

Polymers & Manufacturing

Briefing Session 4

What are Plastics?

Plastics is a general term that describes materials composed of very large molecules called polymers that are synthetically made or modified from small components called monomers.

Plastics are solids that in some stage have been shaped by flow or molding in the liquid, molten or softened form.

Plastics are those materials which are considered to be plastics by common acceptance.

General characteristics of plastics materials

Versatility

Design Flexibility

Low specific gravity

Transparency

Colorability

Low energy requirements

Chemical resistance

Range of mechanical properties

Electrical insulation

Thermal insulation

Re-usability

Flammability

Poor weather resistance

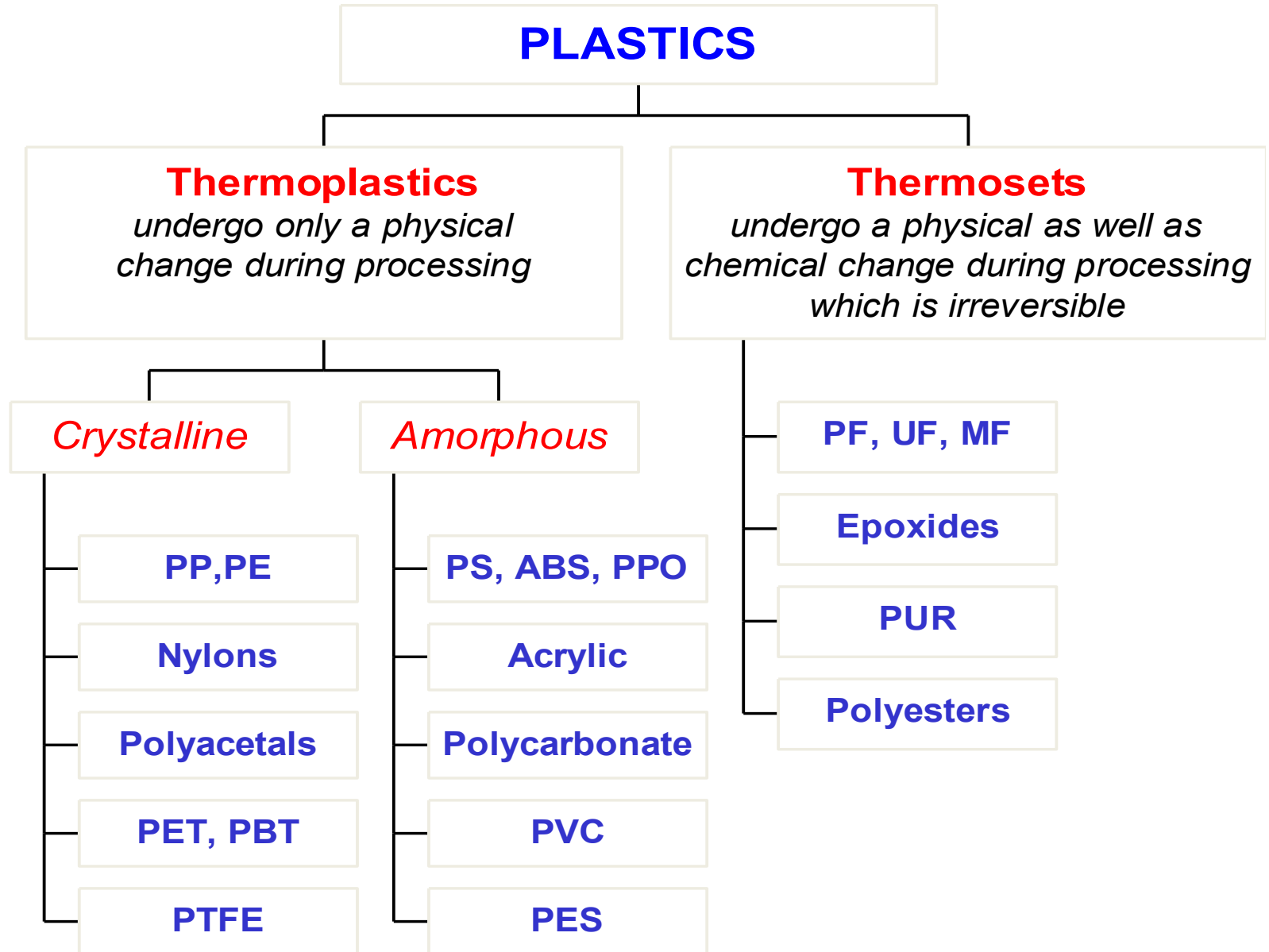
Thermal expansion

Polymers and Plastics

Although the words polymers and plastics are often used interchangeably, there is a distinction between the two. Polymer is the pure material which is the main end product of polymerisation. Pure polymers are seldom used on their own and it is when additives are present that the term plastic is applied.

PLASTIC = POLYMER + ADDITIVES

Classification of plastics



Thermoplastics vs Thermosets

Thermoplastics

- Processing is reversible change --> Recyclable
- Lower total part cost
- *Greater design freedom due to higher ductility*
- *Stable Electrical Properties*

Thermosets

- Processing is irreversible change --> Not Recyclable
- Lower Material Cost
- *High Heat/Creep resistance*
- *High arc resistance*

THERMOPLASTICS

Commodity thermoplastics

Polyolefins
LDPE, HDPE, PP

Styrenics
PS, HIPS, ABS, SAN

Vinyl chlorides
PVC, PVDC

Ethylene copolymers
EVA

Others
PMMA, Cellulosics

Engineering thermoplastics

Polyamides
Nylon-6, Nylon-66

Polyacetals
Homopolymers, copolymers

Polyphenylenes
PPE, PPS

Polycarbonate

Thermoplastic Polyesters
PET, PBT

Speciality plastics

Polyethers
PES, PEK, PEEK

Polyimides
PEI, PI, PAI

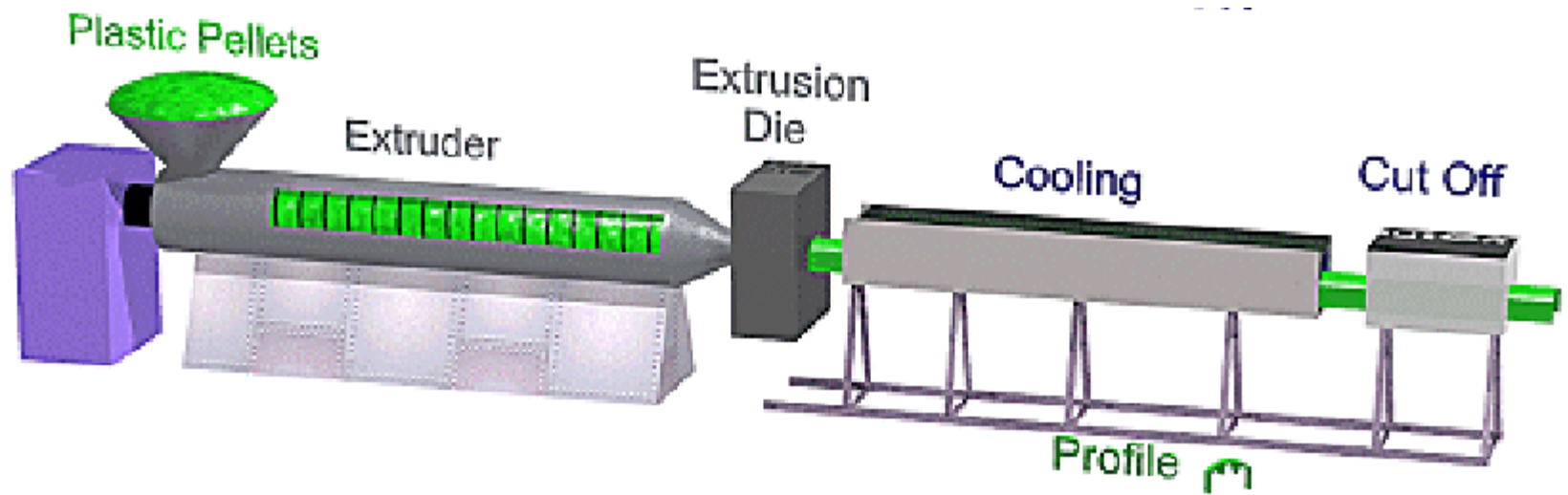
Fluoropolymers
PTFE, FEP

Manufacturing Plastics

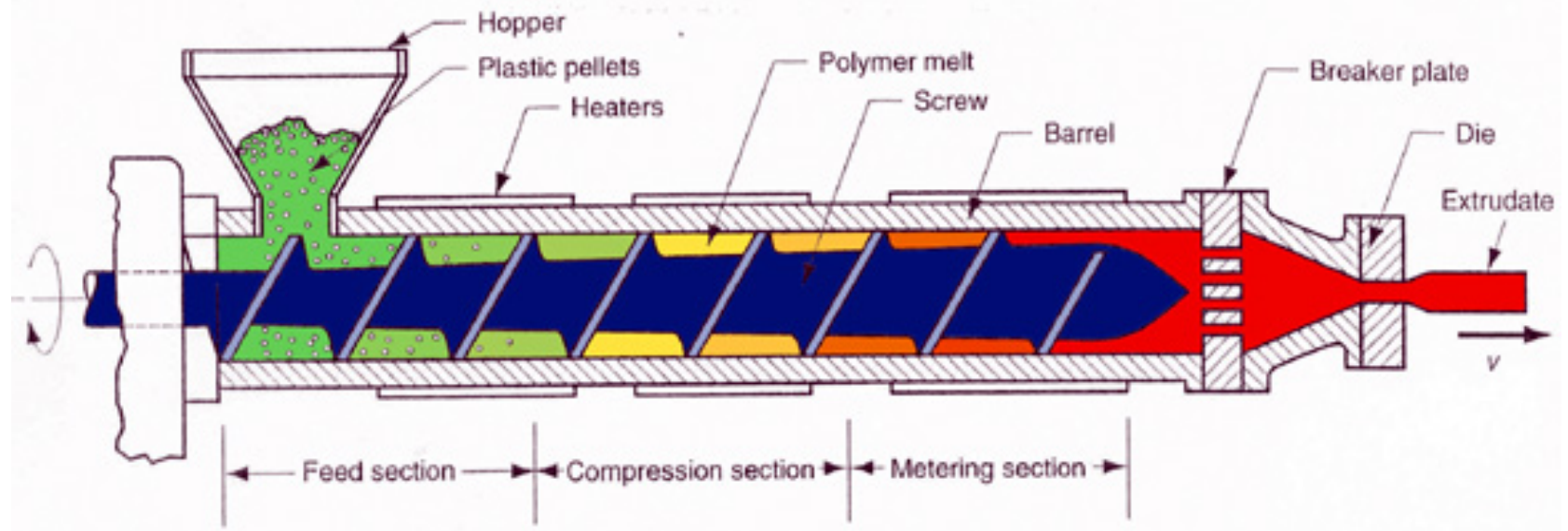


Raw Materials

Extrusion

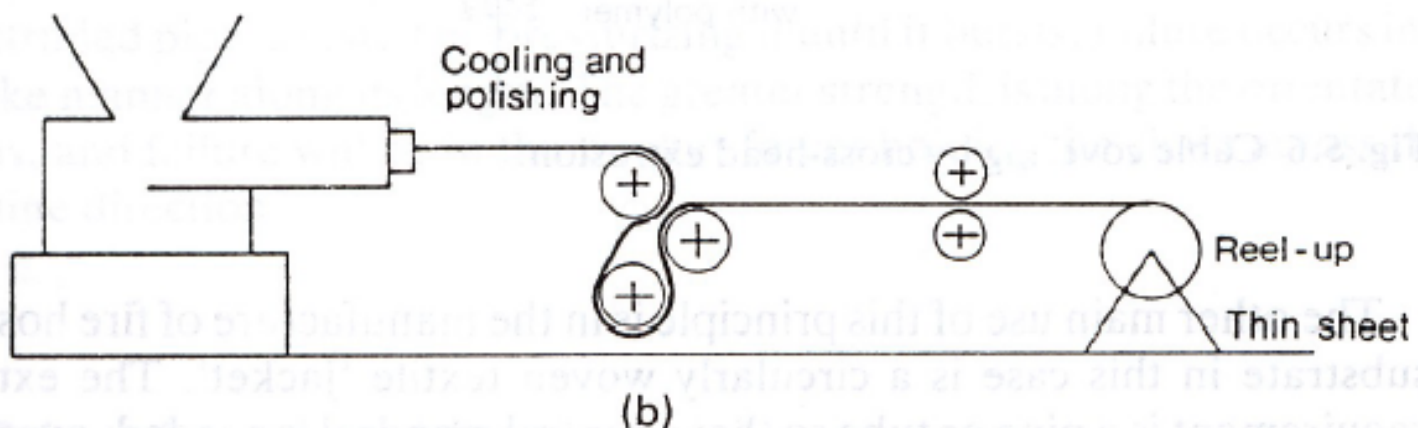
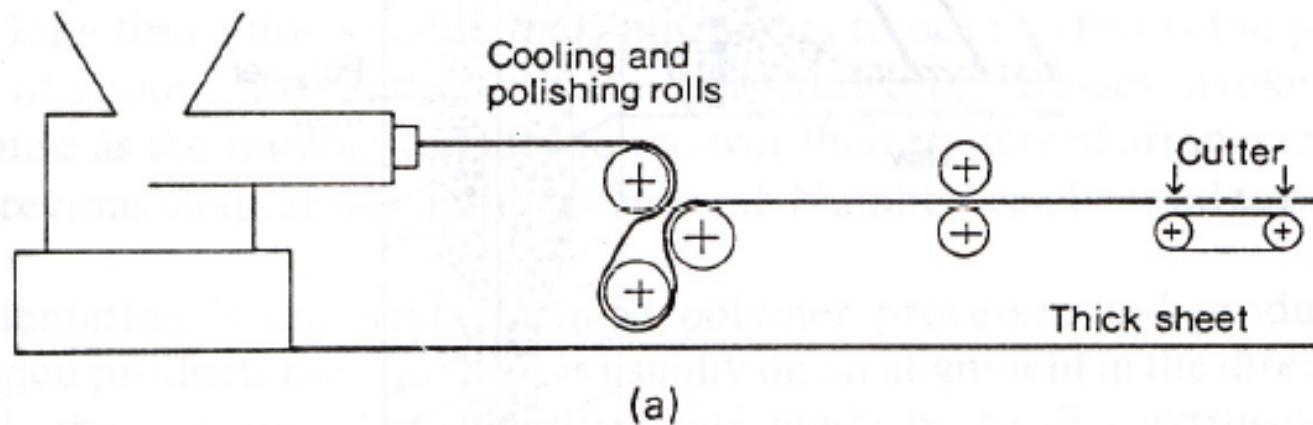


Manufacturing Plastics



Extrusion

Sheet extrusion



Film thickness: 0.5 – 20 mil (1 mil = 0.001 inch)

Extrusion blow molding

Typical products

Bottles and containers

Automotive fuel tanks

Venting ducts

Watering cans



Pipe extrusion

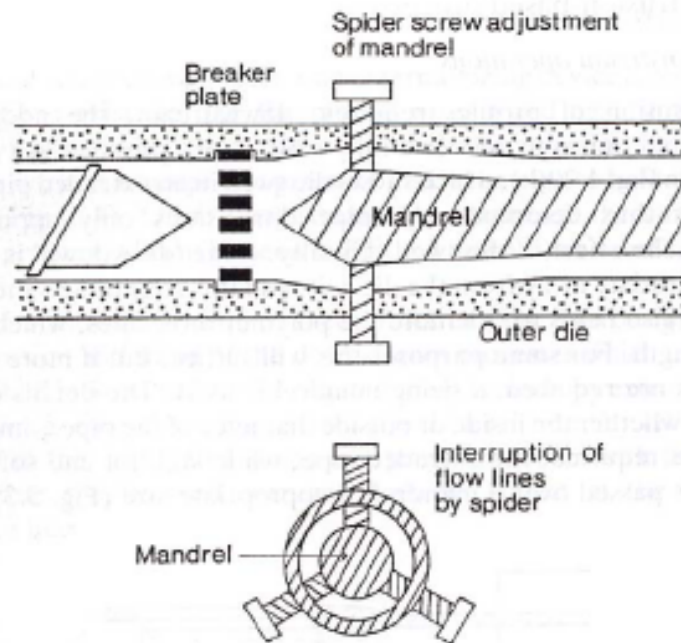
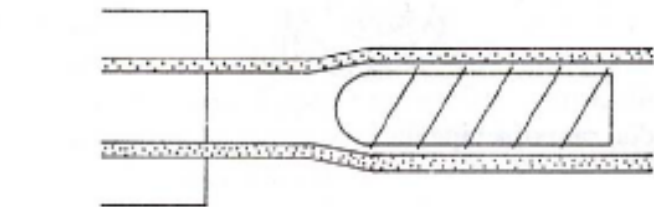
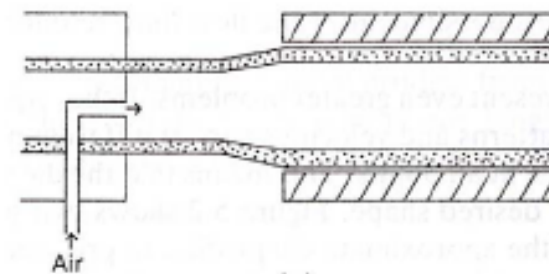


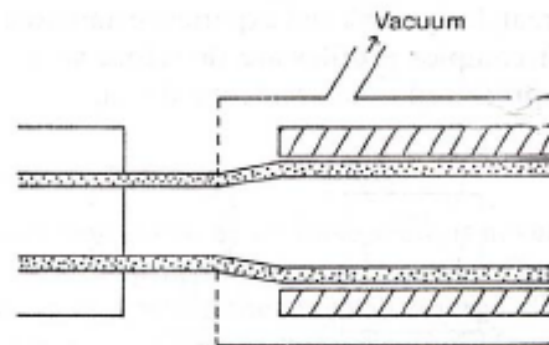
Fig. 5.1 Schematic diagram of a pipe die.



extrusion: internal sizing mandrel.

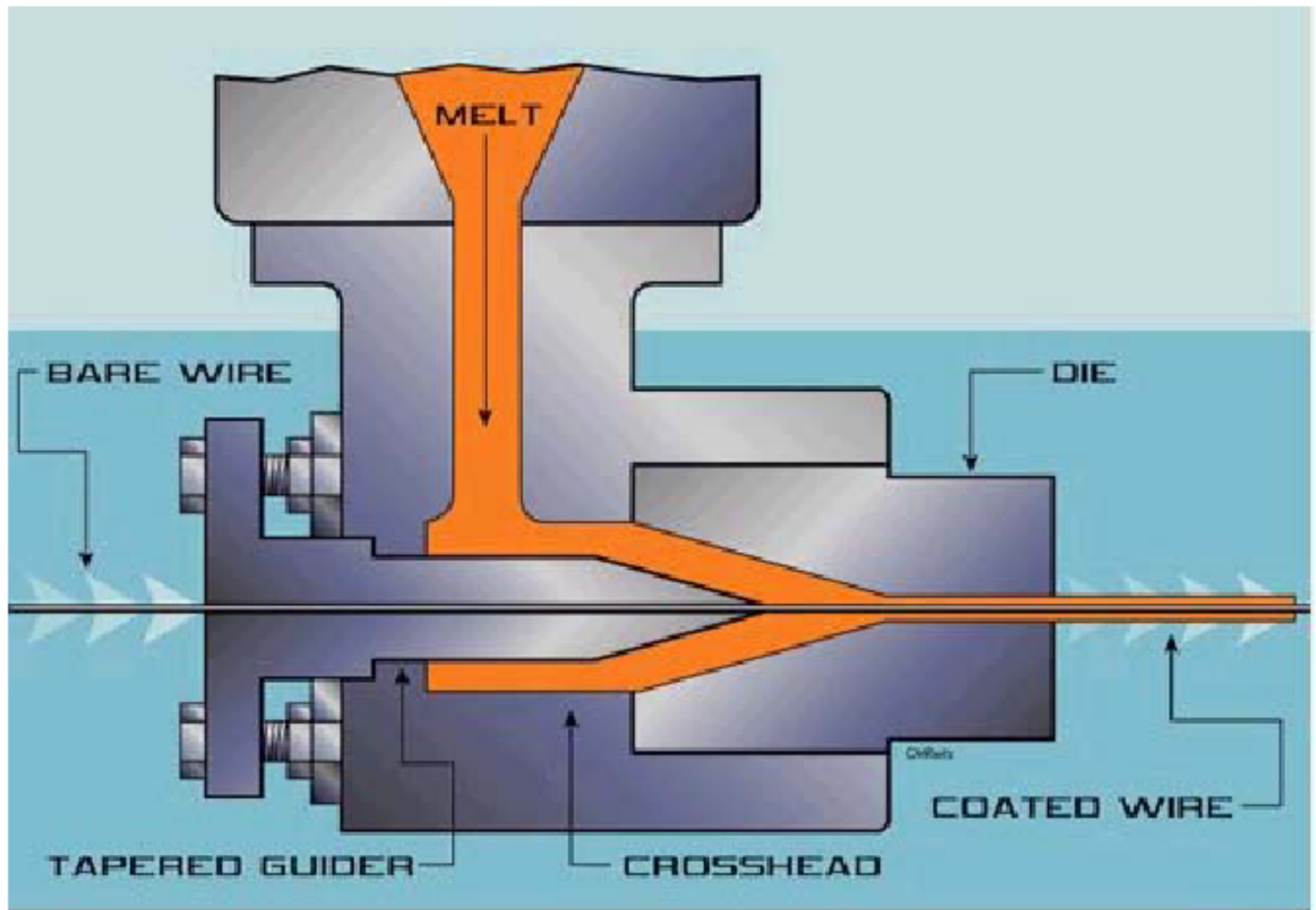


(a)



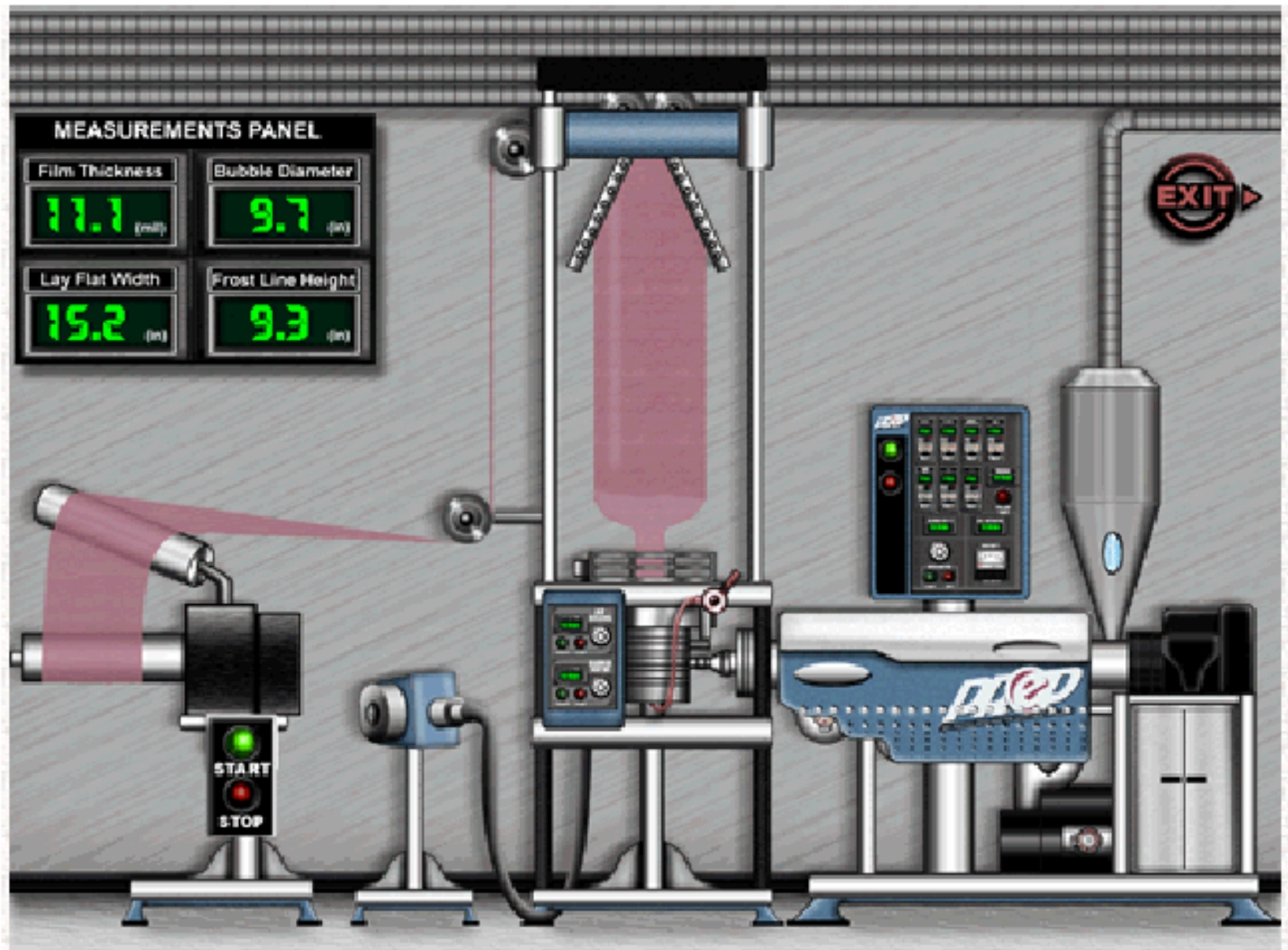
(b)

Fig. 5.4 Pipe extrusion – external sizing: (a) pressure sizing; (b) vacuum sizing.



WIRE COATING IN MELT

Tubular blown film extrusion



Injection Molding

- Injection molding is the most important process used to manufacture plastic products.
- More than one third of all thermoplastic materials are injection molded.
- It is ideally suited to manufacture mass-produced parts of complex shapes that require precise dimensions.

Injection Molding

Most common method for plastics and works at high Pressures (70 to 200 MPa)

Single or multiple parts can be produced in one cycle (Typical cycle times of 5 to 60 secs)

Size of parts are usually small but sometimes large

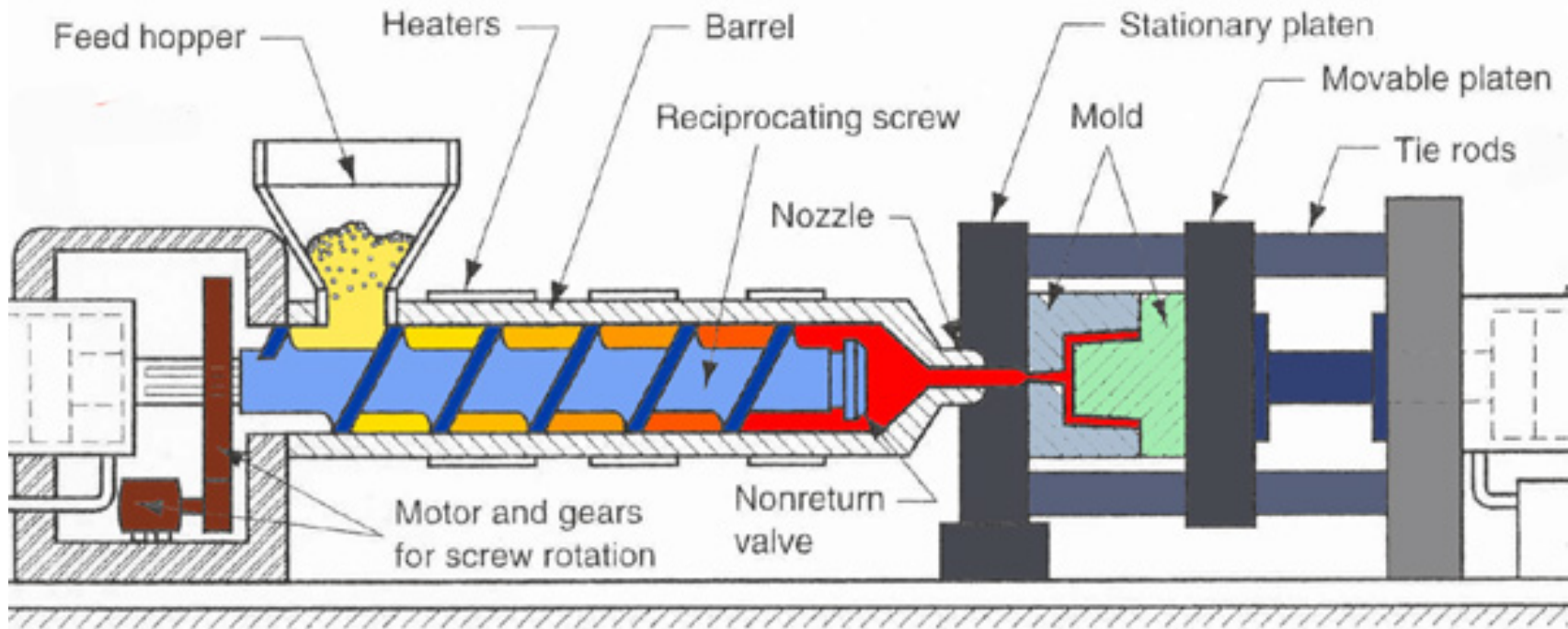
Thermoplastics are more commonly injection molded than thermosets

Temperature, pressure and velocity are important which dictate mechanical properties

Mold is an important part of system which has cavity corresponding to geometry of the part and are subjected to high pressures and temperatures

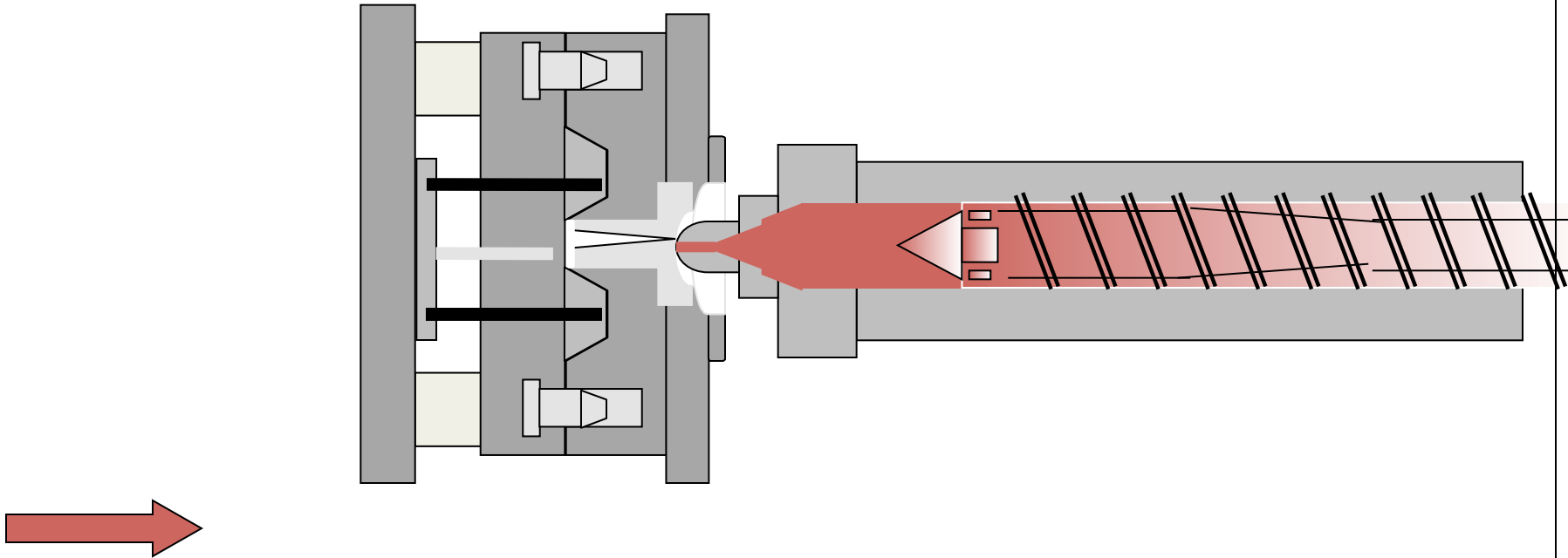
Injection molding machine is specified by its clamping force

Manufacturing Plastics

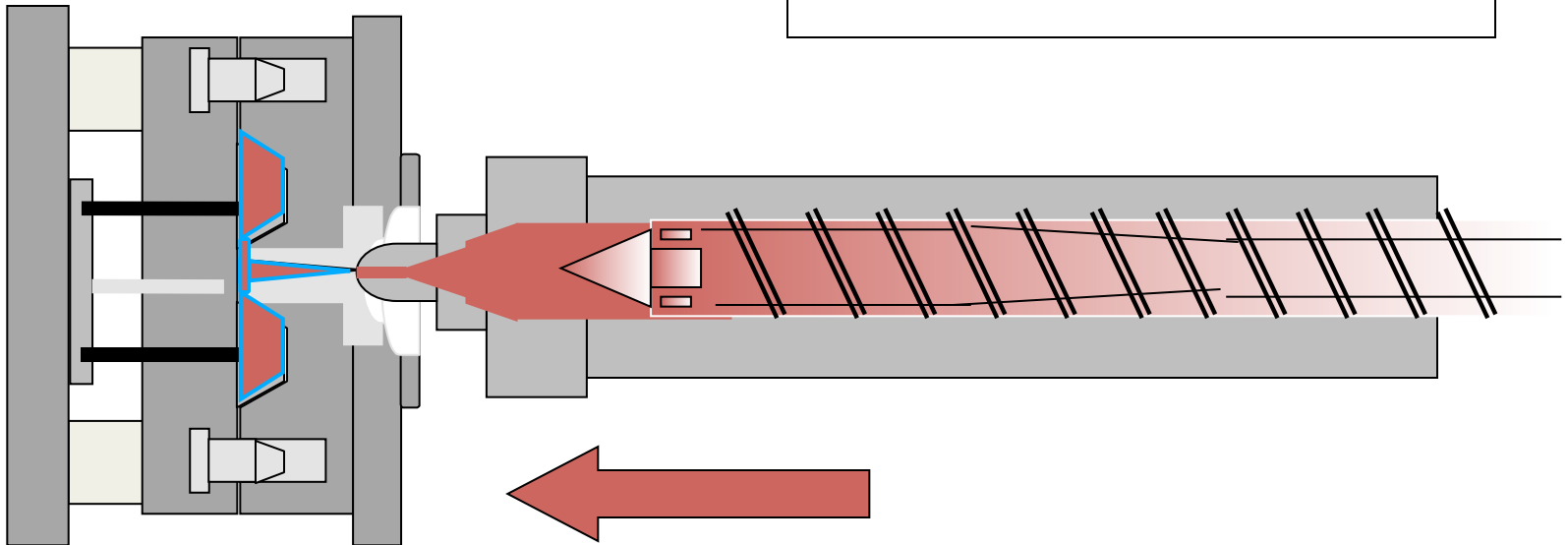


Injection Molding

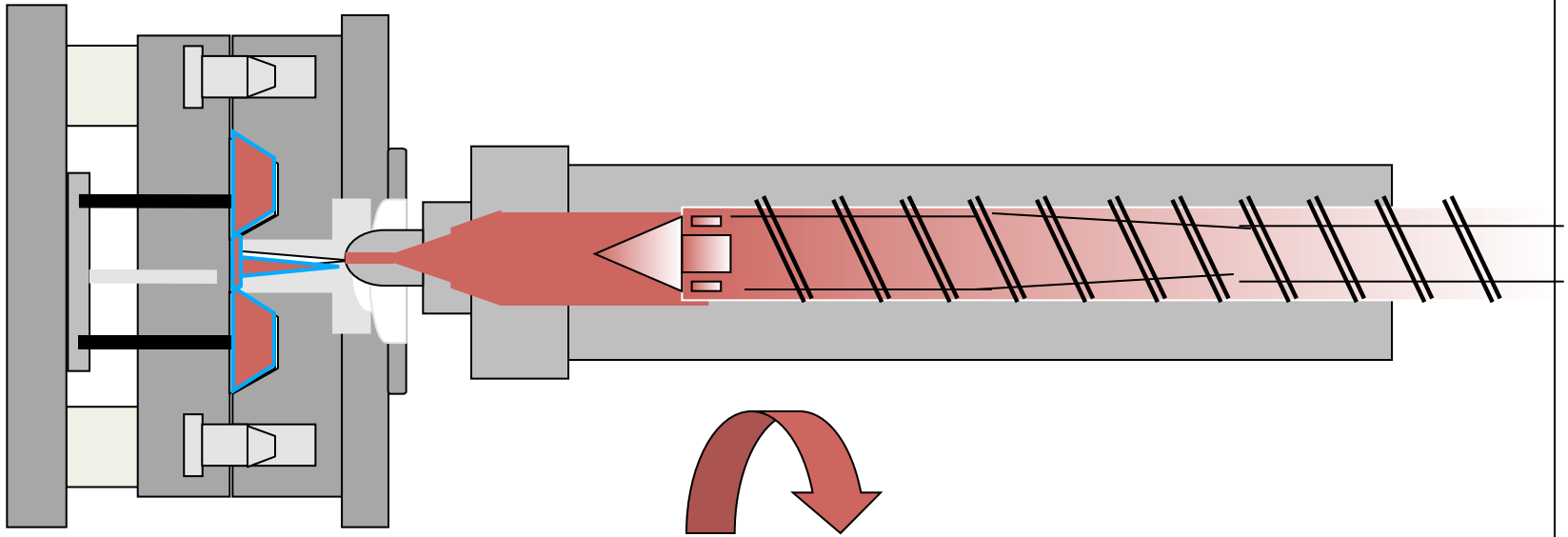
Mould Close & IU Forward



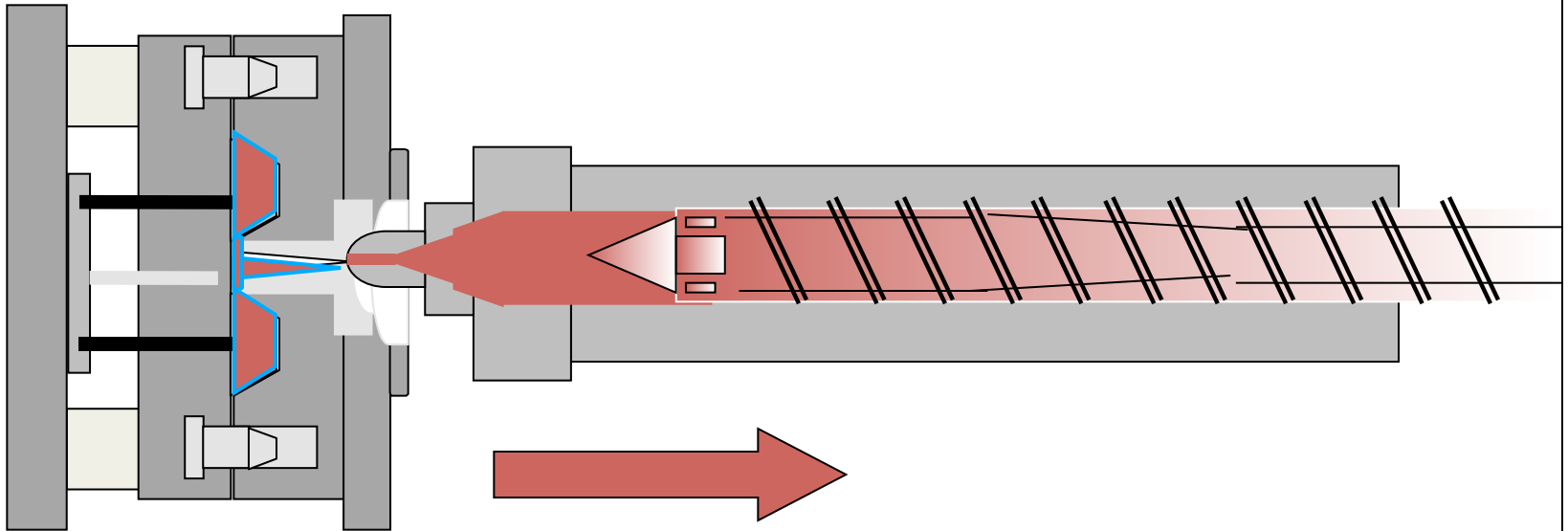
INJECTION AND HOLDON



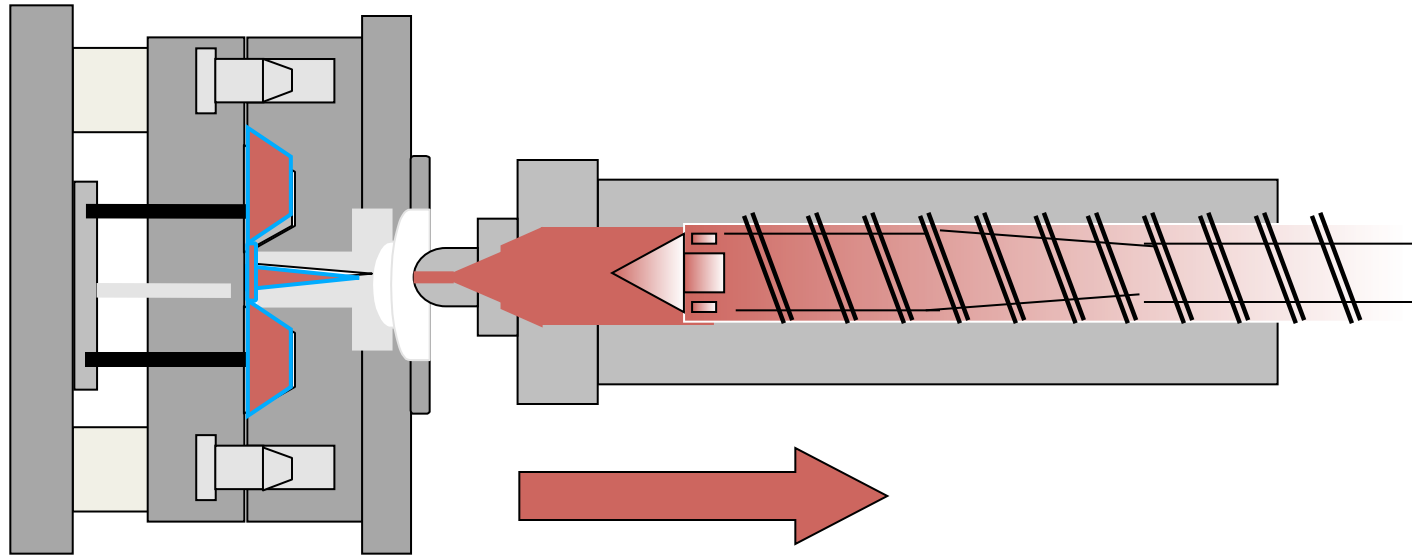
DOSING



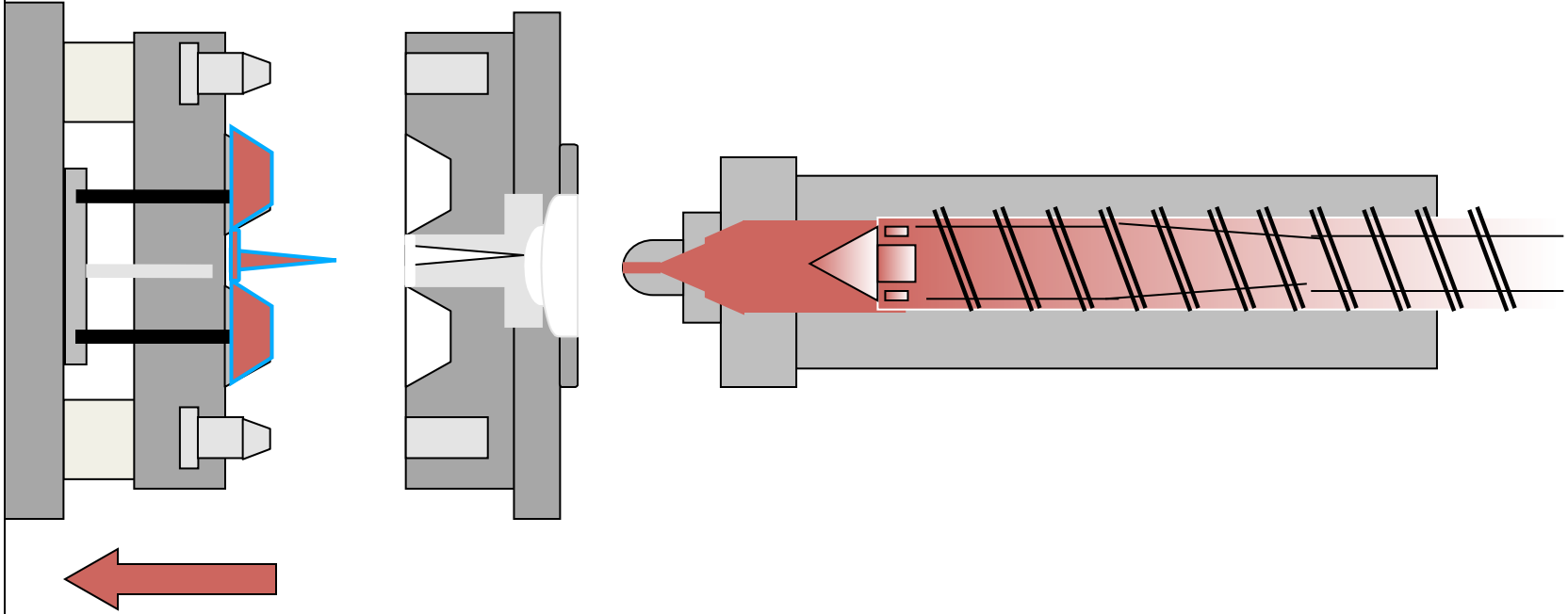
SUCK BACK



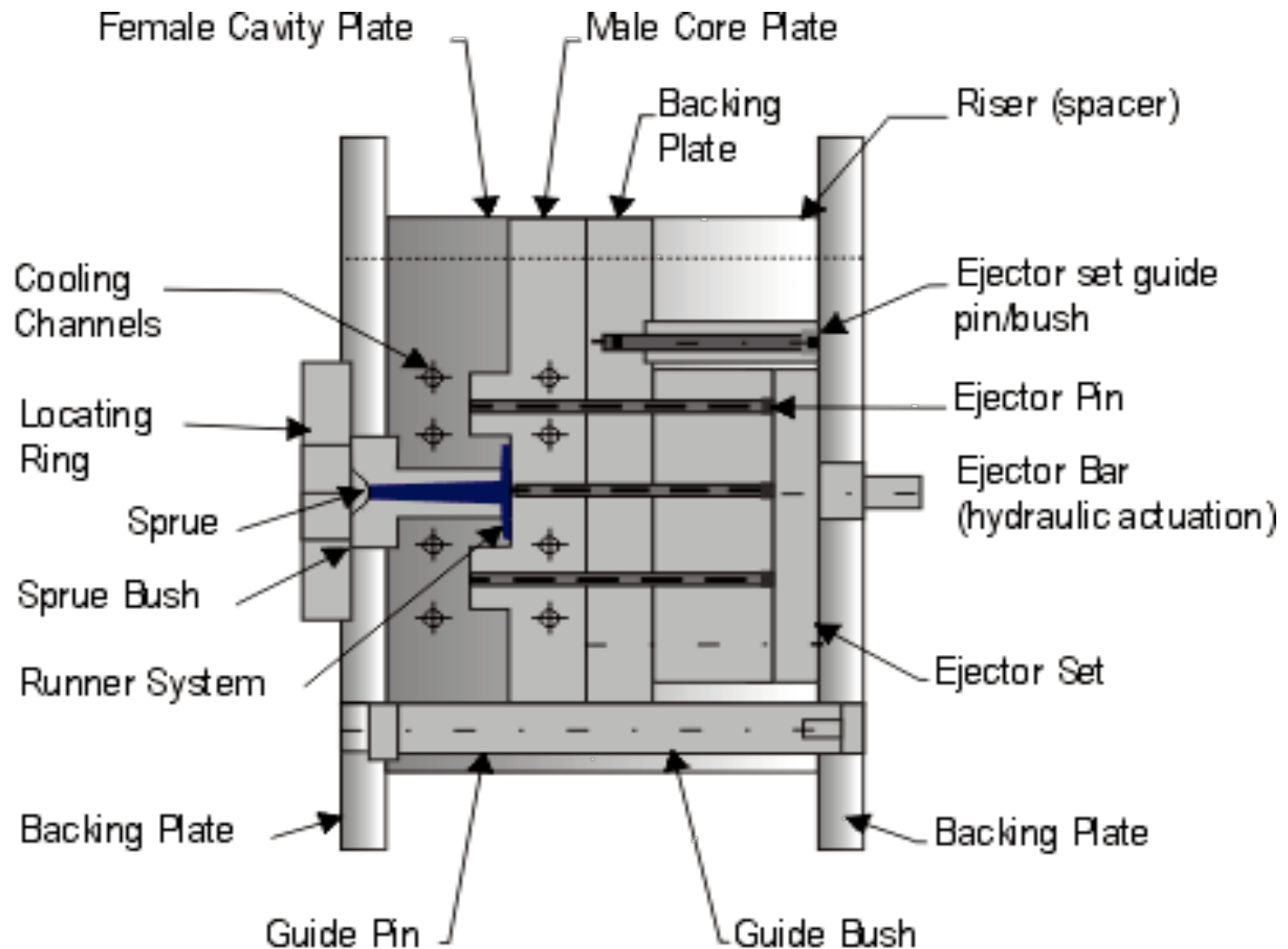
INJECTION UNIT RETRACT



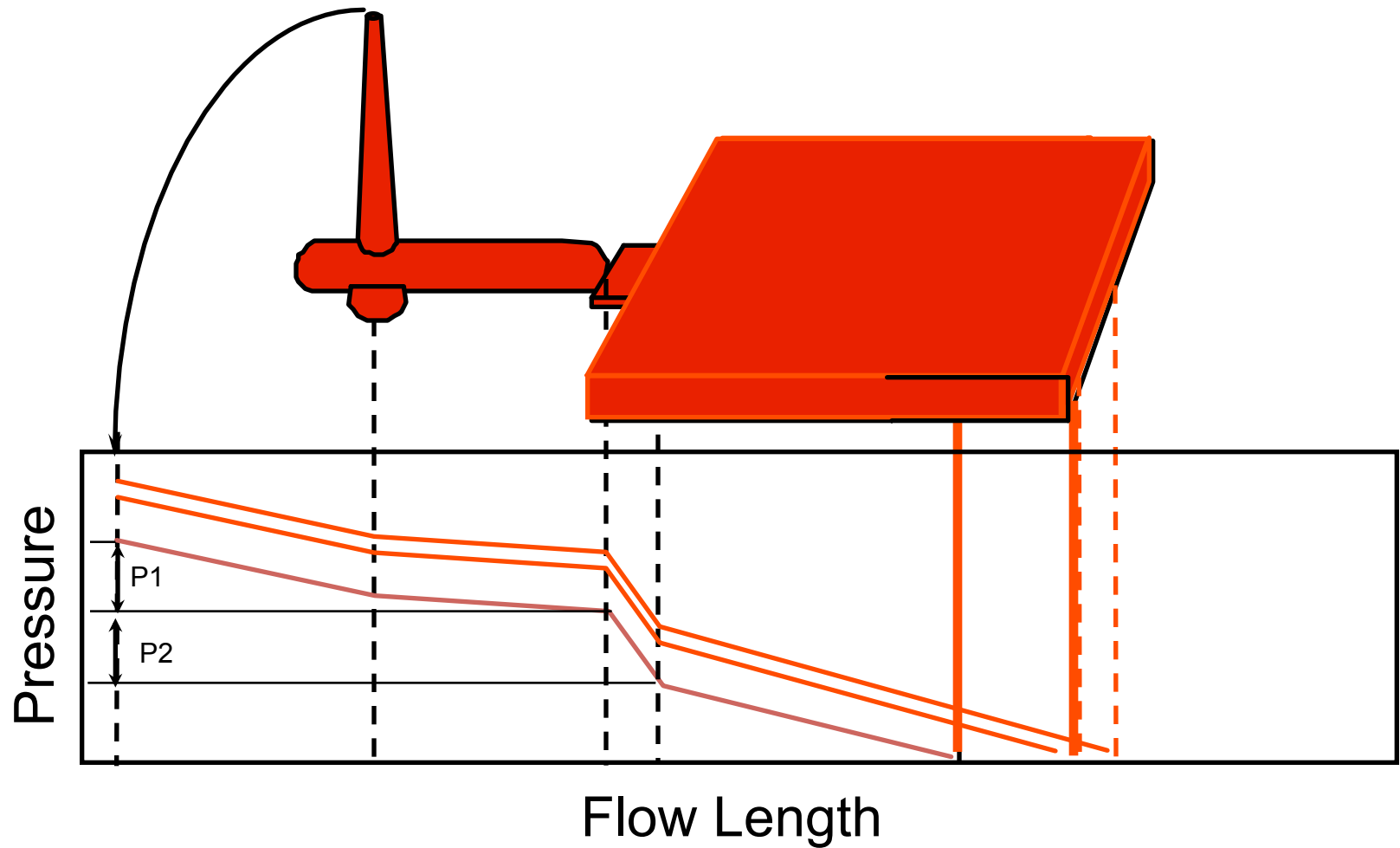
MOULD OPEN



Basic Structure of an Injection Mold



Pressure Requirements



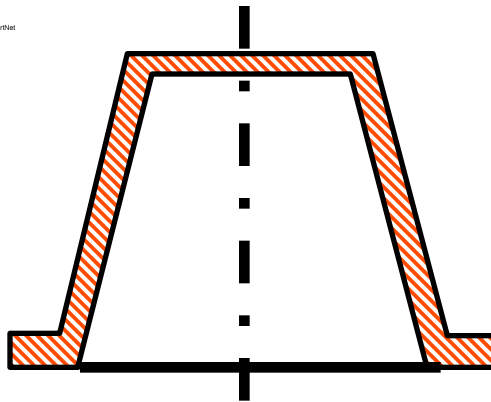
Part Design Impact

Wall Thickness

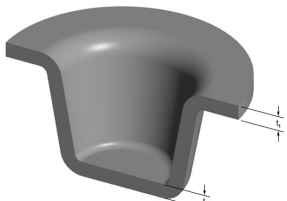


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Thin Part

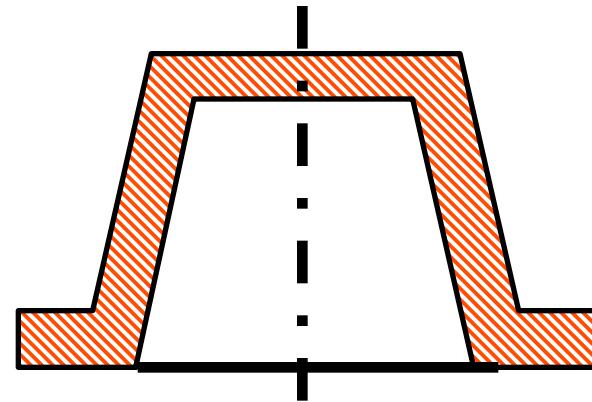


Higher
Pressure

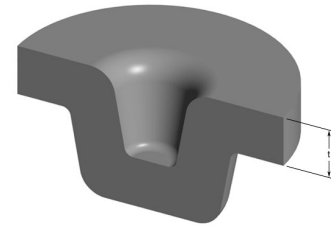


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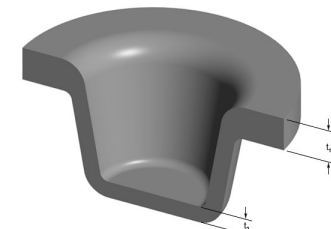
Thick Part



Lower
Pressure

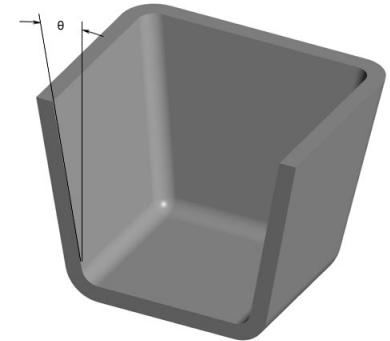
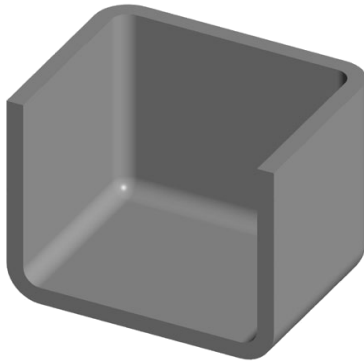


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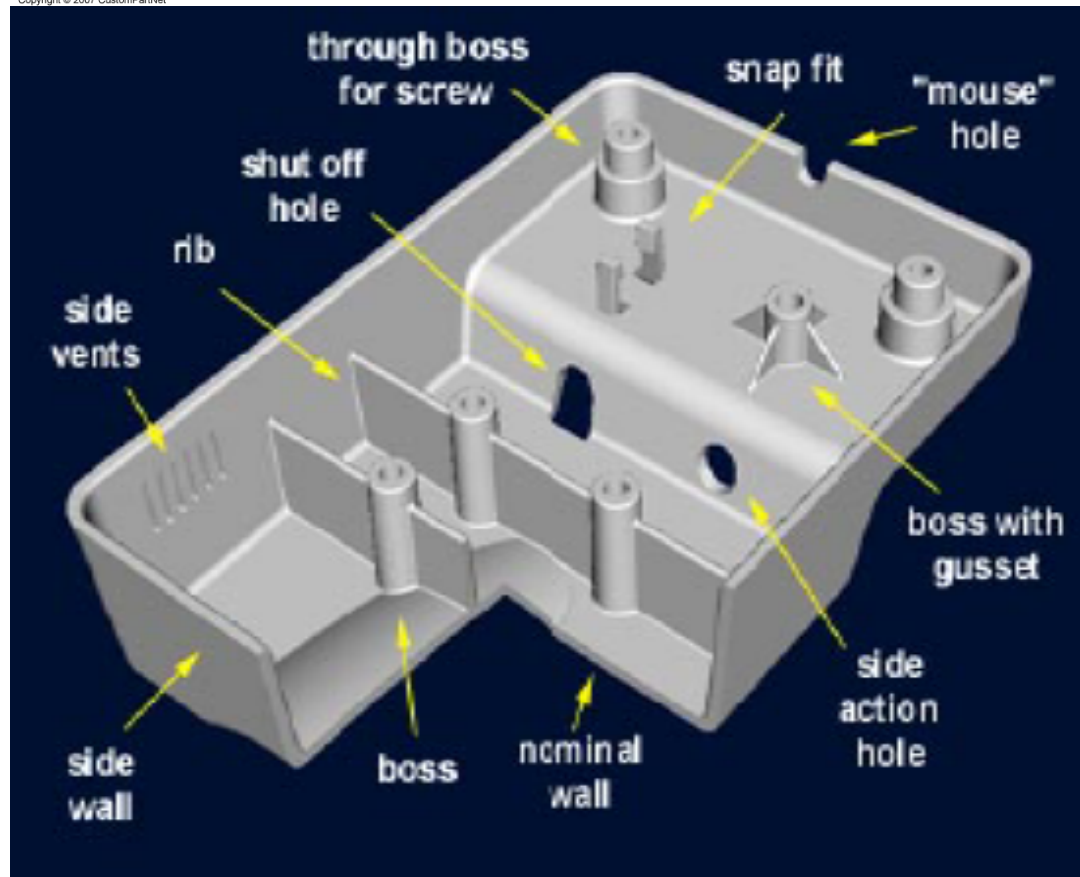
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Part Design for Injection Molding - Draft

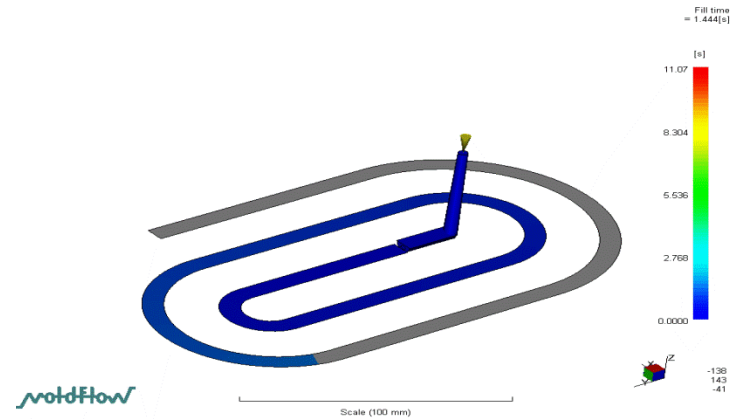


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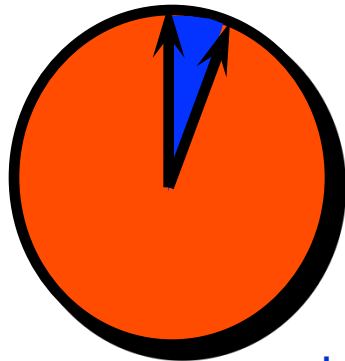
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Process Impact Fill Time

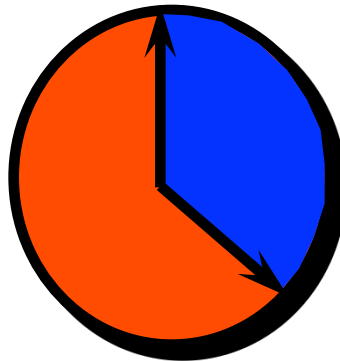


Too Short

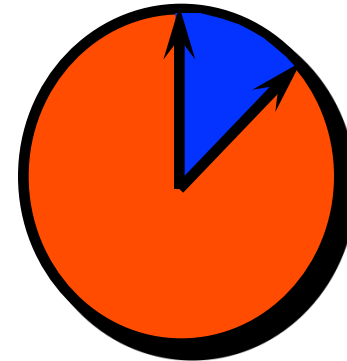


Higher Pressure

Too Long

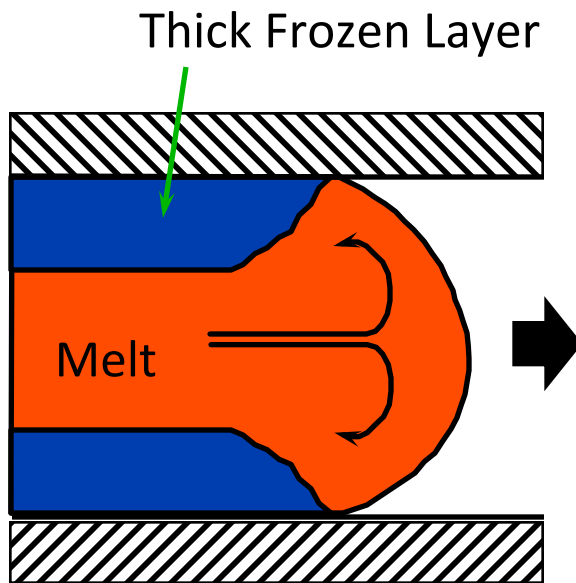


Optimal Fill Time

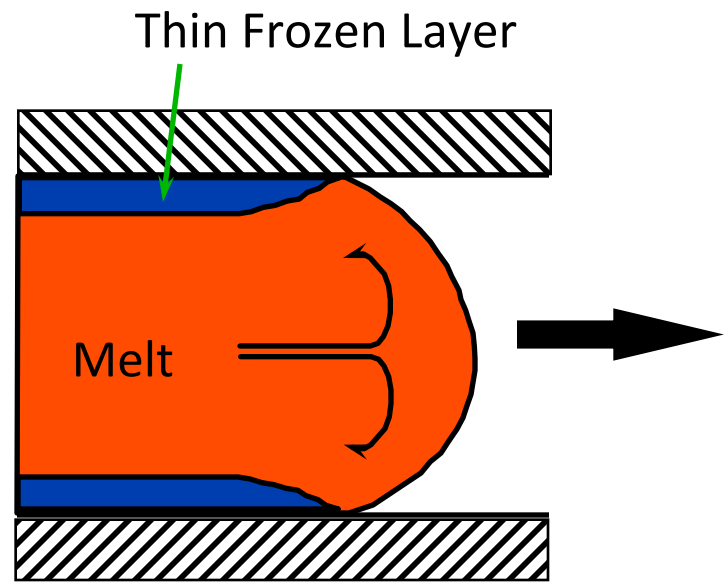


Lower Pressure

Slow vs. Fast Fill Time



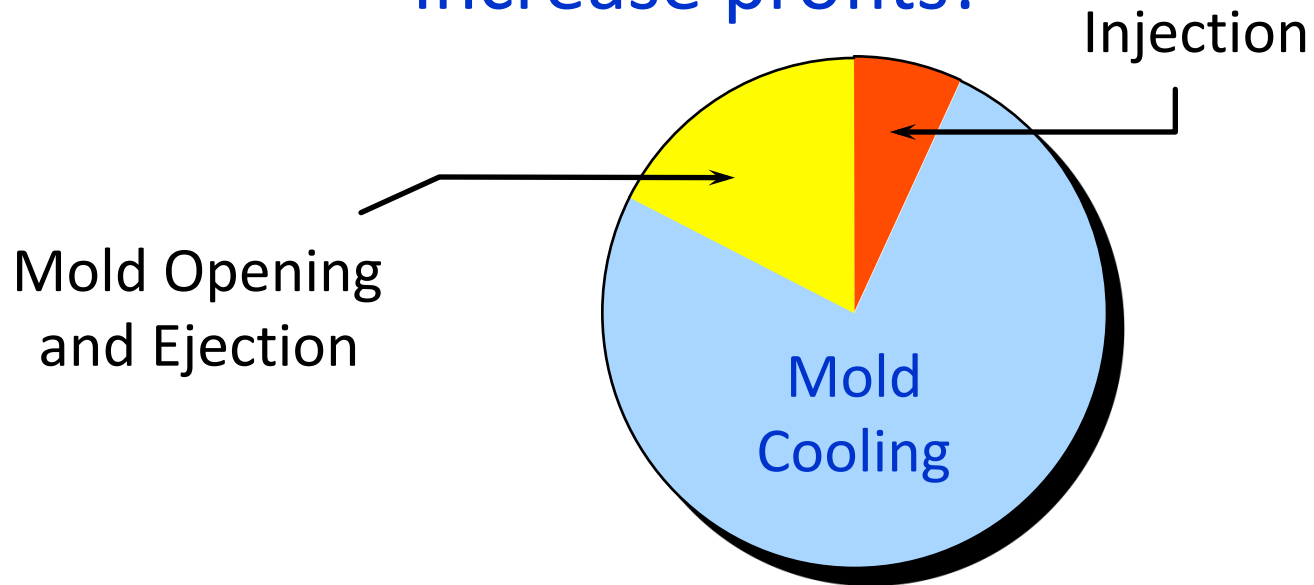
Long Fill Time
Low Injection Speed



Short Fill Time
High Injection Speed

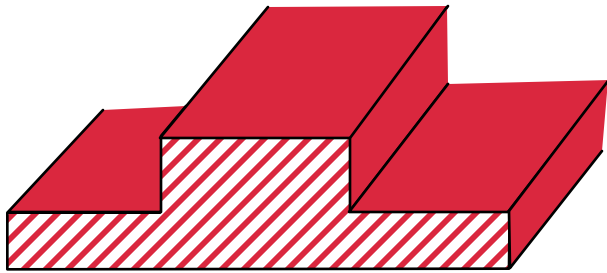
How Cooling Affects the Cycle Time

Reduce Cooling Time
Reduce Cycle Time
Increase profits!

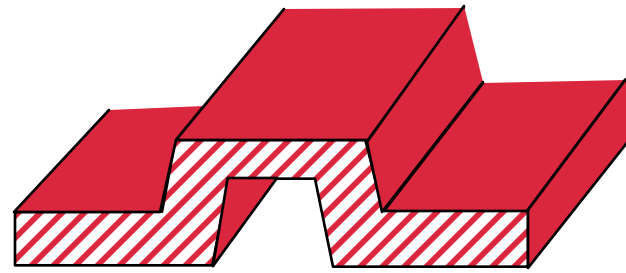


How Wall Thickness Impacts Cooling Time

Cooling Time $\sim \frac{(\text{Heaviest Wall Thickness})^2}{\text{Thermal Diffusivity of the Melt}}$

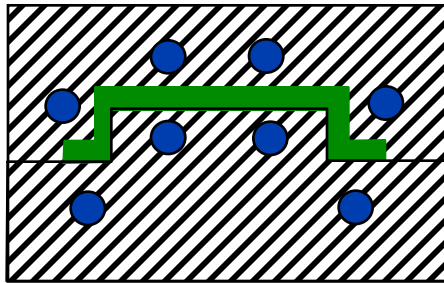


Original Design

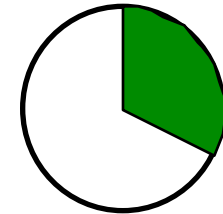
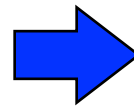


Better Design

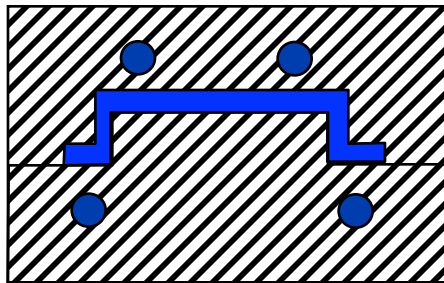
Good Cooling vs. Bad Cooling



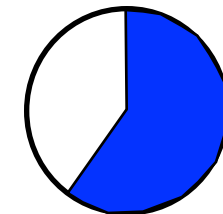
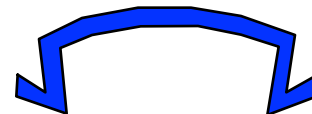
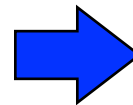
Proper
Cooling



Better Part
in Shorter Time



Poor
Cooling

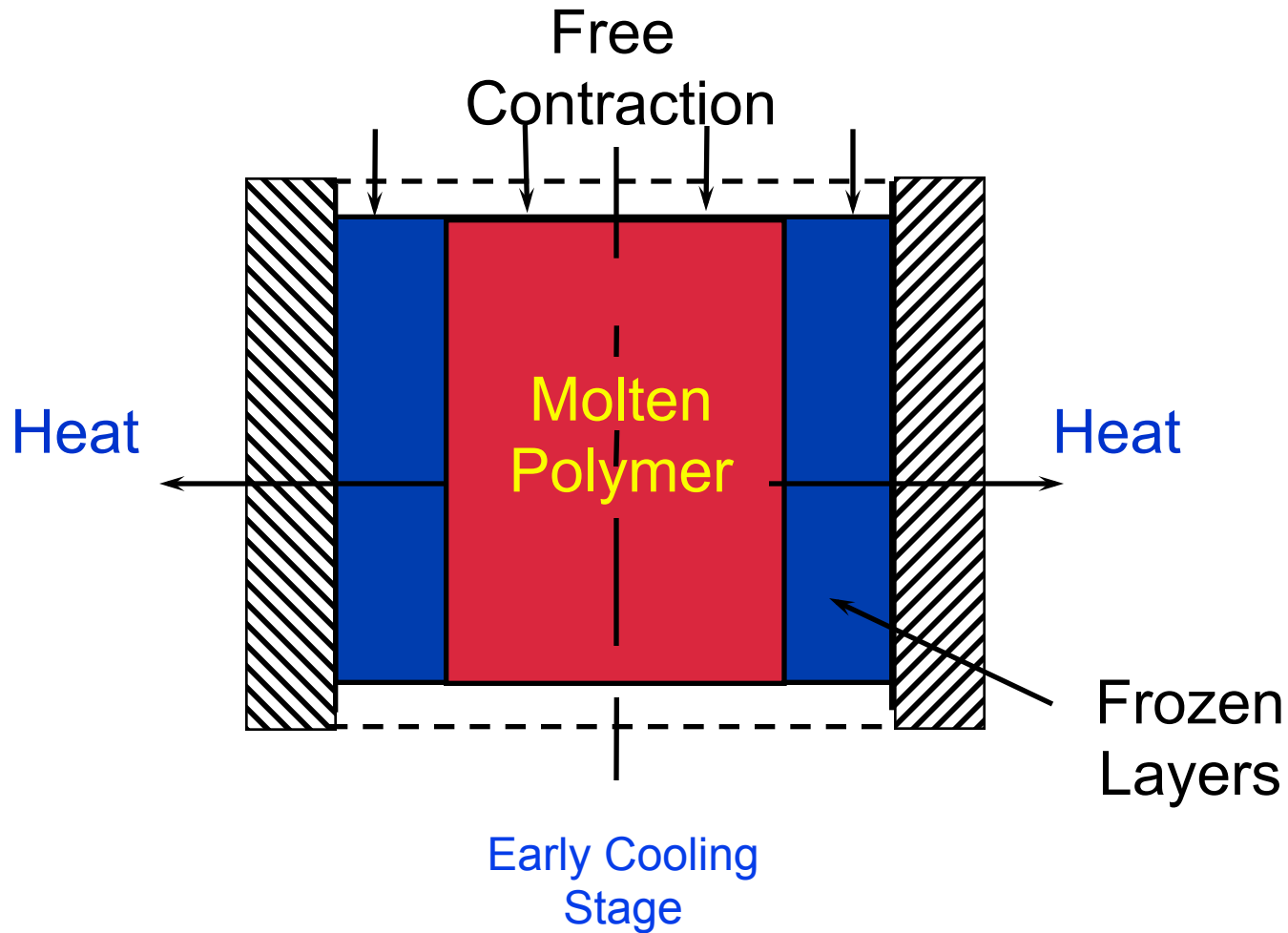


Poor Part
in Longer Time

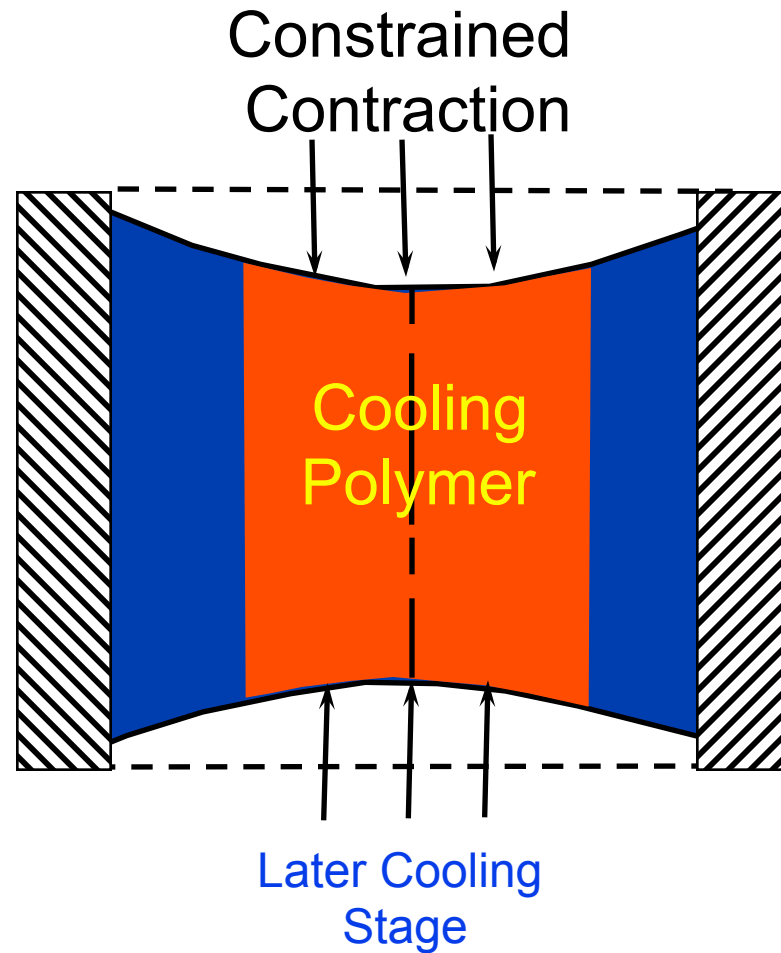
Residual Stress

What Causes Residual Stress?
Unbalanced Residual Stress

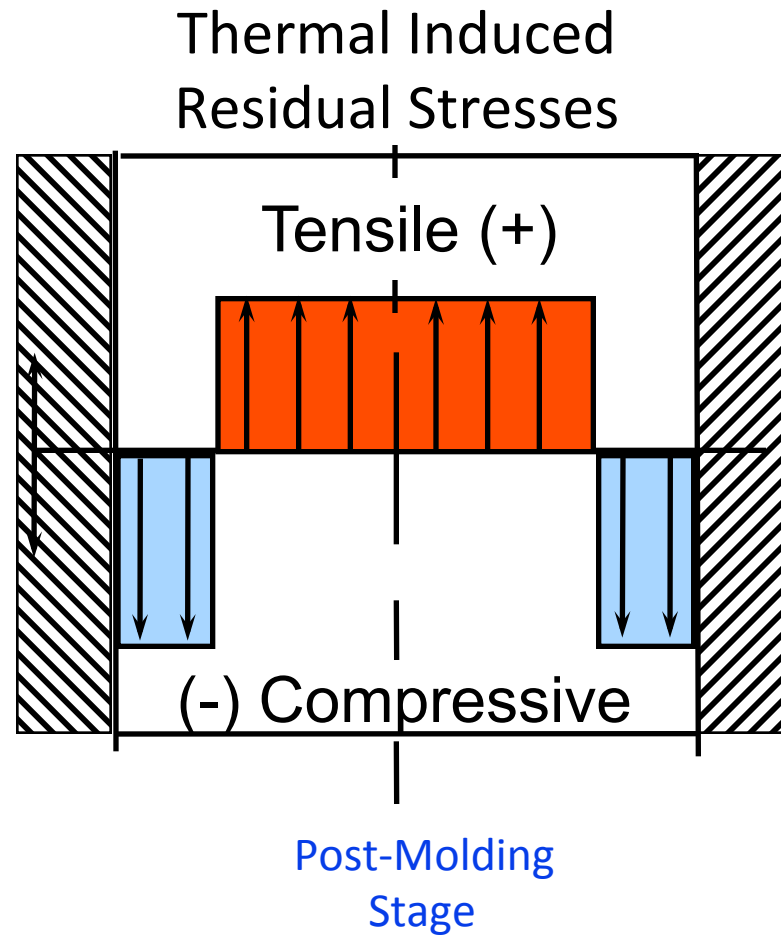
What Causes Residual Stress?



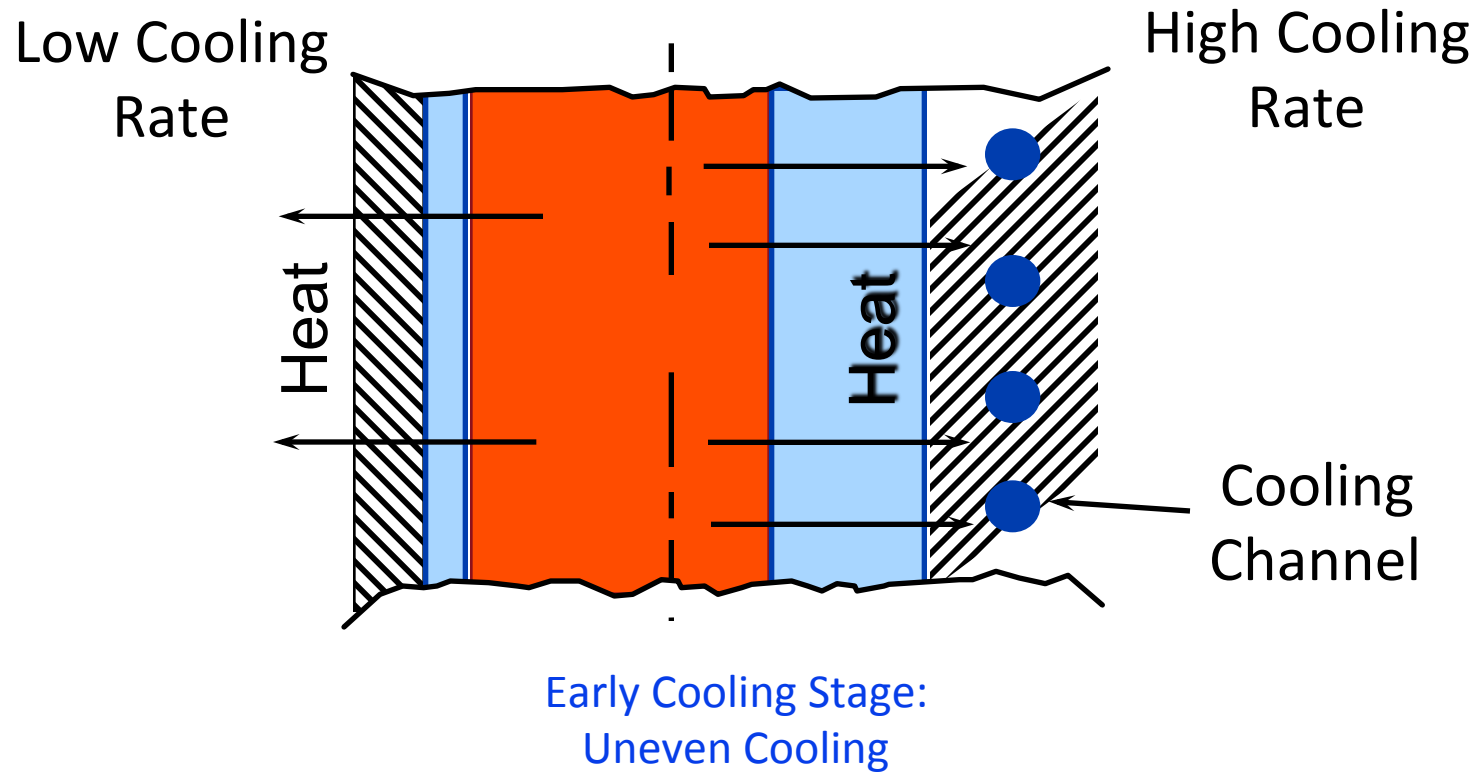
What Causes Residual Stress?



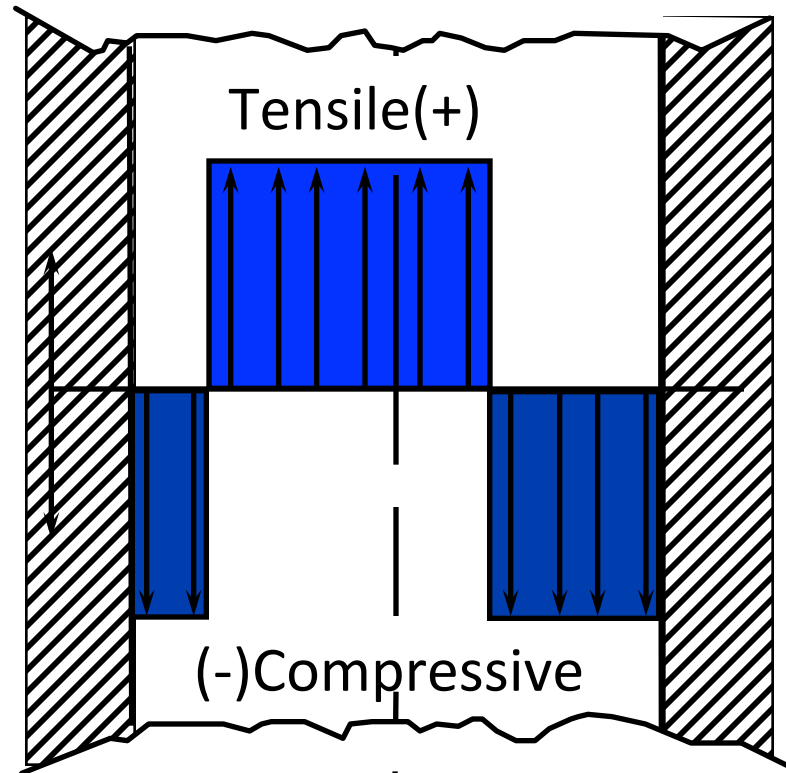
What Causes Residual Stress?



Unbalanced Residual Stress

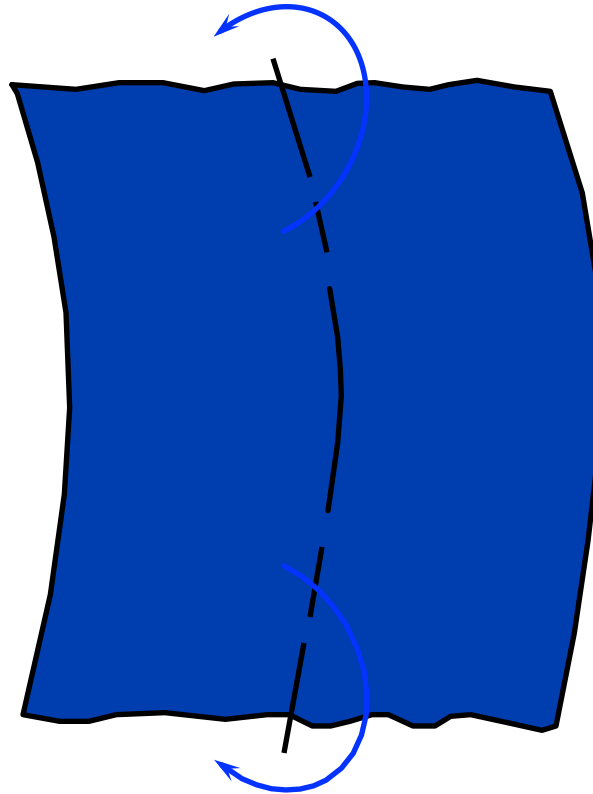


Unbalanced Residual Stress



Post-Molding Stage: Asymmetrical Thermal-Induced Residual Stress

Unbalanced Residual Stress



Warped Part

Examples of modern Car Components

Interiors

- ❑ Cockpit
- ❑ Instrument Panel
- ❑ Door Trim
- ❑ Consoles
- ❑ Interior Hard Trims
- ❑ (Pillar Trims)
- ❑ Air Vents
- ❑ Cup Holders
- ❑ Ash Trays
- ❑ Bezels



Exteriors

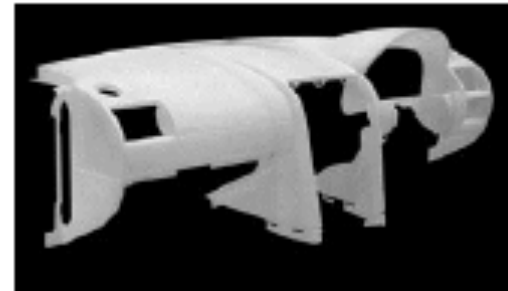
- ❑ Bumper Systems
- ❑ Front Grills
- ❑ Body Side Claddings
- ❑ Cowls
- ❑ Auger Finger



Under the Hood

- ❑ Radiator End Tanks
- ❑ Expansion Tanks
- ❑ Water Outlets





Customer	Model	Scope
Existing Programme Tata Motors	Indica/Indigo Sumo	Part Optimisation, Tool and Logistics Development
Fiat, India	Siena Palio	Tool Development In-house Productionisation
New Programme Tata Motors	New Indica (X1) New UV (X2)	Soft IP design and development Building modularity between LHD, RHD,



Door & Interior Hard Trims

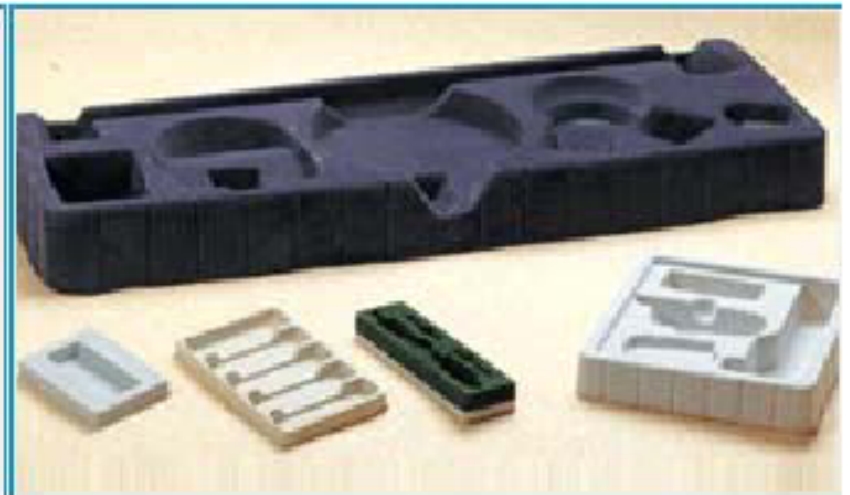


Customer	Model	Scope
Existing Programme Tata Motors	Indica Safari	Design and Development, Tool development, Productionisation and logistics development
Ford, India	B 226	Design Improvement, Tooling development, Productionisation and Logistics development
General Motors, India	Corsa	Tooling and Part Development
Toyota, India	Innova (IMV)	
New Programme Tata Motors General Motors	New Indica Kalos	Part Design, Tooling Development, Productionisation, Logistics development Tooling Development, Productionisation and Logistics development

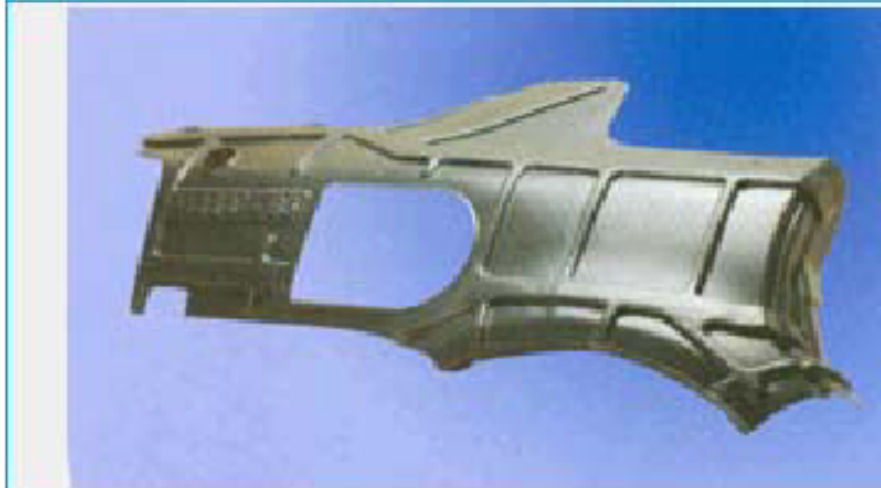
3. Thermoforming



Gift packaging



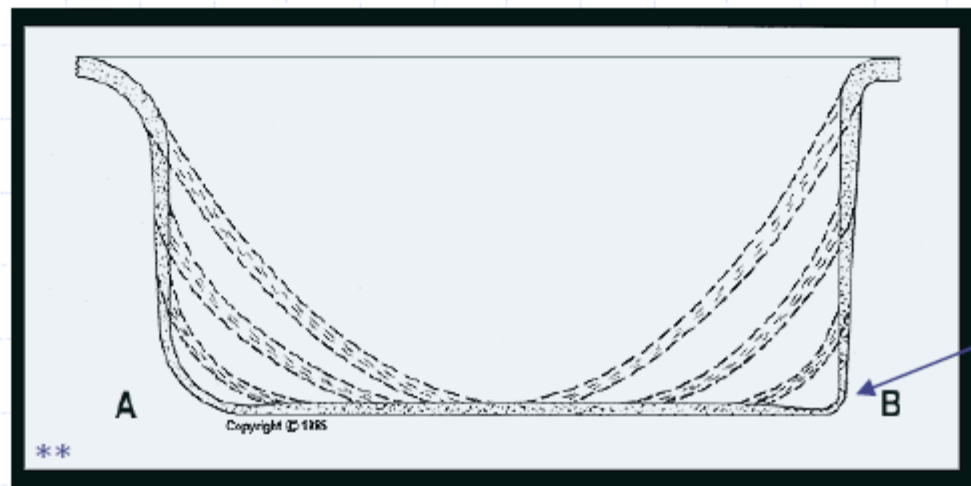
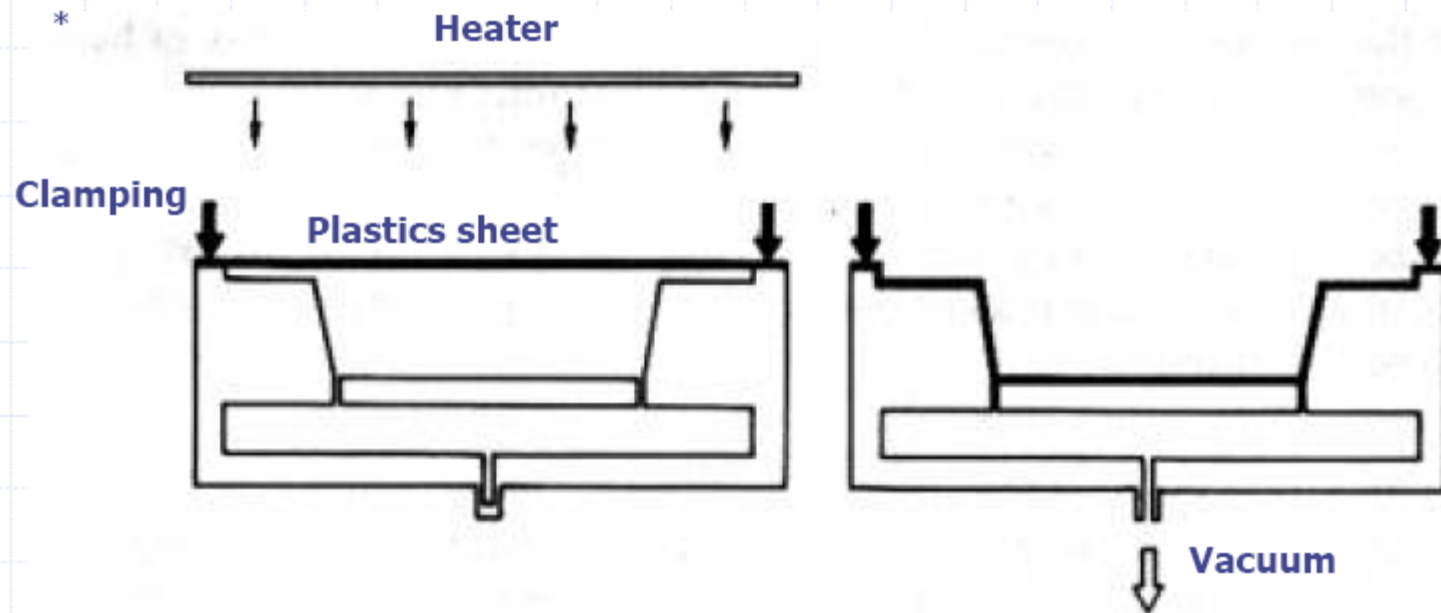
Communication packaging



AUTOMOBILE INNER DECORATION PACKAGING

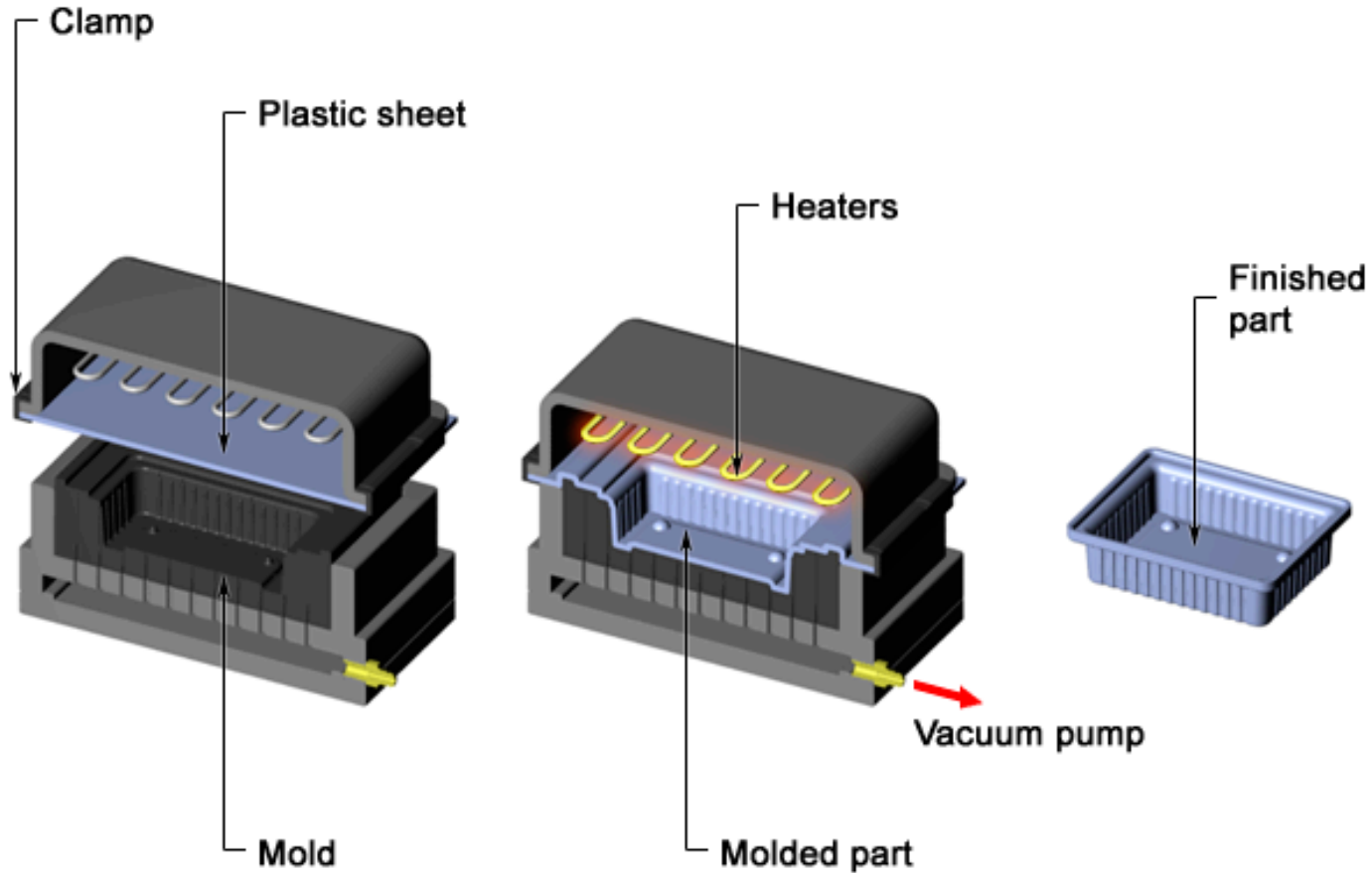


SPECIDIFFERENCE PACKAGING



Thin corner

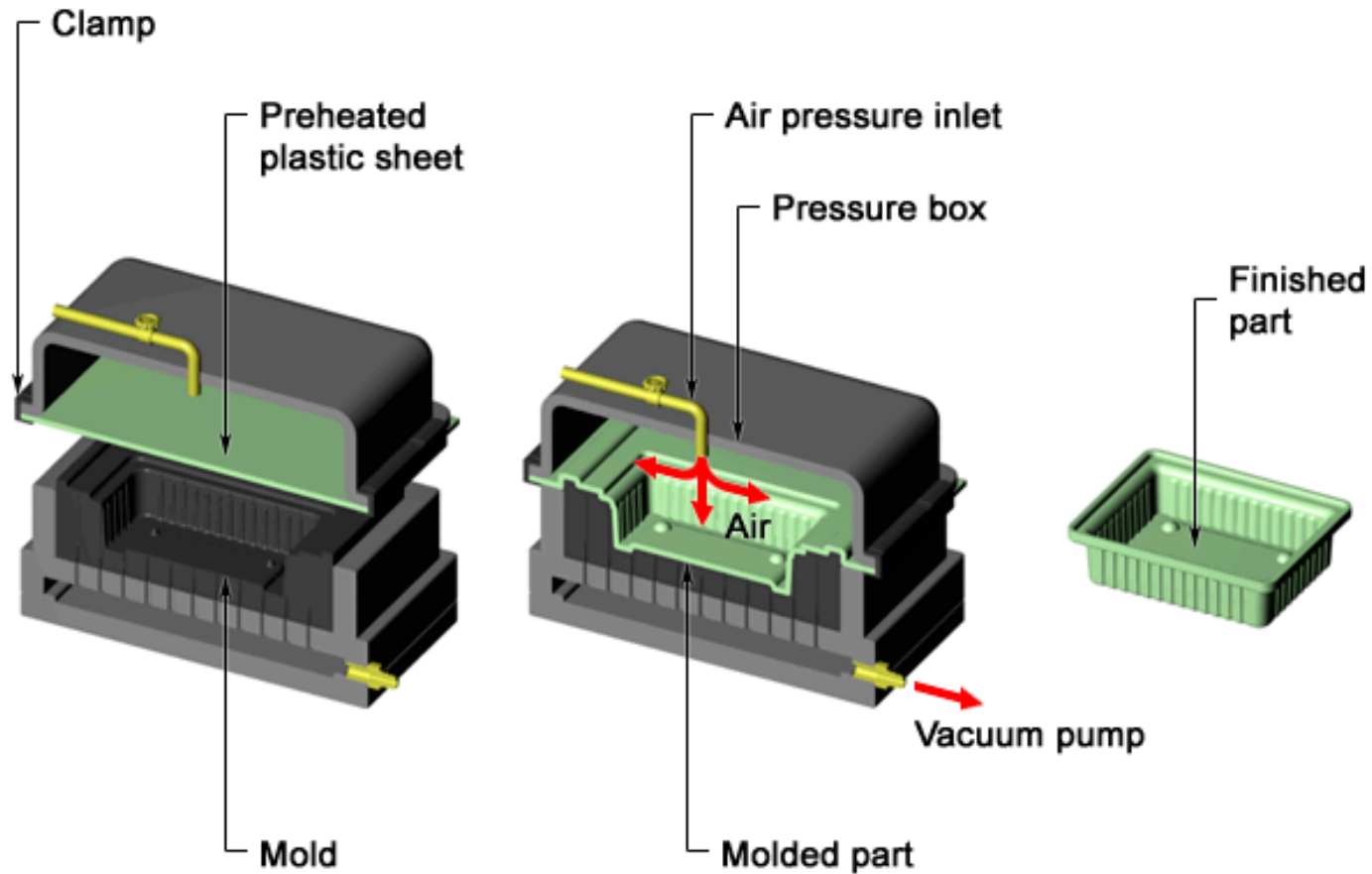
Manufacturing Plastics



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Thermoforming (Vacuum Forming)

Manufacturing Plastics



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Thermoforming (Pressure Forming)

Extrusion blow molding

Typical products

Bottles and containers

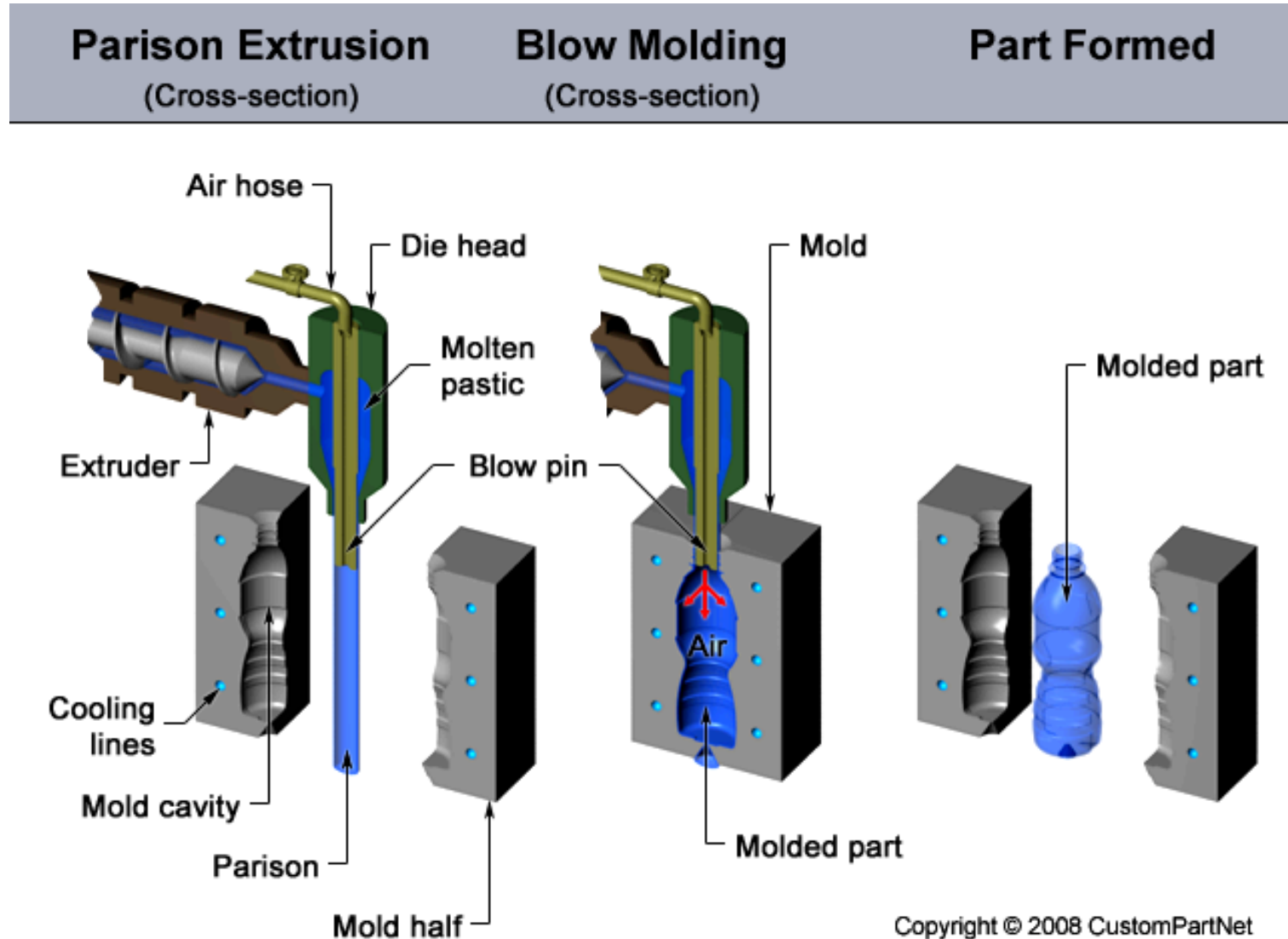
Automotive fuel tanks

Venting ducts

Watering cans

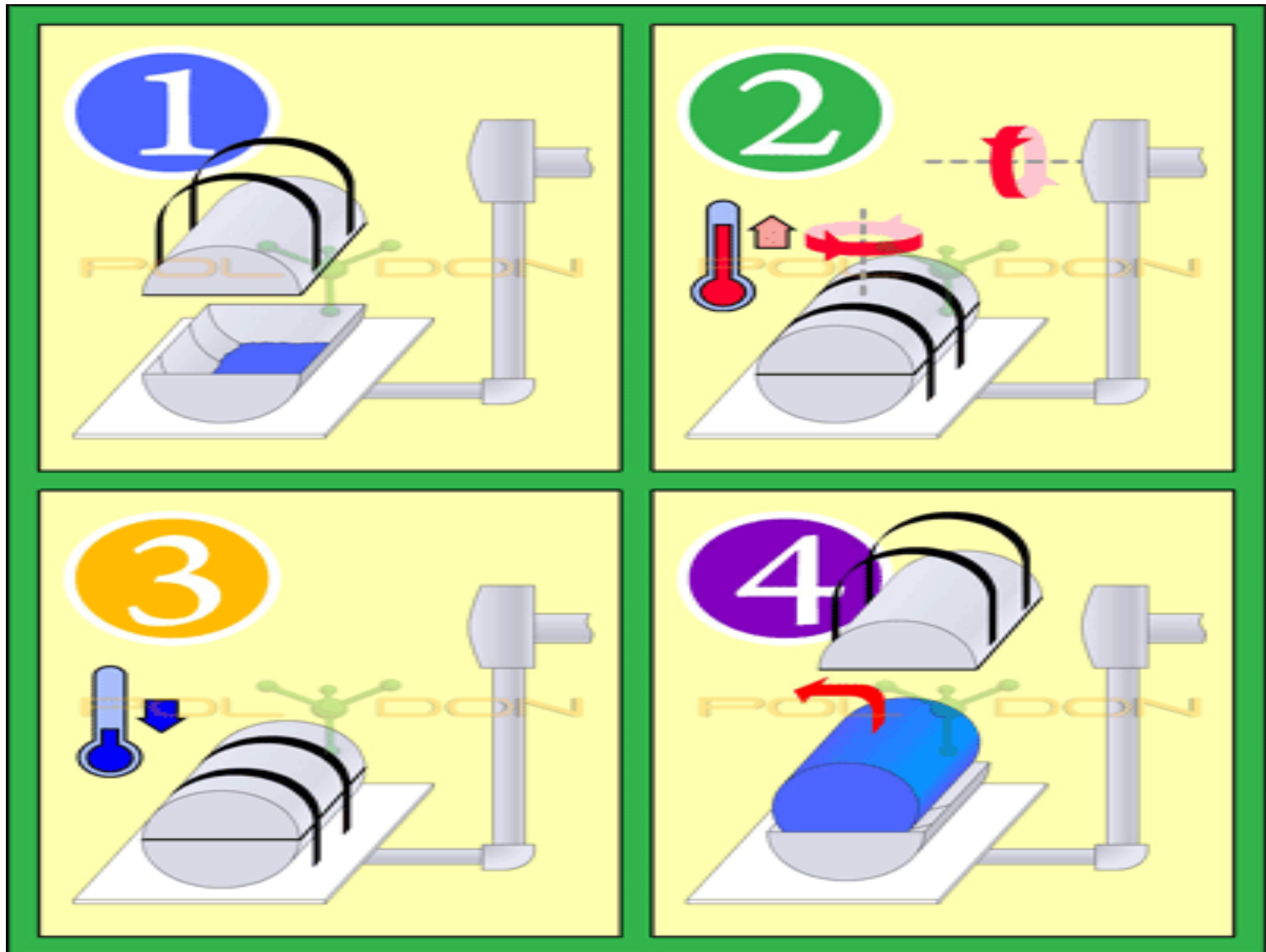


Manufacturing Plastics



Blow Molding

Manufacturing Plastics



Rotational Molding

Manufacturing Plastics

Water Tanks



Various Containers



Accessories for Aquaparks and Playgrounds



Manufacturing Plastics

Furniture



Garbage Containers



Marine Products

