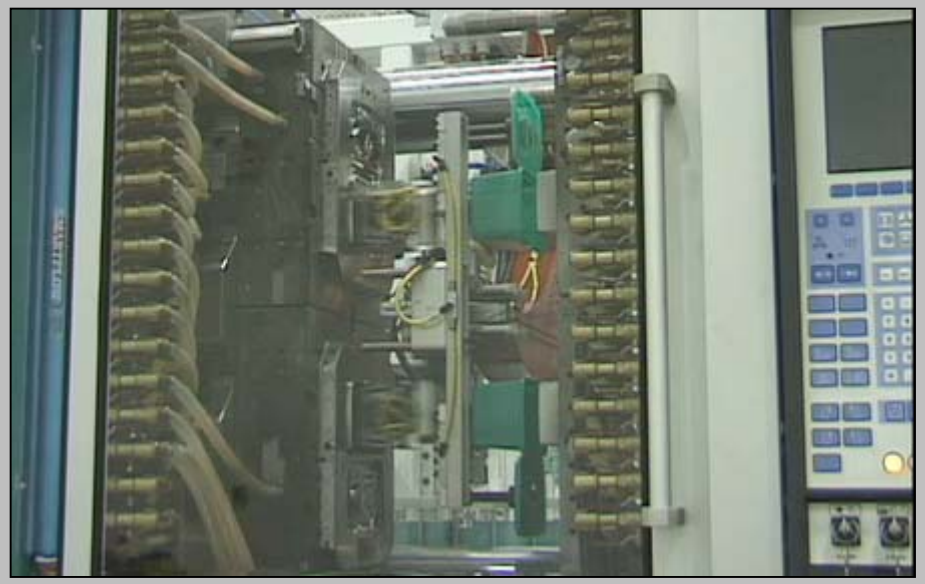
Multi-Material

As a result, companies often use an excessive amount of an inferior material to satisfy everything.

Multi-Material

Cycle Time Reduction Methods...

- Inserts
- Double-Shot Molding
- In-Mold Labelling
- Assembly



Inserts

Features can often be inserted:

- core inserts
- threaded inserts
- screws
- reinforcement

Inserts

Inserts do not only have to be metal:

- plastic
- graphite
- ceramics

Inserts

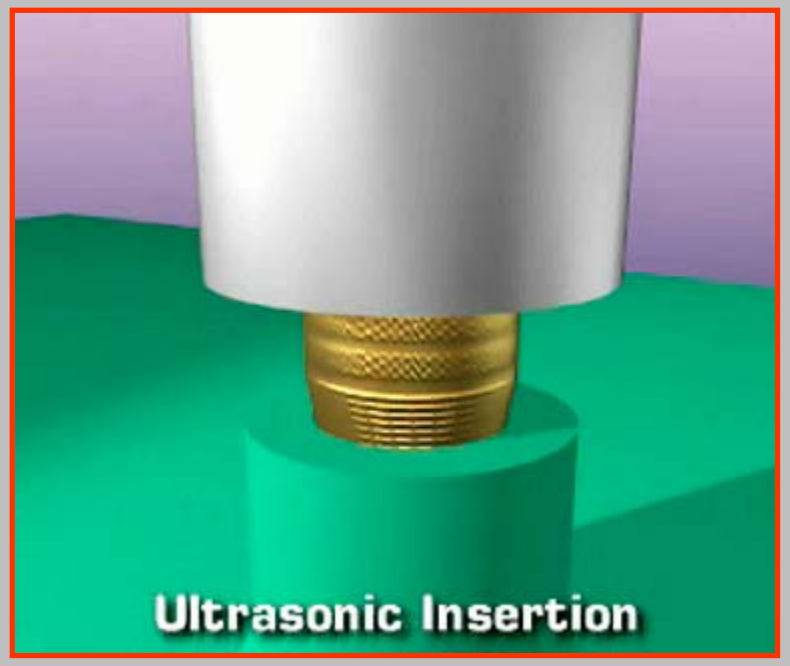
Can be added:

- during molding
  - overmolding
  - robotics
  - manual

Inserts

Can be added:

- after molding
  - snap fit
  - ultrasonic welding
  - assembly



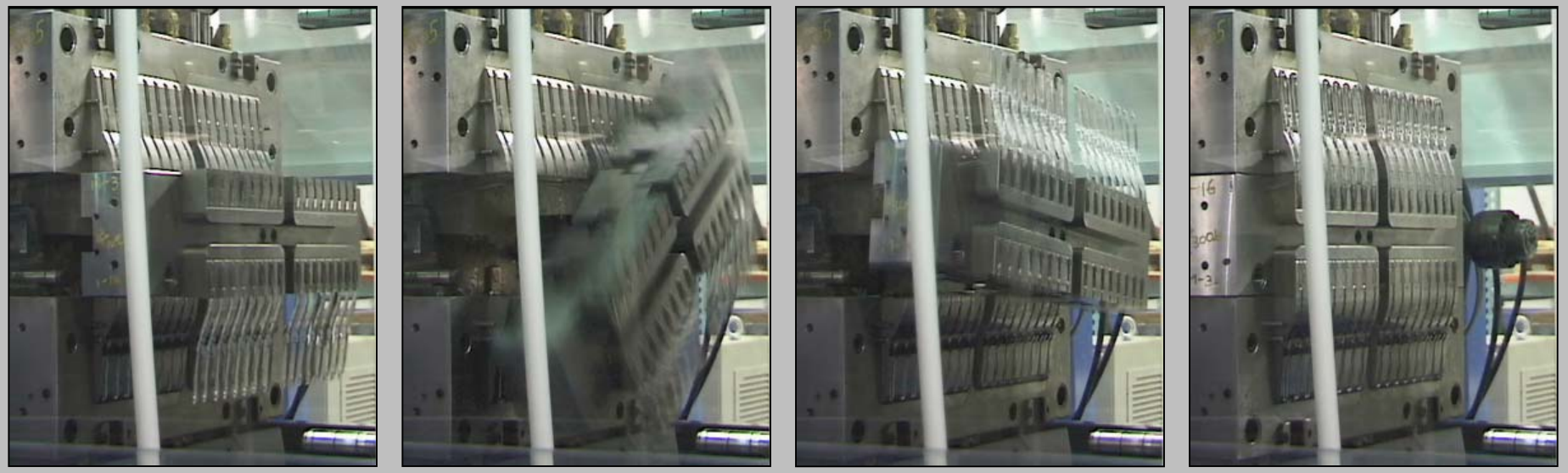
Double-Shot

- Rotary Mold
- Retractable Core

Rotary Mold

Two identical cores with different cavities:

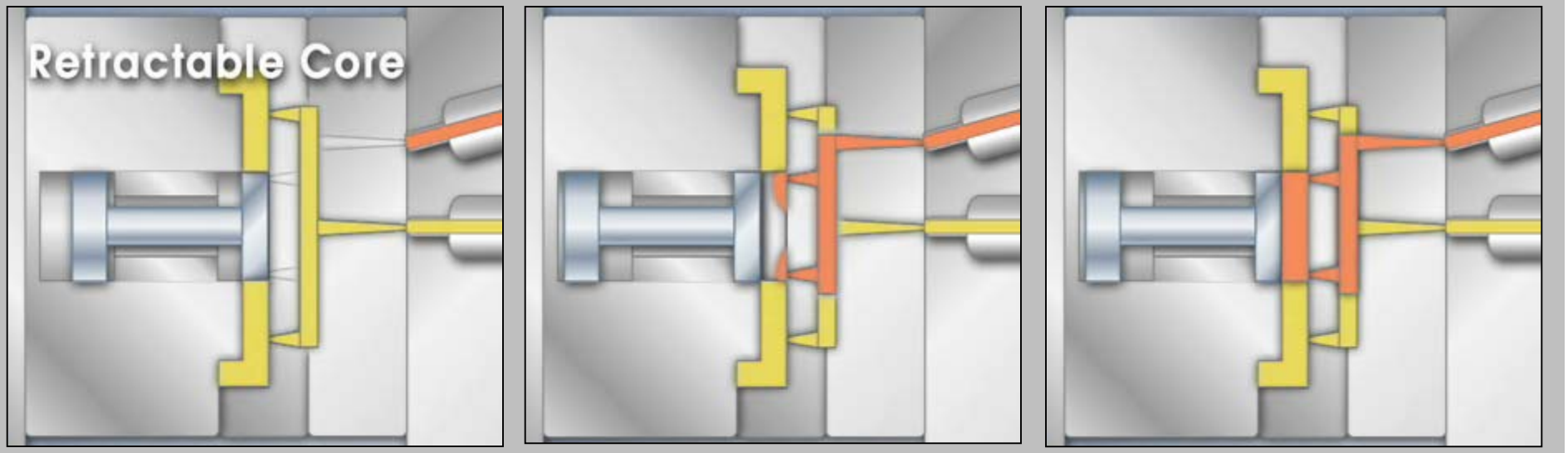
- molds cavity #1
- rotates
- over molds w/cavity #2



Retractable Core

Core can move back and forth:

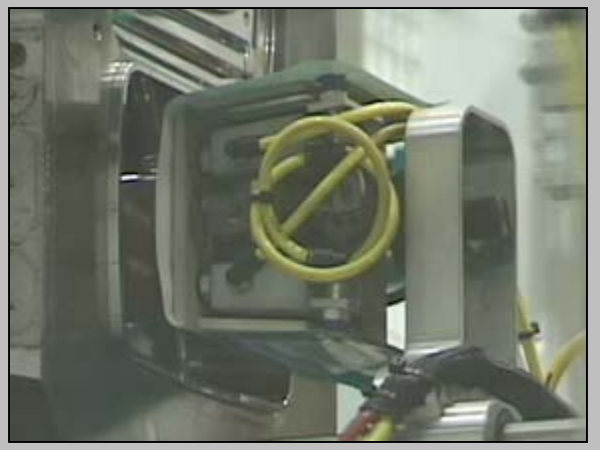
- 1st material is injected
- core retracts
- 2nd material is injected



In-Mold Labeling

Process:

- label or paint is applied
- mold is closed
- part is molded
- mold is opened
- part is removed



In-Mold Labeling

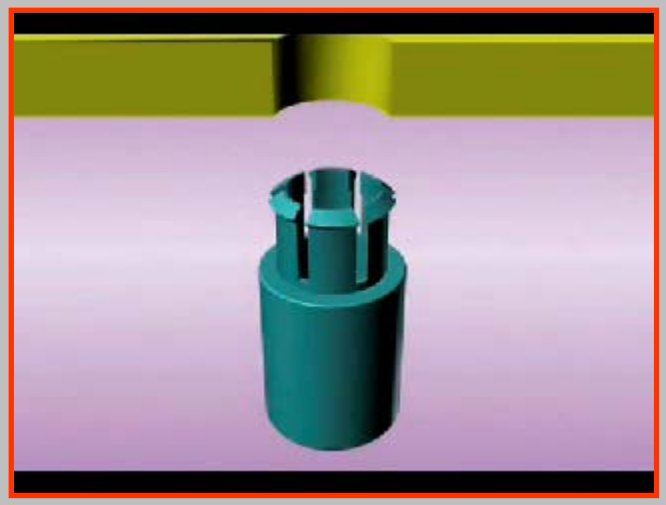
Benefits:

- improves appearance
- can be used with virtually any material
- reduces secondary operations

Assembly

Use many techniques:

- after molding
  - mechanical fasteners
  - snap fits
  - welding
  - adhesives



Assembly

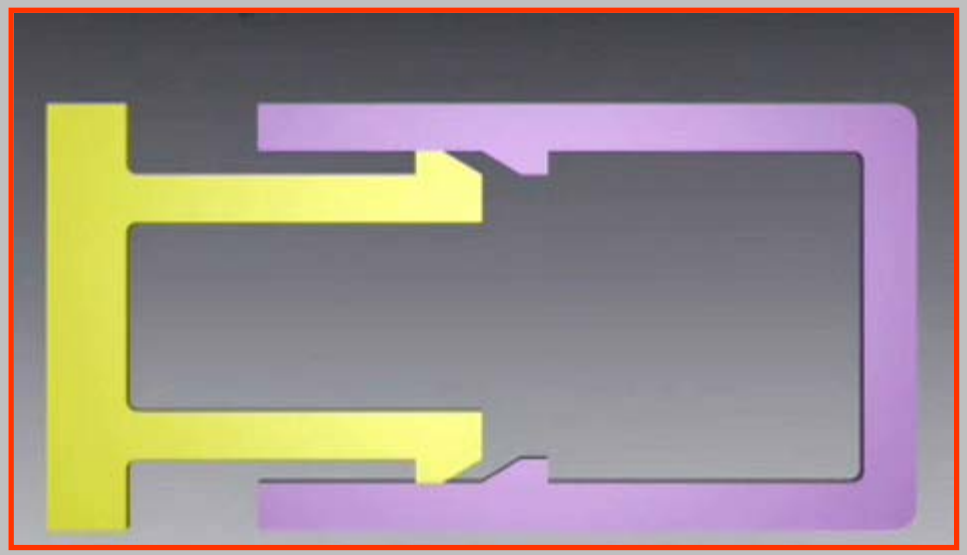
When designing for diassembly, avoid:

- irreversible fasteners

Assembly

When designing for diassembly, avoid:

- non-removable snap fits



Assembly

When designing for diassembly, avoid:

- adhesives

Assembly

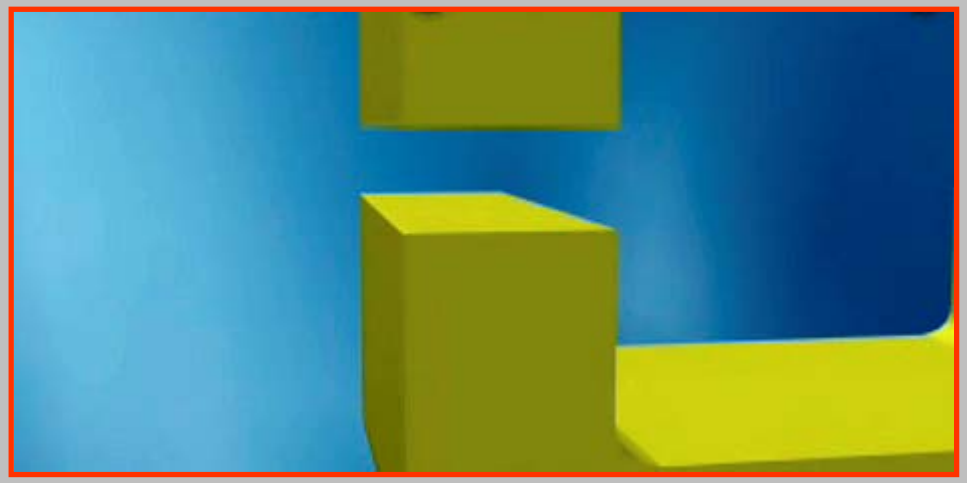
When designing for diassembly, avoid:

- plating

Assembly

When designing for diassembly, avoid:

- ultrasonic welding



Multi-Cavity

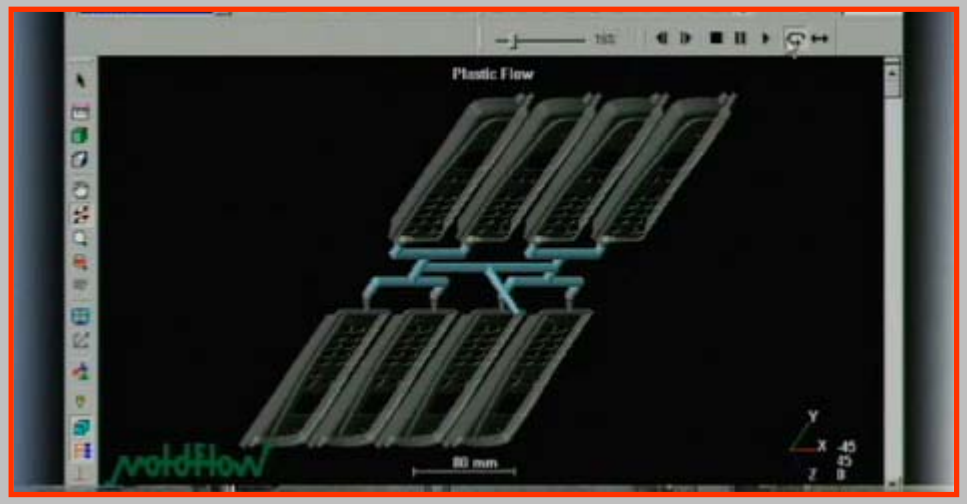
Design for multi-cavity use:

- reduces effective cycle time
- increases potential production capacity
- creates a buffer if cavity gets damaged

Multi-Cavity

Design for multi-cavity use:

- avoid sprue gates
- avoid excessive side actions
- simplify cooling



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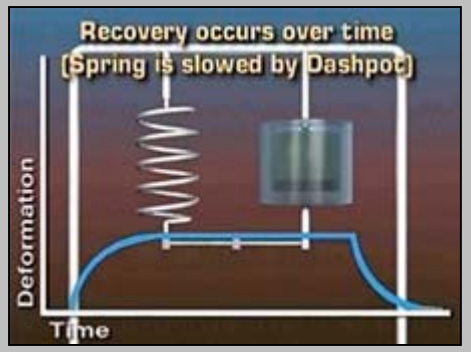

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Q & A Session

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