Introducing Plastic

What are plastics? Plastic comes from the Greek word "plastikos", meaning "pliable". In scientific terms, plastics are polymers, that is, molecules that are very long chains.

Plastics are found in nature, such as bee's wax, tallow, and amber. Useful natural plastics include shellac, which is actually "shell lacca", a material made from the tiny Coccus Lacca insect. The cellulose in wool and cotton is a kind of plastic.

Synthetic plastics (man made) are used in toys. Synthetic polymers have been experimented with since the 1800's, but plastics weren't really understood until the 1920's when British and American names such as B. F. Goodrich and Dow Chemical created PVC and polystyrene.

From this point forward, when we refer to **plastic**, we mean the synthetic variety.

We can divide plastic into two groups. The first group, thermosets, are much like concrete. They are formed once, in a mold, and are allowed to set and harden. We don't find thermosets too often in toys.

Thermoplastics, the second group, are the essential toy plastics. They are heated and softened, then shaped by putting them under pressure in a mold or die. The plastic quickly cools and sets it shape. Thermoplastics can then be reheated and reshaped again and again.

A wide range of quality exists amongst thermoplastics. To simplify the matter, plastics used in toys are called "standard" plastics, making up the low end. "Engineering" plastics are very good stuff that can sometimes be an adequate substitute for metals in automotive applications. There is no hard line between the two -- it's a matter of price vs. performance.

Typical Plastics

Polyethylene (PE) is a polymer formed from ethylene, and offers all-around good plastic properties, and excellent durability.

Polypropylene (PP) is a polymer formed from propylene. It has a wider range of potential hardnesses and rigidities than PE, but is less durable. It is cheaper than PE, but can be better colored.

Polystyrene (PS) is a polymer formed from styrenes. Polystyrene has a very fast cycle time. This means the plastic moves into and out of the mold very quickly, so a molding machine can get more work done in a day. PS products have excellent surface quality, and can be made very transparent. PS products are somewhat more brittle than those made from PE and PP. Lego blocks are famous PS products.

Poly Vinyl Chloride (PVC) has the largest variance in properties and cost. It can be made soft or hard, dense or foamy. It is used in applications from squeeze toys to doll bodies, from inflatable toys to fabric-like materials. PVC, though, is not friendly to the environment.

Acrylonitrile Butadiene Styrene (ABS) is in a gray area between standard plastics and engineering plastics. It is very strong, rigid, and lightweight. It may be machined like a metal. It resists abrasion, and carries excellent mold detail, and subtle surface textures. It is paintable. It may be electroplated with silver- or gold-tone material, or metalized with nickel or chromate. Of course, you pay for this quality. This material is seen more often in collector's figures than true toys.

These **materials** are delivered to the molding company in pellet form, often pre-colored. Large plastic bags of these pellets are fed into a hopper, where they are melted into a flowing slush. Now, additives may be combined.

Additives

- **Plasticizers** may be used to soften the plastic, or add flexibility.
- **Antioxidants** reduce oxidation degradation.
- **UV Stabilizers** reduce the potential for sun damage, often used in outdoor toys.
- **Impact Modifiers** improve stress resistance.
- **Pigments** add color.
- **Barium Salts** may be added so that an accidently swallowed toy may be picked up on an X-ray.
- **Blowing Agents** create a soft, foamy material.
- **Lubricants** improve mold processing.
- **Flame Retardants** slows the material's burn rate in case of fire.
- **Fillers** reduce cost and may enhance certain mechanical properties.
- **Heat Stabilizers** retard thermal damage, often used in outdoor toys, or toys exposed to heat, such as those that may have hot electric motors.

Mold Processes

1) Injection Molding is the way most of our plastic toys are created. The material is injected under pressure into a two-part mold. The material is allowed to cool, the mold is opened, and the solid product inside is ejected into a collection hopper.

Adjustments in heat, ram pressure, and mold set time all affect the density and quality of the finished product, either intentionally or not. Different plastics do better in injection molding than others.

Common problems associated with injection molding are numerous. Poorly designed, poorly made, or deteriorating molds are a typical problem. Molds are subject to abuse in the form of heat, pressure, mechanical damage, and human clumsiness. A mold can wear rapidly because it is created from cheap materials, or because the injection pressure is set higher than it can handle. Higher quality molds are made from steel, and have corrosion resistant, stainless steel surfaces.

Then, there are problems related to the injection process. Plastic that doesn't fully fill out the mold during injection will result in an incomplete part. This can happen if the plastic isn't properly heated, the injection pressure is too low, or the materials are inadequate for the nooks and crannies of the particular mold.

The plastic material is often injected from opposite ends of the mold, and cools as it flows to the middle. You can often see the point where the plastic has melted together mid-mold. It appears as a wavy line if appropriate heat isn't used.

With a good quality mold, proper materials, and proper machine settings, the above problems can be avoided, as well as unwanted surface lines in the product resulting from the ejection pins, injection ports, and mold seam.

Nearly all common thermoplastics are suitable for injection molding.

2) Rotational Molding is similar to injection molding with an extra step. The injected mold is rotated at high speed to sling the material against the sides of the mold to insure a uniform wall thickness. Large, hollow toys, such as Jumbo Machinders, are often made with this technique. PVC's and high density PE's are suitable materials.

3) Blow Molding is another two-step process. The plastic material is extruded into the shape of a tube under heat and pressure. The tube (called a "parison") is blown with high pressure air against the sides of a mold, giving it its shape. Soft vinyl figures are often made using this technique. Again, PVC's and high density PE's are suitable materials.

4) Thermoforming is used to make toy items such as masks. The plastic material is semi-heated, and then smashed into shape in a mold. Pressure and vacuum may be used to insure uniform distribution in the mold. PS, PE, and PP are all used in thermoforming.

More info at: http://toyboxdx.com/infolibrary/plastic.php