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Forming Techniques for Plastics

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Not all plastic products are alike. But what makes them different? One factor is their forming technique, methods used to form the plastics into usable products. There are several ways to form plastics. These forming techniques, or processing methods, can affect the technical and economic feasibility of recycling different products together; therefore, being familiar with some of these methods is very important.

Choosing the Right Forming Technique

When designing a product, the choice of the right forming technique depends on the type of product and its purpose. For example, a product that will be used as a flexible shopping bag would not be processed in the same manner as a rigid plastic milk jug.

Yet, there are other, less obvious reasons for choosing one type of processing method over another. For example, the type of plastics and their chemical properties play an important role when designers decide which processing method to use. Plastic materials can be classified as ***thermosets*** or ***thermoplastics***. Both thermosets and thermoplastics are initially molded by a combination of heat and pressure. However, thermosets cannot later be reshaped by additional heat or pressure. Thermoplastics, on the other hand, can. This means that once thermosets are molded, the best way to reshape them is to use cutting and machining methods, whereas thermoplastics can be reshaped by techniques using heat and pressure. Further classification of plastic materials, or resins, can be used to choose the best technique to form a particular product.

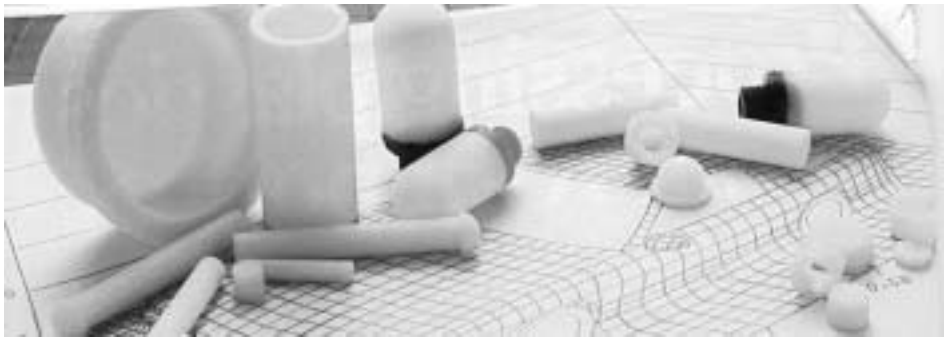
A few common thermoset plastics are epoxy, phenolic, polyester, and silicone. A few common thermoplastics are nylon, polyethelene, polypropylene, polyvinyl chloride, polystyrene, and acrylic.

Blow Molding

Blow molding (blowing) is a method to manufacture hollow plastic objects, such as bottles, by expanding molten plastic inside a mold. The hollow inside of the product is formed by air pressure. The mold is cooled using water which circulates in cooling jackets within the mold. Once the plastic solidifies, the product is removed, and any excess material is trimmed off. There are several ways listed below to blow mold a product.

Extrusion Blow Molding

Extrusion blow molding, the most common type of blow molding, forms bottles from thermoplastics such



Plastics lend themselves to many terrific shapes and forms. Due to processing variations, not all these pieces are recycled by recyclers.

as high density polyethylene, polyvinyl chloride, and polypropylene. The molten plastic is extruded (pushed out) as a hollow tube from a type of mold called a die. This tube, called a *preform* or *parison*, is clamped in a mold and expanded by air pressure. When it comes in contact with the relatively cool mold, the plastic freezes into the shape of the mold's surface. After the mold is opened, the product is removed and trimmed into shape.

Injection Blow Molding

Injection blow molding is a two-stage process used to manufacture bottles. This process requires injecting the molten plastic into the first of two steel molds to form a test-tube shaped preform. This preform is then inserted into the second mold, where it is expanded by air pressure to achieve the desired final shape.

Stretch Blow Molding

In this process, the preform is stretched both radially and axially to increase the strength of the plastic material. These products can be blown on one or more machines depending on specific structural needs.

Coextrusion (Multilayer) Blow Molding

Coextrusion blow molding is used for products, such as squeezable ketchup bottles and gasoline containers, that contain four to six layers of different materials. Because coextrusion packages can be manufactured using recycled plastic in the inner plies and virgin material for the exposed layers, this multilayering process allows manufacturers to use up to 80 percent recycled material without sacrificing the visual and performance qualities.

Calendering

In calendering, molten thermoplastic is forced through a die to form a film. The film is then passed between heated calender rollers which determine the finished film thickness. These rolls can produce extremely accurate and thin sheets with an almost perfect surface finish. Polyvinyl chloride sheeting used for making binders and notebooks is an example of a product using this process.

Casting

This process is used for either thermoplastics or thermosets. Nylons and acrylics are the thermoplastics most commonly cast, whereas epoxies, phenolics, polyester, and polyurethanes are the most commonly cast thermosets. Casting a product involves pouring liquid plastic into a mold and allowing it to solidify at a predetermined rate. Casting produces components with thick-wall sections or with solid sections. Typically, casting is used for sheets, tubes, rods or specialty shapes.

Compression Molding

The compression molding process started years ago with the manufacture of lumber from wood chips and glue. This process is also used today for some plastics, mainly thermosets. Compression molded products are made by placing plastic pellets in a mold. Pressure and heat are applied until the plastic conforms to the mold and solidifies into the desired shape. To strengthen the finished product, reinforcing material, such as fiberglass or carbon fibers, can be added to the process. Some plastic lumber is made in this fashion, although extrusion molding (see below) is also utilized to form various plastic construction items.

Extrusion Molding

In the extrusion process, a machine, called an extruder, changes thermoplastic powder or pellets into a continuous melt. This melt is forced through a die, then cooled to a solid. Some extruded products include customized shapes (profiles), sheets, pipes, tubing, and films. Co-extrusions, or multilayered products made with more than one material or color, can also be formed by this method.

Injection Molding

During the injection molding process, a powdered, pelletized, or granulated plastic resin enters a heated cylinder where heat and pressure soften the material. This molten plastic is then injected into a metal mold which determines the various wall thicknesses of the part. The plastic remains under pressure as it cools and solidifies into the shape of the mold. Another type of injection molding, called co-injection (sandwich) molding, can be used to manufacture a product with solid-skin outside layers of thermoplastic material and a foamed core of a different material.

Foam Molding

Foam molding, a type of injection molding process, uses blowing agents to expand and mold beads into lightweight, rigid products such as polystyrene drink cups, packaging materials, insulation panels, and fast

food cartons. When exposed to heat, these blowing agents expand the beads from two to 50 times their original size. In the past, blowing agents usually were chlorofluorocarbons (CFCs), substances which deplete the ozone layer in the earth's atmosphere. Today, the plastics industry uses less damaging blowing agents to manufacture foam molded products. Three common methods of foam molding are listed below.

Pre-expansion Foam Molding

The most common method of foam molding, pre-expansion, uses steam and air to pre-expand the polystyrene beads. When these beads reach equilibrium, they are placed into a mold and subjected to more steam. The beads become heated, causing the plastic to expand and conform to the shape of the mold. The mold is cooled by water, before the finished product is ejected.

Extrusion Foam Molding

Foam molded products can be made by mixing the plastic material with a nucleating (crystallizing) agent and a blowing agent. The mixture is forced through an extrusion die, exiting into an area of low pressure. This low pressure causes the blowing agent to transform to a gas which expands. The gaseous bubbles attach to the nucleating agent to give the product a porous, cellular structure throughout.

Structural Foam Molding

Structural foam molding differs from other foam molding processes because the product has a cellular core and a solid plastic outside skin. The core is formed by mixing a gas and resin under pressure during the melting process. As the mixture is injected into the mold, the material is de-pressurized, allowing the gas to expand and create the cellular core. Structural foam products can be large, durable, and extremely rigid, expecially when they are reinforced with glass fibers.

Reaction Injection Molding (RIM)

Reaction injection molding (RIM) uses two or more liquid plastic compounds, called intermediates. The components are mixed and injected under pressure into a mold, where they can fully polymerize (cure) to form lightweight, flexible products. RIM products can be reinforced by adding preformed inserts to the mold before injection of the intermediates takes place. Preforms of RIM are typically glass fiber woven mats, continuous strand mats, or chopped fibers. Because RIM products are inherently tough, two of the biggest end markets for RIM products are the automotive and construction industries. Some common examples include automotive bumpers, dashboards, and hoods.

Reinforced Plastic Processing

Basically, reinforced plastic processing changes formless reinforcing agents and plastic resins into a solid structure. This is accomplished by first arranging the plastic material and reinforcing agents into a desired shape before adding heat and pressure to polymerize the material. There are a variety of different reinforced plastic processing techniques, which are classified either as ***closed mold processing*** or ***open mold processing***.

Closed Mold Processing

In this process, a two-piece mold is filled with a mixture of resin, reinforcement, filler, and additives. The two mold pieces are heated and closed, then pressure is added to form a solid reinforced plastic part. There are several different ways to close mold a product (Table 1).

Open Mold Processing

Open mold processing includes three techniques: hand layup, sprayup, and filament winding. In the first two techniques, the mold is filled with layers of glass

Table 1: Methods of Closed Mold Processing.

Method	Description
Compression Molding	Material is placed in a mold and subjected to pressure until the plastic is set
Pultrusion and Pulforming	Used for continuous length, filament-reinforced cross sections; polymerization occurs in a heated steel die as the shap is pulled from the die
Injection Molding	Thermoset or thermoplastic material is forced into a machined mold; some fiber degradation usually occurs
Resin Transfer Molding (RTM)	Preform and a glass mat are clamped into a mold; plastic, pigments, and fillers are injecte into the mold
Stamping	Thermoplastic material is heated, softened, and placed into steel mold until cool

reinforcement and a plastic resin. These layers can be added either manually (hand layup) or by specialized spray equipment (sprayup). In filament winding, the material is wound onto a rotating bar and allowed to solidify into a product, such as tubing or pipe, that is smooth on the inside.

Rotational Molding

Rotational molding is one of the fastest growing closed mold plastic processes. It forms hollow, seamless products, such as industrial and agricultural spray tanks, fuel storage tanks, automotive parts, and sporting equipment. The process begins by filling a mold with a powder or liquid plastic, usually a thermoplastic. The mold is placed in a heated oven and rotated on two axes while the resin melts, fuses, and densifies into the shape of the mold. The mold is cooled by air and water to produce the finished product.

Thermoforming

The first step in thermoforming is to raise the temperature of the thermoplastic material. This makes the material workable, allowing it to be formed into a different shape. There are nine different techniques used in thermoforming to produce a product. All of these techniques require the use of a vacuum to draw the soft plastic sheet or film onto a mold to form the final shape.

Transfer Molding

In the transfer molding process, thermoset material is placed in a preheated pot before it is injected into a closed-mold. The flow of the material from the pot into the mold is directed by channels called sprues and runners. After the material polymerizes and becomes set, the plastic product is ejected.

Conclusion

This fact sheet describes only some of the most common methods to manufacture plastic products. In reality, there are many more. It is important to remember that plastics are a 20th century invention. Therefore, as engineers gain a better understanding of plastics and their chemistry, new and improved techniques will be developed to optimize the properties and increase the possible end uses. The development of these new methods will be especially influenced by the push to “design-for-recycling,” manufacturing products with recycling in mind. These considerations, along with consumer demand for improved products and the manufacturer’s desire for increased efficiency, will affect the future development of new forming techniques for plastics.

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