Injection Molding:
The Art of Making Plastic Parts

By Helen Anderson and Jason Atkins
History

Stemmed from die-casting bullets in the Revolutionary War.

First modern injection mold was for a billiard ball using the synthetic organic resin celluloid.
Injection Mold

Major parts of the injection molding machine:

- Mold cavity
- Parting line
- Nozzle
- Plastic pellets
- Screw
- Barrel
- Plates
- Cold side
- Hot side
- Heating coils
- Hopper
Process

Plastic pellets fill the hopper…

...fall into the barrel...

...which is pushed into the mold.

...to form melt in the nozzle...

...where heat and pressure are applied...
Process

After cooling, the mold opens and the finished part is removed.

The sprue is then removed from the final part.

It is reground and placed back into the hopper.
The diameter of the screw inside the barrel gradually increases to generate more pressure and heat helping to melt the material.
Advantages

- Materials Available
- Shape Complexity
- Cost per Unit
- Quality
- Quantity
Disadvantages

Complex geometry can render parts impossible or extremely expensive.

Unless mass producing, the cost of the mold can outweigh the benefits of injection molding.
Materials

Two main types:

Thermosets: Thermal Insulator
        High Strength and Hardness
        Nonreversible

Thermoplastics: Low Cost
               Manufacturability
               Reversibility
Polyethylene
(UHMWPE)

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>Density (g/cm³)</td>
<td>0.945</td>
</tr>
<tr>
<td>Surface Hardness</td>
<td>RR50</td>
</tr>
<tr>
<td>Tensile Strength (MPa)</td>
<td>35</td>
</tr>
<tr>
<td>Flexural Modulus (GPa)</td>
<td>0.5</td>
</tr>
<tr>
<td>Notched Izod (kJ/m)</td>
<td>1.06+</td>
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<tr>
<td>Elongation at Break (%)</td>
<td>500</td>
</tr>
<tr>
<td>Strain at Yield (%)</td>
<td>25</td>
</tr>
<tr>
<td>Operating Temp. (°C)</td>
<td>-81 - 100</td>
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<tr>
<td>Minimum Operating Pressure (MPa)</td>
<td>20</td>
</tr>
<tr>
<td>Melting Temp. Range (°C)</td>
<td>144 - 152</td>
</tr>
<tr>
<td>Mold Shrinkage (%)</td>
<td>~0.2</td>
</tr>
<tr>
<td>Mold Temp. Range (°C)</td>
<td>120 - 180</td>
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</table>
Plastic pellets come in all colors, shapes, and sizes.

Dyes can be included to achieve specific colors when mixed in the barrel.
Materials

No longer limited to plastics!

Powder Injection Molding (PIM)
Injection molding the parts for this assembly keeps functionality up and cost down.
Design

Rib features provide rigidity without adding lots of weight and extra material.

Draft on surfaces perpendicular to the ‘pull’ direction help remove parts from molds.
Assembly for Injection Molded Parts

Snap fits are common in injection molded parts. They can be separable or not, depending on the demand of the part.

Heat staking is a good secondary operation for permanent assembly of parts.
Finite Element Analysis (FEA) helps engineers of today design parts to be injection molded.

Although not an exact science, FEA can help determine whether or not a mold will work the way it is expected to.
Injection molding in action.

Watch the real thing!
Mold Cavity

Interior of mold cavity.
Multiple Cavity Molds

Eight parts can be made at once in this mold.

Each cavity must fill at the same rate for the parts to be consistent.
Removal of Parts

Parts can be removed manually…

…or with the help of ejector pins.
Flow Defects

Jetting is caused by an undersized gate.

Surface defects can be caused by improper melt flow throughout a part.

‘Rheology’ is the study of flow under stress
Injection Molding

From art...

...to part.