



Sharing The Knowledge

Module 5

Conversion Processes



Module 5

Conversion Processes

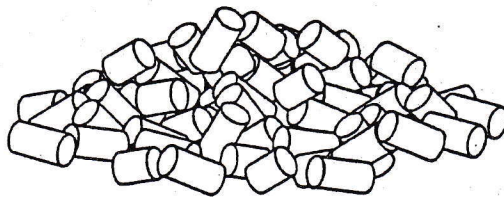
- Types
 - Extrusion
 - Blow Molding
 - Injection Molding

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Participant's Notes: _____



Thermoplastic Pellets



Thermoplastics are manufactured and sold
in pellet form.

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Participant's Notes: _____

Introduction

Conversion Processes

Modules 1 through 4 dealt primarily with thermoplastic materials: thermoplastic families, thermoplastic structure, thermoplastic modification, and thermoplastic properties. Throughout these modules, we learned that one of the greatest attributes that thermoplastics can offer the converter is formability. This module is devoted entirely to the forming of thermoplastic parts. **STK 501**

Objectives:

At the end of this module, participant should be able to:

- Define conversion processes.
- Describe the major types of conversion processes: extrusion, injection molding and blow molding.
- Describe the advantages and disadvantages of each type of conversion process.
- Determine which type of conversion process is used for various applications.
- Identify the types of conversion processes used in your company.

Thermoplastics are typically manufactured and sold in pellet and sheet form using the conversion process of extrusion.

Thermoplastic Pellets

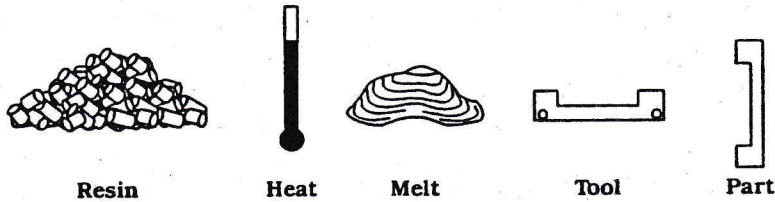
In previous modules, we learned that plastic materials are made by isolating certain molecules and polymerizing them to form long, chain-like molecules. These thermoplastics are sold in the form of tiny pellets or sheet. It is the responsibility of the converter to convert these raw thermoplastic shapes into thermoplastic parts. **STK 502**



GE Plastics

STK 503

Soften & Form



Thermoplastics are heated until they flow then forced by pressure to form a finished part.

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Participant's Notes: _____



GE Plastics

STK 504

Heat & Pressure

Conversion processes vary by the combination of methods used to:

- Raise the temperature of the material to make it flow and to apply pressure.
- Apply pressure to the flow to make it form a part.

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Participant's Notes: _____

Conversion refers to the act of converting the plastic pellets into final part shape.

Soften and Form

There are many methods of converting thermoplastics into usable parts. In each conversion method, the thermoplastic must first be softened, then formed. The ability of thermoplastics to soften when heated, form into a shape when molded, and solidify into a part when cooled is what makes them unique. Conversion processes vary only by the combination of methods used to soften the material and form it into a finished part.

STK 503

Each conversion requires the application of heat and pressure.

Heat and Pressure

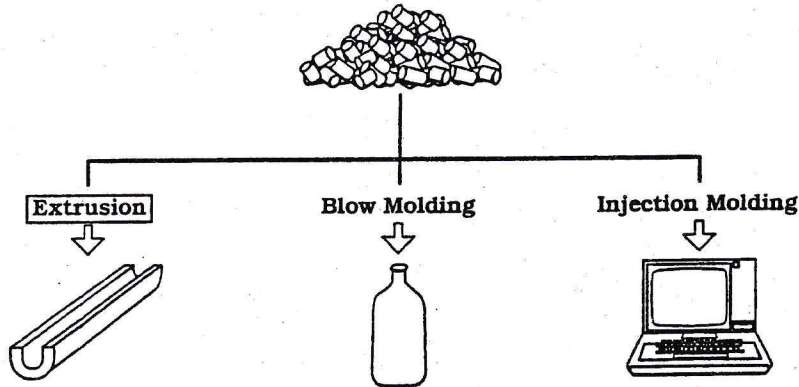
To soften a thermoplastic material, heat energy must be applied to raise its temperature. This heat energy is usually generated either electrically or mechanically, or by a combination of the two. The method used to raise the temperature of the material to make it flow depends on the process of conversion. Once the material is flowing, pressure can be applied to make it form into a part. Pressure can be applied in a variety of ways – by squeezing, by pressing, by clamping, by injecting, by extruding, or even by inflating the thermoplastic so it forms to the contours of the mold. The method used to mold the material depends on the process of conversion.

STK 504



GE Plastics

Conversion Processes



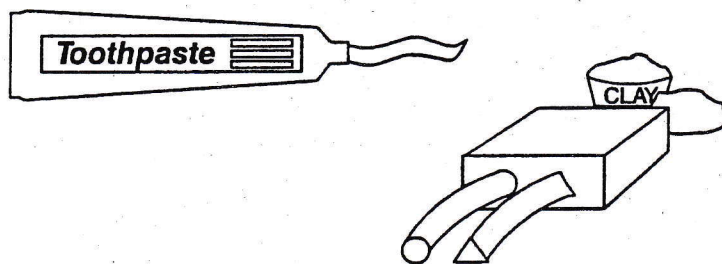
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Participant's Notes: _____



GE Plastics

Extrusion



Extrusion is the act of squeezing, pressing, or pushing material through a die in order to make a shape.

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Participant's Notes: _____

Extrusion

Three major types of primary conversion processes: extrusion, blow molding, and injection molding.

Conversion Processes

The many pellet conversion processes available today can be broken down into three general categories: extrusion, blow molding, and injection molding. Most other conversion processes stem from one or more of these technologies.

STK 505

Extrusion is the act of squeezing, pressing, or pushing material through a die to make a shape.

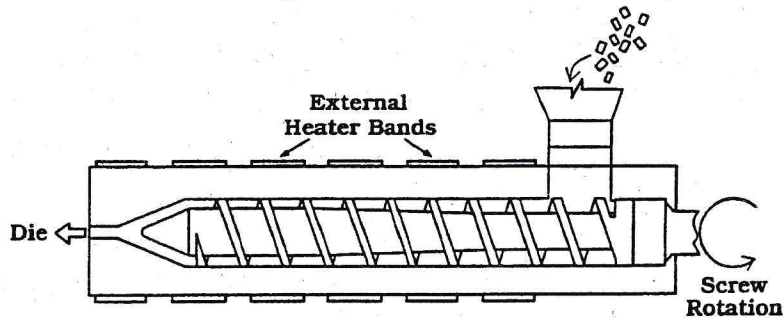
Extrusion

Extrusion was first used by the rubber industry during the 1930s. In general, it is the act of pushing or pressing a material through an opening. For example, toothpaste is extruded from its tube, and Playdoh™ is extruded through an opening in the Playdoh Fun Factory™. Thermoplastic extrusion involves the pushing of a thermoplastic melt through a die to form a shape.

STK 506



Thermoplastic Extrusion



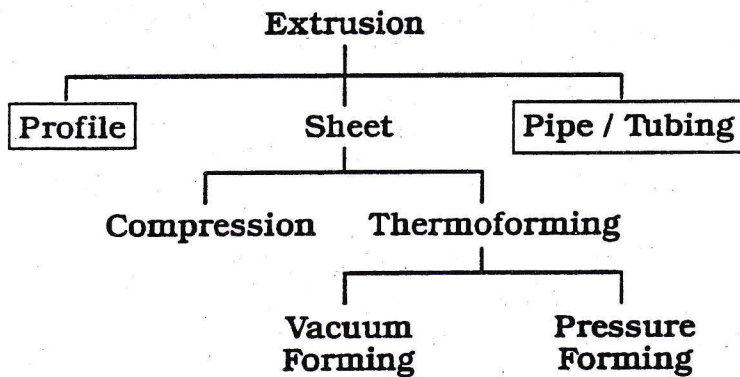
Heater bands provide electrical heat energy and screw rotation provides mechanical heat energy to soften the pellets and make the material flow.

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Participant's Notes: _____



Extrusion



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Participant's Notes: _____

In extrusion, electrical and mechanical heat soften the pellets.

Thermoplastic Extrusion

Thermoplastic extrusion uses a combination of electrical and mechanical heat energy to soften the pellets until they flow. Heater bands provide the electrical energy and screw rotation provides the mechanical energy that, together, serve to raise the temperature of the material so it softens and flows.

STK 507

Once softened, the plastic can be extruded into many different shapes or products.

Extrusion

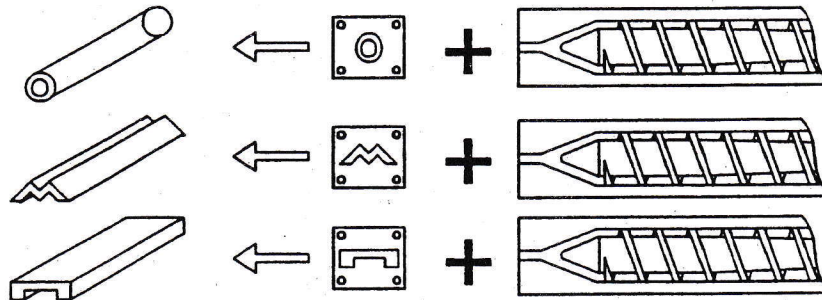
Once flowing, the material can be extruded into a variety of different shapes and products such as profiles, pipe, and sheet. The extrusion of sheet is the first step in compression molding and thermoforming. Extrusion is also an integral part of processes involving either blow molding or injection molding.

STK 508



GE Plastics

Uniform Profiles and Indefinite Length



The plastic flow is extruded through a die using mechanical back pressure to form a part with a uniform profile that can be cut to any desired length.

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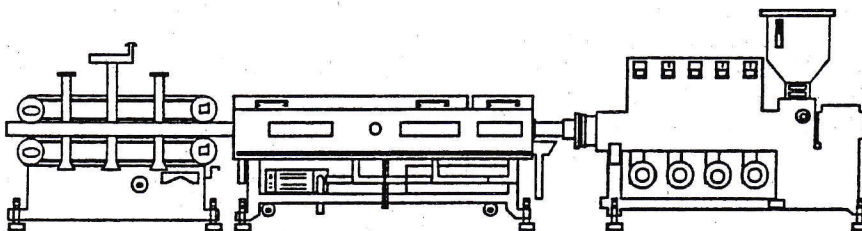
Participant's Notes: _____



GE Plastics

Engineering Extrusion Line

Caterpillar Puller ← Sizing Tank or Cooling Rack ← Extruder



A thermoplastic profile is extruded, then its shape is held till cooled below its glass transition temperature.

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Participant's Notes: _____

Many different profiles (shapes) can be extruded.

Once a thermoplastic profile is extruded, its shape must be held until it is cooled and solidifies.

Uniform Profiles and Indefinite Length

The thermoplastic material is first softened, then formed. In extrusion, the plastic flow is formed by extruding it through a die using mechanical back pressure. The melt takes the shape of the die and emerges as a uniform profile that can be cut to any desired length. Profile extrusions are uniform cross sections of infinite length.

Pipe and tubing are both profile extrusions. They are often called out as a separate product category due to the tremendous quantity of pipe and tubing that is extruded in a year. Profile extrusions can take many shapes and can be cut to any length. Products such as lighting fixtures, window blinds, and display frames are all profile extrusions.

STK 509

Engineering Extrusion Line

After the thermoplastic melt is extruded through the die, its shape must be held until it cools. The melt is above its glass transition temperature so it is able to flow and form. It must then be cooled below its glass transition temperature so it can solidify into a part. The extrusion is pulled by a caterpillar puller through a vacuum sizing tank which cools the material while still maintaining its extruded shape. Once solidified, the extrusion is cut and trimmed.

Because an extrusion must be able to support its own weight after emerging from the die, special resin grades are used that provide greater melt strength. Polymers are often branched to make them flow more stiffly. When polymer molecules contain branches, they tend to provide greater melt strength.

STK 510



Extrusion

Advantages:

- Continuous Process
- Long Simple Shapes
- Low Tooling / Die Costs

Disadvantages:

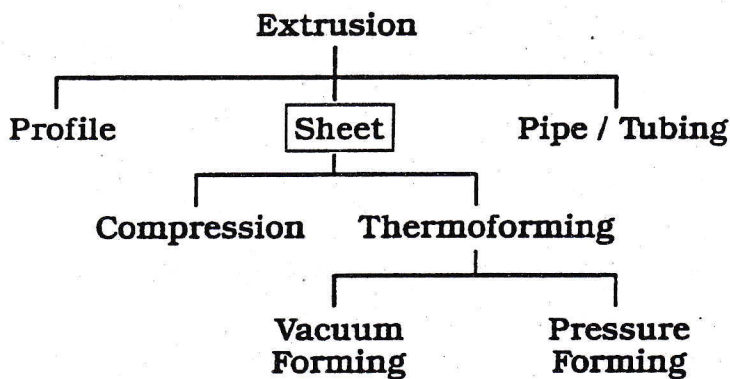
- Limited Part Complexity
- Constant Cross Section

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Participant's Notes: _____



Extrusion



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Participant's Notes: _____

Extrusion has advantages and disadvantages depending on the complexity of the shape required.

Extrusion

Extrusion poses many advantages to the manufacturer. It is a continuous process capable of molding long, constant cross section without incurring high tool and die costs. Still, it offers limited part complexity and is typically used to manufacture parts with constant cross sections.

STK 511

Extruded sheet

Extrusion

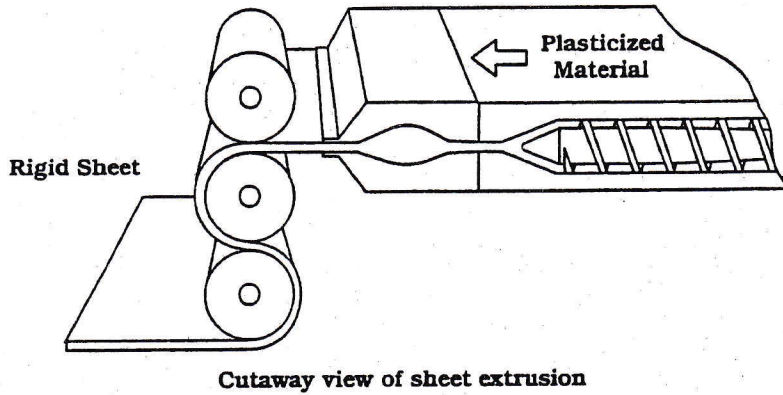
Thermoplastic sheet must first be extruded, then it can be converted into a variety of products by such methods as compression or thermoforming. The material can be used as a flat sheet or formed into other shapes.

STK 512



GE Plastics

Extruded Sheet



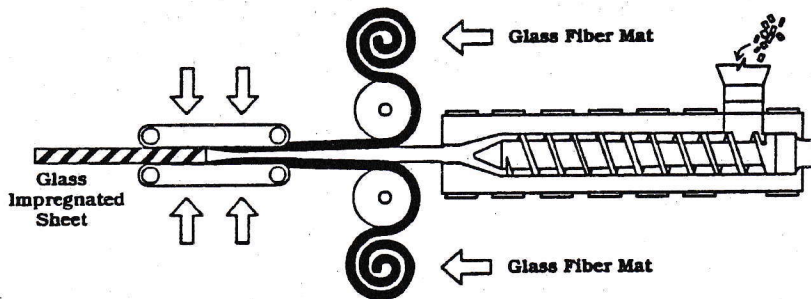
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Participant's Notes: _____



GE Plastics

Glass Impregnated Sheet



Glass impregnated sheet is a combination of glass mat and thermoplastic resin - it has both high stiffness and good impact strength.

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Participant's Notes: _____

Rolls are used to support and polish/texture the sheet.

Extruded Sheet

This is a cutaway of the sheet extrusion process. The plastic is still extruded through a die but instead of being supported and cooled downstream, the wide piece of sheet is nipped by a stack of polishing rolls. It is dragged through these rolls which support its shape as it begins to cool. It is still cooling as it passes through the next set of horizontal draw rolls. Eventually it cools below its glass transition temperature and can be cut and trimmed.

STK 513

Glass mat can be incorporated in the thermoplastic sheet to increase its stiffness and strength.

Glass Impregnated Sheet

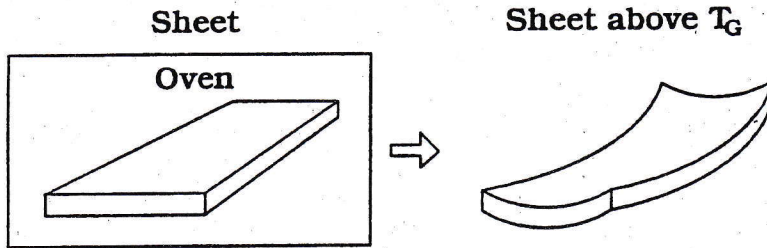
Glass mat can be incorporated into the thermoplastic sheet to increase its stiffness and strength. Glass impregnated sheet is manufactured by extruding thermoplastic sheet between layers of glass fiber mat. The glass and the resin mesh together and form glass impregnated sheet. This new material offers stiffness and impact strength. AZDEL®, AZMET®, and AZLOY® are three examples of glass impregnated sheet currently being used in applications requiring a combination of high stiffness and strength.

STK 514



GE Plastics

Heating Sheet



Sheet must be heated above T_g to soften it.

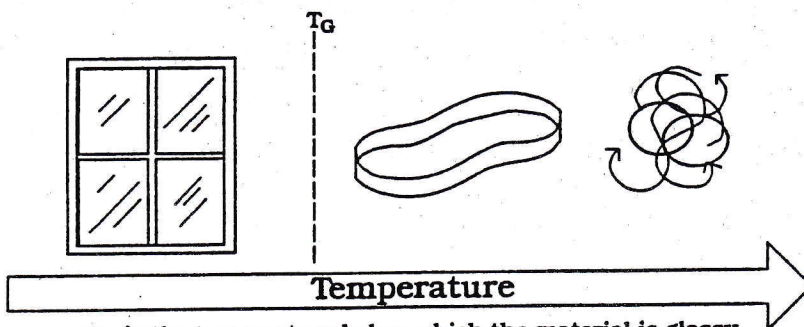
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Participant's Notes: _____



GE Plastics

Glass Transition Temperature



T_g is the temperature below which the material is glassy and above which the material is rubbery. Sheet is heated just above its T_g but not enough to be very fluid.

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Participant's Notes: _____

Sheet must be heated above its T_g in order to be formed.

Heating Sheet

Once extruded, sheet is sold for conversion the same way thermoplastic pellets are sold for conversion. In fact, after polymerization, thermoplastic pellets are extruded and then cut into tiny pellets. Both pellets and sheet must then be softened again before being converted into a part. Therefore, thermoplastic sheet is placed in an oven and heated above its glass transition temperature so it softens.

STK 515

Thermoforming sheet should be done above T_g .

Glass Transition Temperature

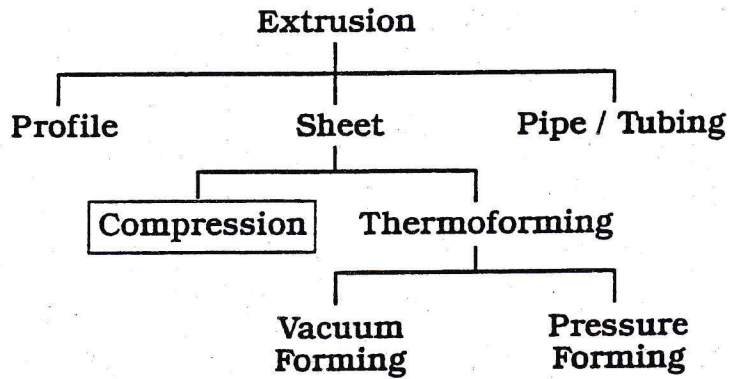
A material's glass transition temperature (T_g) is the temperature at which a material turns from a "glassy" state to a "rubbery" state.

Below T_g , the thermoplastic sheet is hard and rigid and would require an extraordinary amount of pressure and energy to make it form into a part. Too far above T_g , the sheet would soften into its melt state, rendering the entire process of extruding it into sheet useless. Just above T_g , the sheet is soft and pliable, but not fluid. It still will support its own weight, but it is supple and can be easily formed into a part.

STK 516



Extrusion

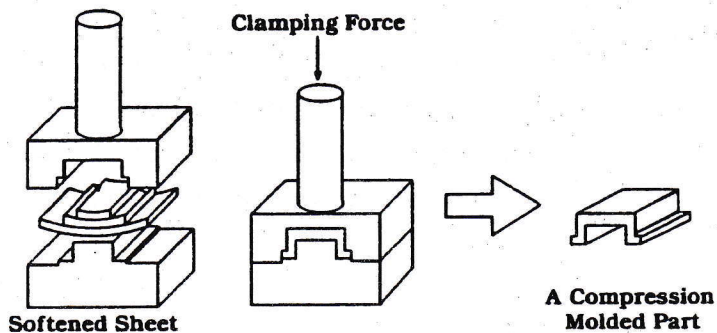


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Participant's Notes: _____



Compression Molding / Stamping



The softened sheet is placed in the mold then pressed into shape by compressive force.

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Participant's Notes: _____

Compression molding

Extrusion

Sheet can be formed into a part by either compression molding or thermoforming.

STK 517

In compression molding compressive forces are used to shape a softened thermoplastic sheet.

Compression Molding/Stamping

Compression molding, or stamping as it is commonly called, is similar to the process used to mold thermoplastic parts and stamp sheet metal. It presses the softened sheet into a part using compressive force. This cutaway depicts the process. The softened sheet is first placed in the mold. The mold is then clamped closed and this clamping force presses the sheet, causing it to form to the contours of the mold. Once cooled, the part is removed from the mold and trimmed.

Compression molding gives the converter the ability to mold a deep draw part with interior detail. Compression molding is often used in the fabrication of glass impregnated sheet because of its ability to mold rather complex parts without damaging the material's long glass reinforcement fibers. Many other processes, such as injection molding, involve screw rotation which tends to break these reinforcement fibers and render the material less useful in terms of rigidity.

STK 518



GE Plastics

STK 519

Compression Molding / Stamping

Advantages:

- Long Glass Fiber Capability
- Low Tendency Towards Warpage and Distortion
- Large Variation in Wall Thickness

Disadvantages:

- Secondary Trimming
- Longer Cycle Time

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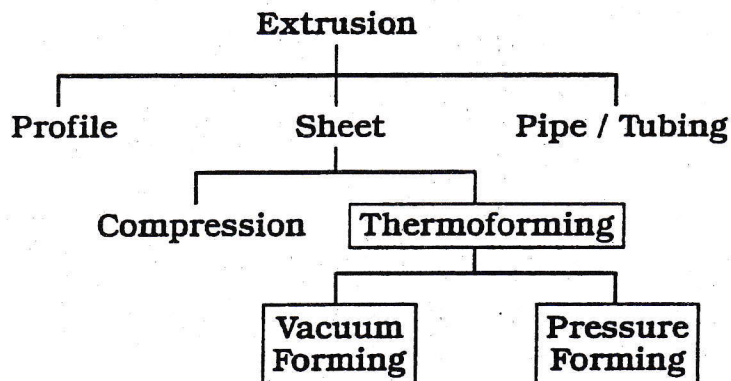
Participant's Notes: _____



GE Plastics

STK 520

Extrusion



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Participant's Notes: _____

**The advantages and
disadvantages of
compression molding.**

Compression Molding/Stamping

Compression molding provides a variety of advantages to the converter. It is considered a good alternative to injection molding, especially when molding glass impregnated sheet. Compression molding is also capable of producing parts that have large variations in wall thickness with little or no warpage, distortion, or voids. Compression molding also requires longer cycle times and secondary trimming

STK 519

Thermoforming

Extrusion

There are two types of thermoforming: vacuum forming and pressure forming.

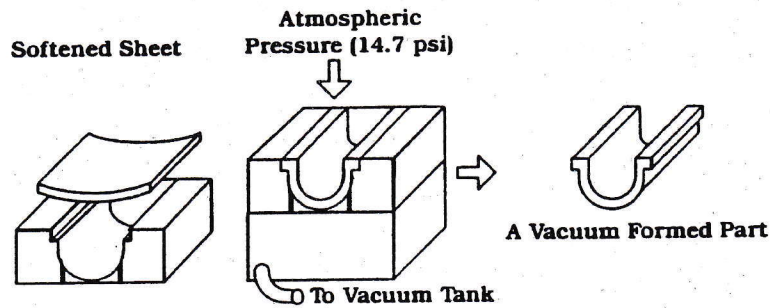
STK 520



GE Plastics

STK 521

Vacuum Forming



The predried heated sheet is placed over the mold and the sheet is evacuated. Atmospheric pressure forces the sheet to form to the contours of the mold.

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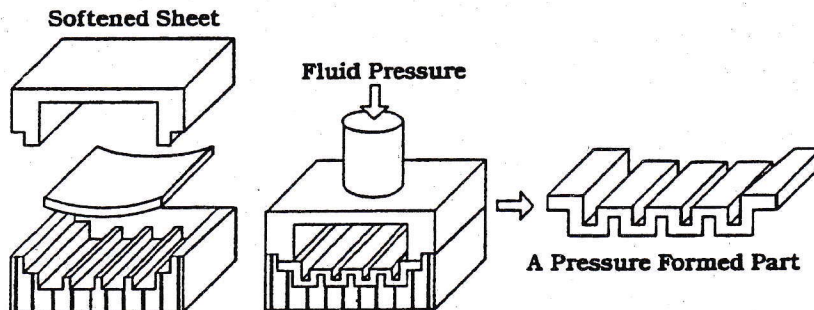
Participant's Notes: _____



GE Plastics

STK 522

Pressure Forming



The predried heated sheet is placed over the mold and the edges sealed. Fluid pressure forces the sheet to form to the contours of the mold.

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Participant's Notes: _____

Atmospheric pressure forces the sheet to form to the contours of the mold.

Vacuum Forming

Of all the sheet fabrication processes, vacuum forming uses the least amount of pressure. It relies on atmospheric pressure and therefore can exert no more than 14.7 psi. This cutaway depicts the process. Softened sheet is first placed in the mold. The mold is then closed and the air underneath the sheet evacuated. Atmospheric pressure then forces the sheet to form to the contours of the mold.

Vacuum forming is a low pressure process and is therefore less capable of molding sharp corners, deep draws, or interior detail. Because it is a low pressure process, inexpensive tooling can be used. Vacuum forming is often used in prototyping. **STK 521**

Fluids are used to apply pressure.

Pressure Forming

Pressure forming utilizes more pressure than vacuum forming but less pressure than compression molding. This cutaway depicts the process. The softened sheet is first placed in the mold and the mold is then closed and the edges sealed. Fluid pressure is then exerted onto the sheet forcing it to form to the contours of the mold.

The pressure formed part may have more detail than the vacuum formed part, but less detail than the compression molded part. **STK 522**



Thermoforming

Advantages:

- Low Pressure Process
- Automation
- Low Tooling Cost

Disadvantages:

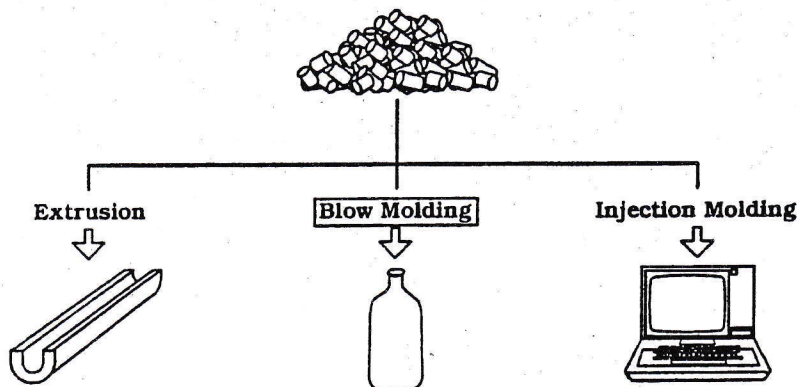
- Longer Cycle Times
- Lower Part Complexity

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Participant's Notes: _____



Conversion Processes



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Participant's Notes: _____

The advantages and disadvantages of thermoforming.

Thermoforming

Thermoforming is a low pressure process that can be automated and incurs relatively low tooling costs. For example, large quantities of plastic coffee cup lids can be vacuum formed all at once, then stamped out. Thermoforming calls for longer cycle times than even compression molding and offers limited part complexity.

STK 523

Blow Molding

Blow molding.

Conversion Processes

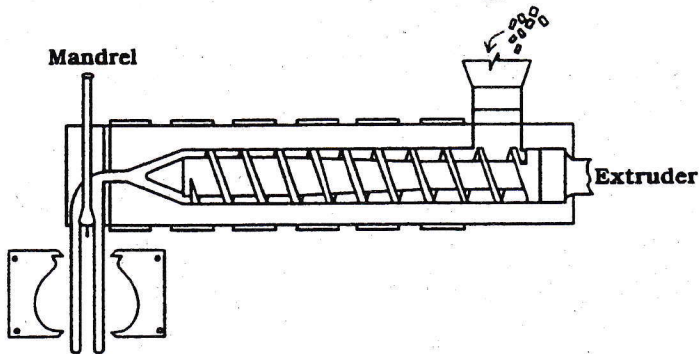
Blow molding is one of three conversion processes. There are many types of blow molding; however, in this module we will discuss extrusion blow molding.

STK 524



GE Plastics

Blow Molding



The material is softened and pushed through a die head to form a parison.

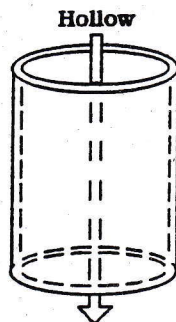
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Participant's Notes: _____



GE Plastics

Parison



A parison is a hollow tube of softened plastic. Its shape is determined by screw speed and/or the die opening.

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Participant's Notes: _____

A parison is extruded through a die head.

Blow Molding

In blow molding, the thermoplastic is first softened by electrical and mechanical heating in the extrusion barrel. The resulting melt is then extruded through a die head to form a hollow tube of molten plastic called a parison.

STK 525

A parison is a hollow tube of softened plastic.

Parison

As the parison is extruded, it must be capable of supporting its own weight for several seconds. Therefore, blow molding calls for resins with flow characteristics similar to resins that are used in profile extrusion. Blow molding resins are typically polymers that provide superior melt strength. As we'll see later, the size and shape of the parison is determined by the shape of the die opening and the speed of extrusion.

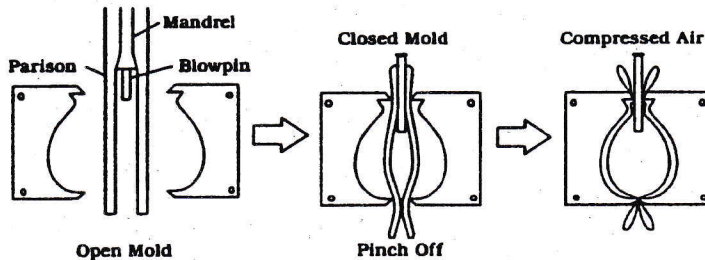
STK 526



GE Plastics

STK 527

The Process of Blow Molding



The parison is let down (dropped) into an open mold. The mold then closes, pinches off the parison, which is then inflated with air until it takes the shape of the mold.

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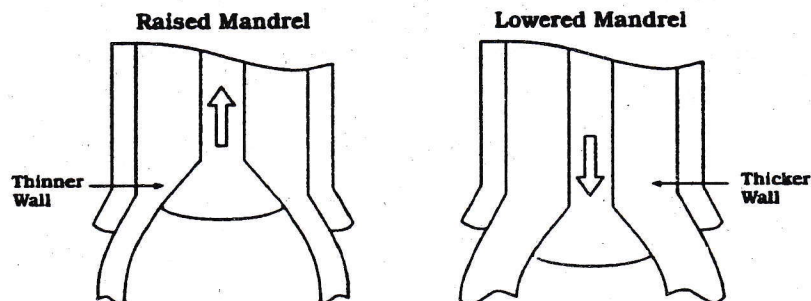
Participant's Notes: _____

STK 528



GE Plastics

Controlling Wall Thickness



The mandrel in this programmable die can be moved to either increase or decrease wall thickness of the parison.

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Participant's Notes: _____

Blow molding uses compressed air to form a shape.

The Process of Blow Molding

This cutaway depicts the process of blow molding. First the hollow parison is extruded. Then the mold closes, pinching off the extruded parison which surrounds the blow pin. The blow pin provides the opening for compressed air to enter the parison, and inflate the thermoplastic so it forms to the contours of the mold. **STK 527**

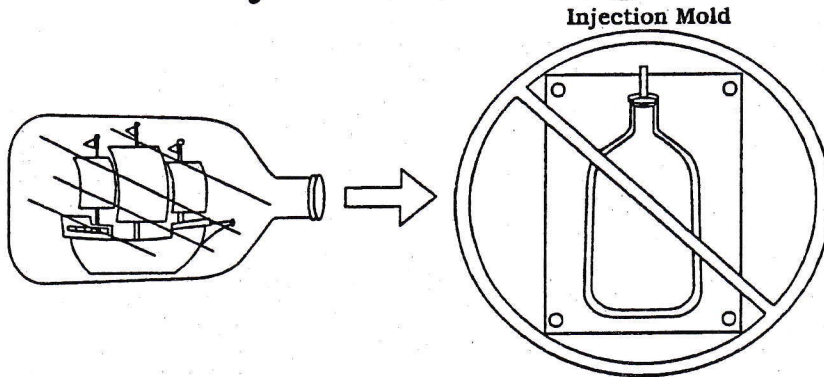
Wall thickness can be controlled by the die gap and/or the screw speed.

Controlling Wall Thickness

The thickness of the wall of the blow molded part is determined by the thickness of the parison. As we stated earlier, the size and shape of the parison is determined by the shape of the die opening and the speed of extrusion. The thickness of the wall is determined by the programmable die opening. Raising and lowering the mandrel decreases and increases the die opening for thinner and thicker parts. Raising the mandrel, for example, narrows the die opening, making the parison wall thinner and therefore the part wall thinner. Lowering the mandrel widens the opening, making the parison wall thicker and therefore the part wall thicker. **STK 528**



Why Blow Molding?



Blow Molding is an effective way to process hollow parts.

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Participant's Notes: _____



Blow Molding

Advantages:

- Double Wall Geometry (Hollow)
- Good Stiffness-to-Weight Ratio
- Low Cost Tooling

Disadvantages:

- Longer Cycle Times
- Secondary Trimming
- High Start-up Cost

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Participant's Notes: _____

Blow molding is an effective way to process hollow parts.

Why Blow Molding?

Blow molding is an effective way to process hollow parts. It also lets us mold hollow parts without seams. Imagine trying to injection mold a hollow part. The mold would be like a ship in a bottle. Once the part was molded, it would be impossible to remove the mold from the part without splitting the part and creating a seam.

STK 529

The advantages and disadvantages of extrusion blow molding.

Blow Molding

Blow molding is an effective way to produce hollow parts. It also molds parts with good stiffness-to-weight ratios while incurring relatively low tooling costs. Still, it requires longer cycle times, secondary trimming, and high start-up costs.

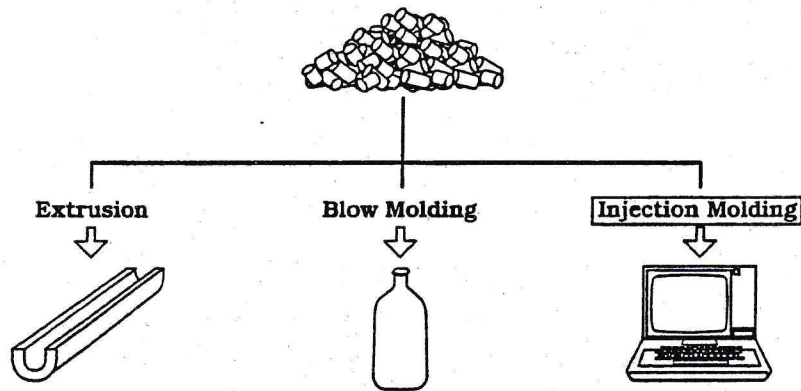
STK 530



GE Plastics

STK 531

Conversion Processes



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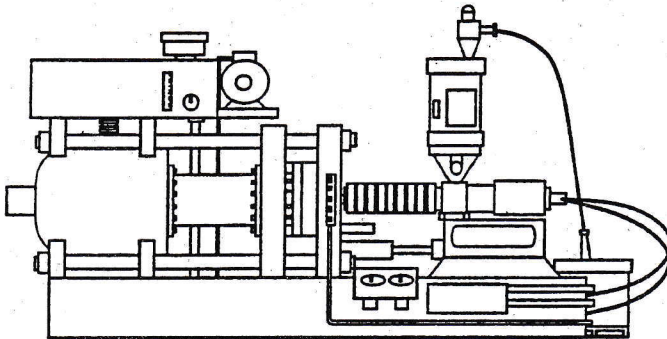
Participant's Notes: _____



GE Plastics

STK 532

Injection Molding



Injection molding makes possible the mass production of intricate, high performance, high tolerance parts with little secondary labor and minimal waste.

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Participant's Notes: _____

Injection Molding

Conversion Processes

The last process to be discussed is injection molding.

STK 531

Injection molding can produce intricate, high performance, high tolerance parts.

Injection Molding

Injection molding makes possible the mass production of intricate, high performance, high tolerance parts with little secondary labor and minimal waste. It is the function of the injection molding machine to heat and soften the thermoplastic pellets, and then inject the flowing material into a mold, where it cools and freezes into a part.

STK 532



Injection Molding Machine

An injection molding machine consists of two systems:

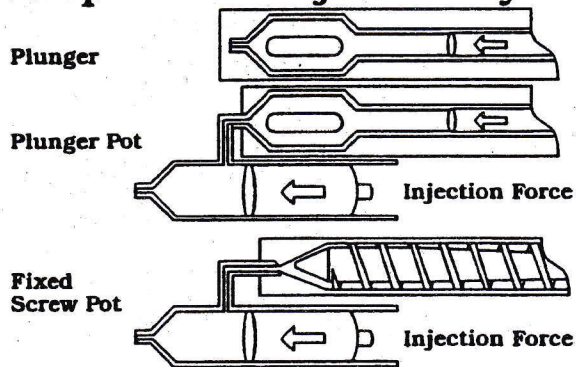
- An injection system is used to plasticize the material and force it into a mold.
- A clamping system is used to hold the two halves of the mold together as plastic is forced into it to form the part.

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Participant's Notes: _____



Development of Injection Systems



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Participant's Notes: _____

An injection molding machine consists of an injection system and a clamping system.

Injection Molding Machine

The injection molding machine first plasticizes the material and injects it into a part. This constitutes the injection system. The machine maintains pressure on the closed mold while the material cools and hardens into the part. This function is carried out by the clamping system. Together, these systems make possible the high volume production of sophisticated, close tolerance parts.

STK 533

The injection system evolved from a plunger to a reciprocating screw machine.

Development of Injection Systems

It is the speed and efficiency of the injection molding process that makes it so suitable for high volume part production. It is the consistency of the injection system that makes possible the production of close tolerance parts.

The injection system is responsible for first plasticizing material, then injecting it into the mold. The first injection molding machine plasticized the thermoplastic pellets using electrical heat. Electrical heater bands on the side of the machine barrel transferred enough heat to the pellets to cause them to soften and flow. Once the material was flowing, a plunger system was used to force it into the mold. Not all the pellets were getting sufficiently heated before injection. So a pot was added. Instead of forcing the material into the mold, the plunger now forced the material into a plunger pot. The plunger pot was also electrically heated and allowed the material more time to soften thoroughly before final injection.

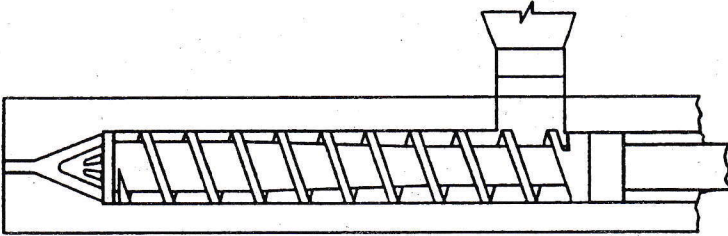
Eventually it was learned that an extruder provided a more consistent plasticized melt. So the plunger portion of the system was completely replaced by a rotating screw. With this system, the material is plasticized by both the mechanical heat generated by the rotating screw and the electrical heat generated by the electrical heater bands. The thermoplastic melt is extruded into a fixed screw pot which serves the same purpose as the plunger pot: to allow the material further time to soften before injection. Then, the material is injected from the fixed screw pot into the mold.

STK 534



GE Plastics

The Reciprocating Screw



A reciprocating screw is a combination plasticizing and injection unit.

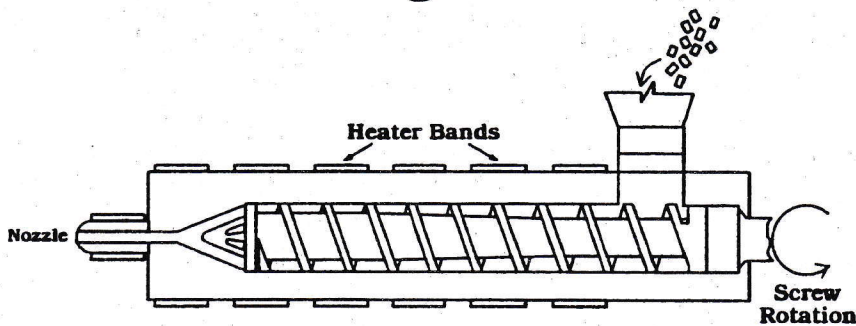
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Participant's Notes: _____



GE Plastics

Plasticizing the Pellets



The pellets are plasticized using both electrical energy from the heating bands and mechanical energy from the rotation of the screw.

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Participant's Notes: _____

A reciprocating screw is a combination melting, softening, and injection unit.

The Reciprocating Screw

As each injection system developed, the injection molding process became increasingly more accurate and productive. The reciprocating screw is the latest injection method to have evolved. It is a combination plasticizing and injection unit. The screw first acts as a rotating screw to plasticize the pellets and convey the plastic melt to the front of the barrel. As the material accumulates, it forces the screw back. Once the shot size is accumulated, the screw is pushed forward to inject the material into the mold.

STK 535

The pellets are softened and melted using electrical energy from heater bands and mechanical energy from the rotation of the screw.

Plasticizing the Pellets

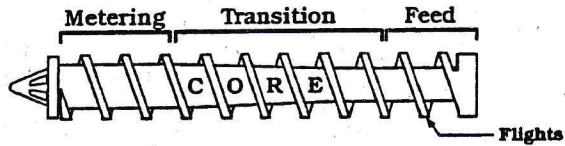
Today, the plasticizing process in injection molding is the same as the plasticizing process in extrusion: a combination of electrical and mechanical heat energy softens the pellets until they flow. Heater bands provide the electrical energy and screw rotation provides the mechanical energy that, together, serve to raise the temperature of the material so it flows.

STK 536



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Screw Description



- Feed Section:** Initial portion of screw which picks up pellets and carries them forward.
- Transition Section:** Central portion of screw with reduced channel depth which compresses the plastic, eliminating the air between the pellets and heating & melting them.
- Metering Section:** Shallow end of screw which does final plasticizing of melt.

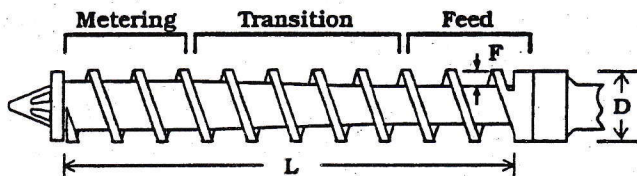
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Participant's Notes: _____



GE Plastics

Screw Configuration Terminology



Terminology

- L:** Length of Screw
- D:** Diameter of Screw
- F:** Flight Depth

Design

- Length/Diameter (L/D)
- Feed Depth/Meter Depth
(Compression Ratio)

5

Participant's Notes: _____

A screw consists of the feed section, the transition section, and the metering section.

Screw Description

The screw is crucial to the plasticizing process. It is the design of the screw that determines how well the material is plasticized. The core of the screw is tapered. It starts out narrow, then becomes wider as it nears the nozzle. Screw design can be broken down into three sections: feed, transition, and metering. The feed section is the initial portion of the screw which picks up the pellets as they enter the barrel and carries them along to the transition section. The transition section does most of the plasticizing. In this central portion of the screw, the core begins to widen thus reducing the channel depth. The reduction in channel depth serves to compress the plastic, eliminating the air between the pellets and encouraging them to flow. The transition section then conveys the plasticized material to the metering section. In the metering section, the screw core is at its widest which further compresses the material and completes the plasticizing of the melt.

STK 537

The common terminology used to describe injection molding screws.

Screw Configuration Terminology

The specific dimensions of a screw can greatly affect the processing of a material. A screw has several critical dimensions: length (L), diameter (D), and flight depth (F). It is important to understand these critical dimensions and the affect they have on the plasticizing of a material.

(L) is the length of the screw, from the first flight to the last. (D) is the diameter of the flights of the screw. The screw's tapered core has nothing to do with its diameter. (F) is the flight depth, or the distance from the edge of a flight to the core of the screw. The flight depth is therefore greater at the narrower feed section than at the wider metering section of the screw.

Screw designs vary by these dimensions. The important design ratios to understand are L/D and the compression ratio. L/D describes the relationship between the length of the screw and its diameter. L/D is an important indication of a material's residence time. The compression ratio describes the relationship between the feed depth and the meter depth of the screw. It indicates to what degree the core of the screw is tapered. The compression ratio is an important indication of the degree to which the plastic will be compressed as it is conveyed from the feed to the metering section of the screw.

STK 538



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Screw Design

Excessive Mechanical Heat Can Be Caused by:

- Low L / D's and Sharp Transition Zones
- High Compression Ratios
(ie. 3:1 or 4:1)

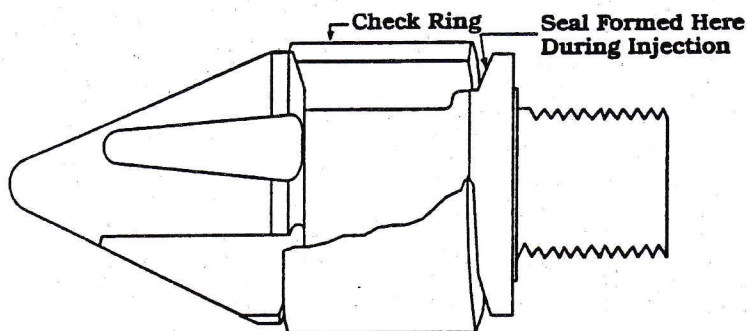
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Participant's Notes: _____



GE Plastics

Check Ring Function



The check ring must be forward to extrude the plastic and must slide back into a sealed position to inject the part.

5

Participant's Notes: _____

Small L/D and/or sharp transition zones can create excessive mechanical heat.

High compression ratios can create excessive mechanical heat.

Screw Design

The higher the L/D, the longer the screw is in relation to its diameter. A high L/D means less mechanical energy, but longer residence time. A very long residence time or excessive mechanical heating could cause the material to degrade. An L/D of 20:1 is suggested to ensure enough residence time for thorough mixing without adding excessive mechanical energy.

The compression ratio describes the volumetric transition of the screw. A high compression ratio such as 3:1 or 4:1, may create excessive mechanical energy which could cause the material to degrade.

STK 539

The check ring slides forward for extrusion and backward for injection.

Check Ring Function

The differentiating factor between the reciprocating screw used in injection molding and the rotating screw used in extrusion is the check ring. The check ring is a floating ring that encircles the screw at its tip. This floating ring slides back and forth to convert the screw from "plasticizer" to "injector." As we've seen, the reciprocating screw first acts as a rotating screw to plasticize the pellets and convey the melt to the front of the barrel.

As more and more of the melt accumulates in the metering section, it begins displacing the screw and forcing it to retract to a predetermined position equal to the volume of material needed for the shot. At this time, the screw stops rotating, and on the proper signal, will move forward to inject the material into the mold. It is this forward movement of the screw that causes the ring to retract into the sealing position. The check ring must be forward to plasticize and extrude the plastic, and must slide back into a sealed position to inject the plastic into the mold.

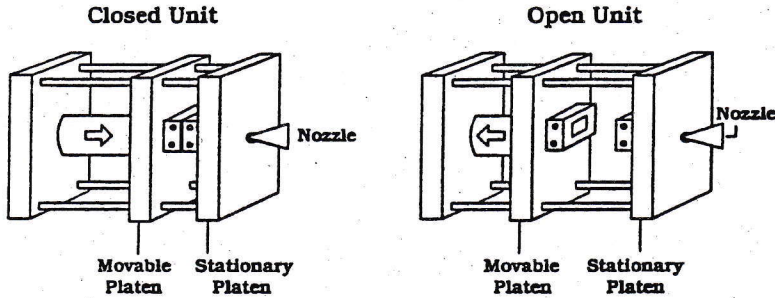
STK 540



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STK 541

Clamping System



The mold is mounted on the clamping unit which provides the motion and force to open and close the mold, and to hold the mold closed during injection.

5

Participant's Notes: _____



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STK 542

Machine Clamping Capacity

Clamping Capacity is the maximum Holding Force (expressed in tons) that a machine is capable of maintaining.

5

Participant's Notes: _____

The clamping unit provides the capability to open and close the mold and to hold the mold closed during injection.

Clamping System

As stated earlier, the injection molding machine consists of two systems: the injection system and the clamping system. The clamping system is responsible for clamping the mold shut in order for injection, holding it shut so the part can be sufficiently cooled below its T_c , and opening the mold so as to release the finished part. After the part is removed, the mold clamps shut again and the process is repeated. The clamping unit consists of a stationary and a movable platen. The movable platen provides the motion for opening and closing the mold, and for clamping the mold closed during injection.

STK 541

Machine clamping capacity is the holding force that a machine is capable of maintaining.

Clamping Capacity

The maximum holding force that a machine is capable of maintaining is called the clamping force. This maximum clamping force is expressed in tons and it can indicate the size of the injection molding machine and/or its clamping capability. For example, a 500 ton machine is capable of exerting 500 tons (one million pounds) of force.

STK 542



The Injection Molding Process

Requirements:

- Sophisticated Tooling
- Good Tooling and Part Design to Minimize Stress

Benefits:

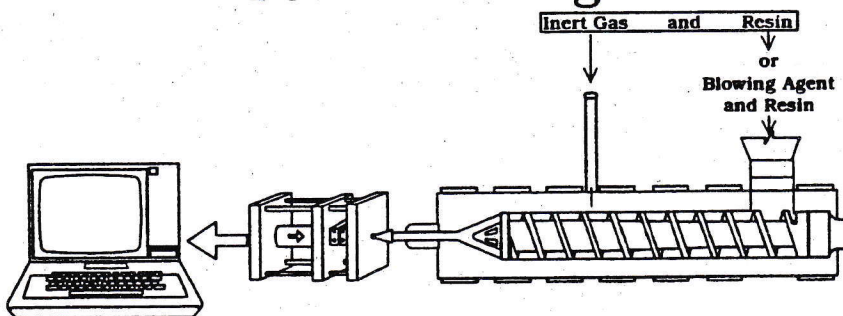
- High Tolerance Repeatability
- Elimination of Scrap
- Elimination of Secondary Operations
- Reduced Labor for Long Runs

5

Participant's Notes: _____



Foam Molding



Foam molding is an alternative method of injection molding using foamable resins, then blending them with inert gas or a blowing agent to mold low stress parts.

5

Participant's Notes: _____

**Requirements and
benefits of injection
molding.**

The Injection Molding Process

Injection molding is a sophisticated process that requires good tool design and good part design to minimize stress during processing. It is the only process that can deliver high tolerance repeatability, with the elimination of scrap and numerous secondary operations. In addition, injection molding is often the most productive processing method for very long runs.

STK 543

**A foam molded part is
often as much as 20%
lighter than an injection
molded part.**

Foam Molding

Foam molding is an extension of injection molding that uses foamable thermoplastic resins. The resins are mixed with a blowing agent as they enter the hopper, or they enter the hopper without a blowing agent and are then mixed with inert gas while in the barrel. This mixture of resin and gas is shot under pressure into a cavity. As the mixture fills the mold, the gas expands and forms tiny bubbles within the plastic. Foam molding requires less clamping tonnage because the cavity is actually filled with less resin, due to the presence of the gas. The resulting part has an internal cellular structure and a tough external skin. A foam molded part is often as much as 20% lighter than an injection molded part.

STK 544



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STK 545

Foam Molding

Advantages:

- Low Pressure Process
- High Stiffness-to-Weight Ratios
- Enhanced Chemical Resistance
(vs. Injection Molding)

Disadvantages:

- Poor Surface Appearance
- Longer Cycle Time (vs. Injection Molding)
- Blending Required

5

Participant's Notes: _____



GE Plastics

STK 546

Understanding Conversion Processes

5

Participant's Notes: _____

The advantages and disadvantages of foam molding.

Foam Molding

Foam molding is a low pressure process capable of molding parts with higher stiffness-to-weight ratios and greater chemical resistance than their injection molded counterparts. But foam molding requires longer cycle time than injection molding, can incur added labor costs due the process of blending and secondary operations. Foam molded parts do not have a smooth surface appearance unless counter pressure is applied.

STK 545

Summary and Performance Feedback

Understanding Conversion Processes

There are many methods used to process thermoplastic materials, each posing its own set of advantages and limitations. This module covered the most basic and most prevalent methods of conversion, though each of these methods can be expanded in ways not even touched upon. Having laid down the basics, you can see the value of having many different processes from which to choose. The conversion process is determined by a variety of selection criteria set forth by the application itself. Nevertheless, injection molding quite obviously holds a position of importance in the evolution of conversion techniques.

STK 546

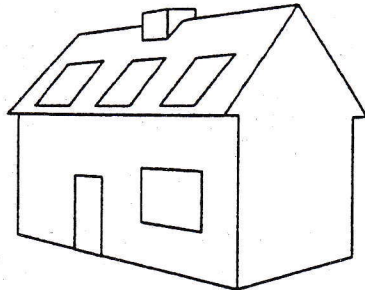


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STK 547

What Process Would You Use to Make...

Skylights



and why?

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Participant's Notes: _____



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STK 548

Thermoforming

Thermoforming is a low pressure process for production of large, relatively simple shapes.

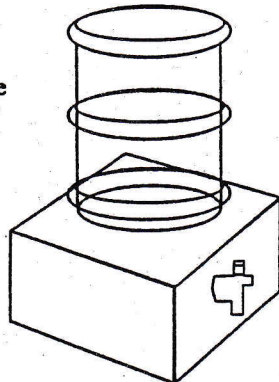
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Participant's Notes: _____



What Process Would You Use to Make...

Water Bottle



and why?

5

Participant's Notes: _____



Blow Molding

Blow molding is often the most economical process for high volume production of hollow parts.

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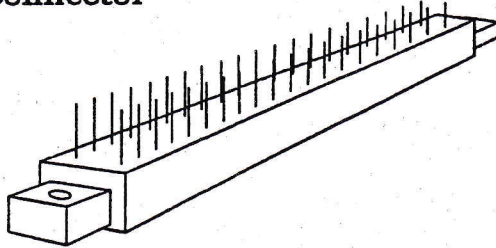
Participant's Notes: _____



GE Plastics

What Process Would You Use to Make...

Connector



and why?

5

Participant's Notes: _____



GE Plastics

Injection Molding

Injection molding is the most cost effective process for high volume production of precise parts with excellent repeatability.

5

Participant's Notes: _____



Module 6

Drying Polymers

- Reasons for Drying
- Critical Aspects
 - Moisture
 - Drying Rates
 - Drying Efficiencies

5

Participant's Notes: _____



Module 5

Performance Feedback

1. Describe five major types of conversion processes and the advantages and disadvantages of each.
2. Determine which type of conversion process is most suitable for various products: a large sign, a small toy, a cup.
3. Identify the types of conversion processes used in your company.