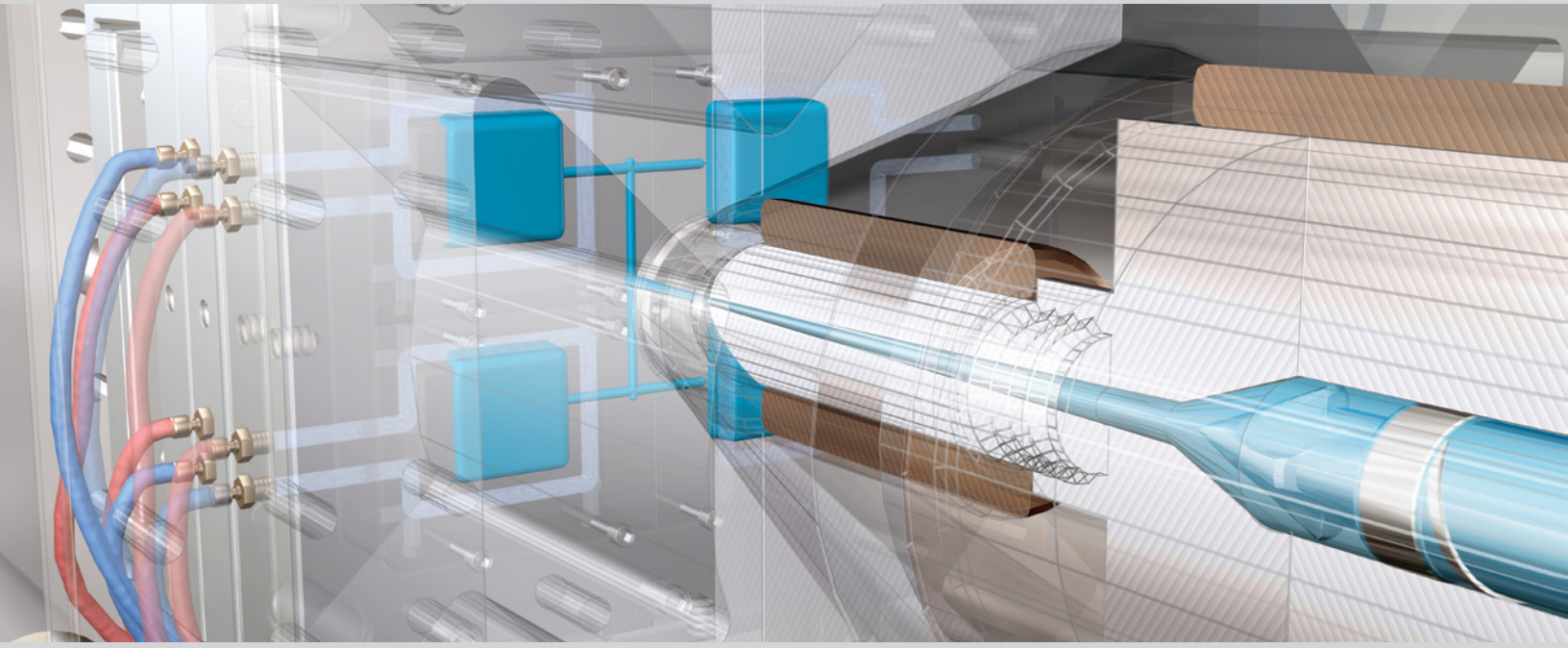
STUDY GUIDE

An Introduction to Injection Molding



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Introduction

This course provides participants with a general introduction to the plastics industry. The primary focus of this training program is the day-to-day operations of a typical injection molding facility.

Topics include:

- An Overview of Plastics & the Industry
- A Typical Molding Facility
- General Plant Safety
- An Introduction to the Molding Process
- Molding Machine Components
- Material Handling
- Injection Mold Terminology
- Common Part Defects

Overview of Plastics & the Industry

Welcome to the Plastics Industry! The plastics industry is the fourth largest industry in the world — right behind the electronics, petrochemical and automotive industries. In fact, all of the top industries rely heavily on plastics.

The plastics industry is also one of the largest manufacturing industries in the United States. In fact, it accounts for more than $350 billion dollars in annual shipments and directly employs nearly 2 million people – and is growing at a steady rate.

What Are Plastics?

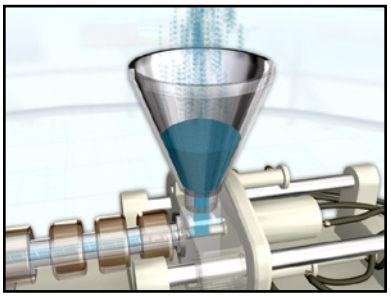
So, what are plastics? According to Webster's Dictionary, they are "complex organic compounds produced by polymerization, capable of being molded, extruded, or cast into various shapes and films." In other words, a raw plastic material is melted and formed into a given shape.

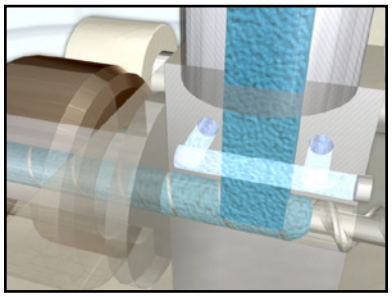


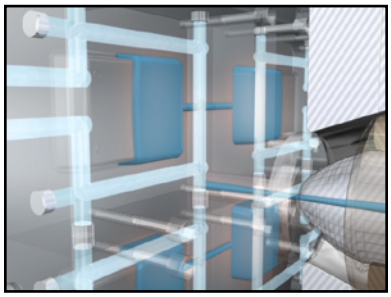
Billions of pounds of plastics are produced every year. Over 30% of that plastic is injection molded into parts – making it the world's most widely used plastics process.

In the industry, plastics are often referred to as polymers, and the actual plastic pellets are commonly referred to as 'resin' or 'raw material'.

This raw material is fed into an injection molding machine and converted into plastic parts. In many cases the molded part is the final product. Other parts may require assembly or other secondary operations, such as decorating, trimming or painting.





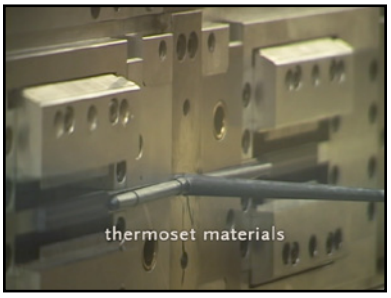


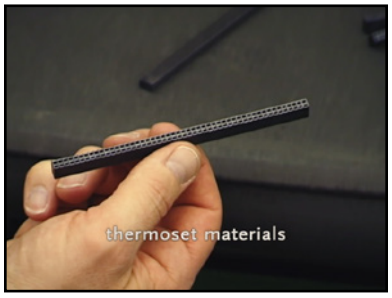
Most plastics are petroleum-based and are derived from crude oil. Plastics can be divided into two groups: Thermosets and Thermoplastics.

Thermosets

Thermoset materials cannot be remelted once formed. These materials offer durability and strength, but can be problematic when processing and cannot be recycled.

Thermosets are reserved mainly for producing construction products and electrical housings for high-voltage applications.





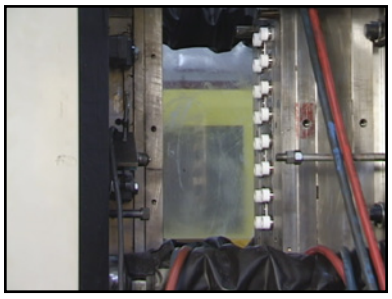


Thermoplastics

Thermoplastics are valued for their versatility. They are easy to recycle and can therefore be formed, heated and reformed repeatedly.

Thermoplastics are much more common in the industry and are used for virtually every application – including packaging, medical, automotive, and consumer goods.







Thermoplastics are used for the majority of injection molding applications. Some of the most widely used thermoplastic materials are PVC, polystyrene, acrylic, polyester, nylon, polypropylene, and polyurethane.

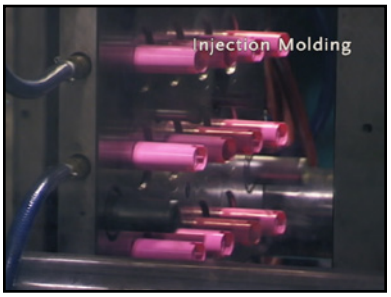
Plastics are being used for just about everything these days – from automobiles, and household goods, to electronics and medical supplies.

Plastics Processing

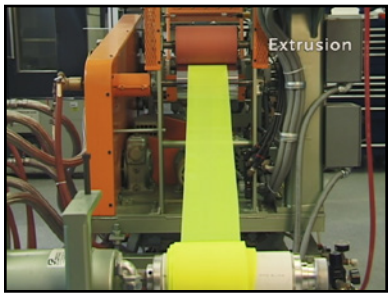
Plastics are processed or formed in a variety of ways. The more common methods include:

- Injection Molding
- Blow Molding
- Extrusion
- Thermoforming
- Rotational Molding

Some parts require multiple processes. For example, a part called a 'preform' is injection molded. After the preform is injection molded, it then is blow molded in order to convert it into a finished bottle.







Injection Molding

Injection Molding, as the name implies, is a process of injecting plastic material into a mold to form a part.

Examples include razors, pens, electrical connectors, compact discs, DVD's, cutlery, trays, cups, plates, containers, medical devices, and automotive parts – such as: distributor caps, dashboards, fenders, door panels and hubcaps.

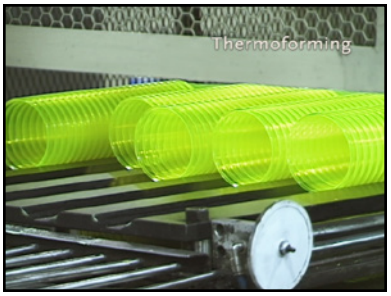
Most injection molded parts are ready for the customer after being ejected from the mold. On the other hand, some parts require secondary operations such as gate trimming, assembly, or decorating before being shipped.

Blow Molding

Blow molding also uses a mold to form the part, but uses air to inflate the plastic like a balloon. This is used for hollow, thin-walled parts such as plastic bottles, jars and other containers.

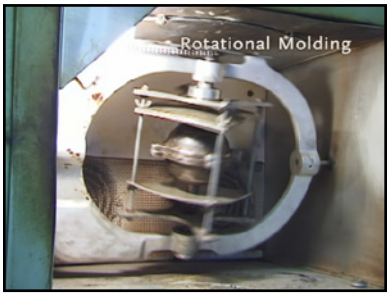
Extrusion

Extrusion is a continuous process used to make hoses, tubing, pipes, straws, window frames, as well as plastic bags and sheets.



Thermoforming

Thermoforming uses sheets of plastic material that are melted to form thin layers of contoured shapes. Common applications include coffee cup lids and blister packs.



Rotational Molding

Rotational Molding typically involves placing a plastic powder into a closed mold. This mold is then heated and rotated, allowing the powder to melt and take on the shape of the mold before it cools. Rotational molding is used for making large, hollow, one-piece parts – such as kayaks, canoes, and balls.

A Typical Molding Facility

A typical molding facility will have areas or departments for:

- Molding Machines And Robotics
- Quality Control And Inspection
- Material Handling And Storage
- Maintenance
- Administrative Personnel

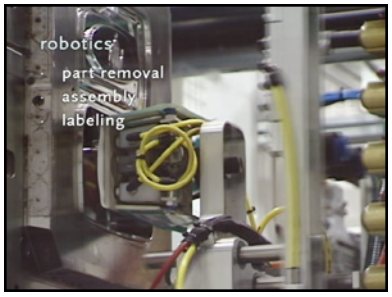
Since each molding facility is different, you should become familiar with the different employees working at your facility and the role that each department plays.

Molding Machines & Robotics

The molding area, or production floor, is where the injection molding machines are located. Be aware that these are powerful machines that use extremely high temperatures and pressures.

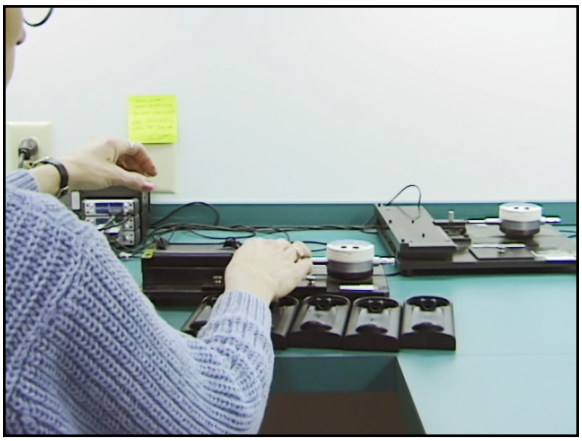
Many machines also use robots to automate tasks such as part removal, assembly or labeling.







Secondary operations, such as gate trimming, assembly, and packaging, can also be performed by plant personnel. This may take place next to the machine, or at another location in the plant.



Quality Control & Inspection

Most production facilities contain Quality Control and Inspection areas. This is where parts are inspected to ensure they meet the customer's specifications.

This information is often entered into computers to track and analyze product quality over time.

Material Handling & Storage

Plastic resins often require preparation before processing. This usually takes place in the Material Handling area of a facility. Some plastics require specific heating and drying – and most plastics are blended with additives to improve their performance.



After a plastic is prepared to specifications, it can be fed directly to a particular molding machine by a facility's material delivery system.



Most operations store bags or boxes of raw material on palettes or large racks. In many cases, this storage area is climate-controlled to regulate moisture and temperature.

Shipping & Receiving

The Shipping & Receiving Department is usually located near the Material Handling area.





Maintenance

Molding facilities also have a Maintenance Department. Maintenance personnel service and repair the machines, molds and auxiliary equipment.



Tooling

Some plants have a Tooling department where they construct their own molds using milling machines, lathes, electrical discharge machines, and grinders.



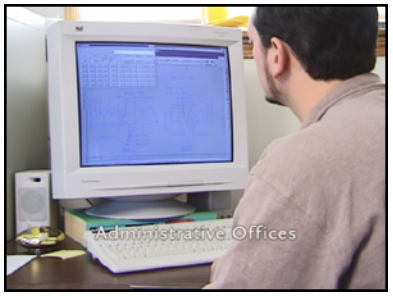
Mold Storage

Molding facilities typically have a Mold Storage area to house molds that are not in use. Forklifts, cranes and carts are frequently used in these areas – due to the immense weight of the equipment.

Administration

Administrative, sales, and executive personnel spend most of their time in offices and meeting rooms – usually located as far away as possible from the noisy production floor.





Job Positions in the Industry

Maintaining consistent production requires common goals and teamwork. Each member must perform their job correctly to ensure success.

Remember: An injection molding operation is selling time. It is the responsibility of everyone on the production floor to ensure that quality parts are being produced and handled efficiently. This helps ensure the company's success and ultimately your employment.

The following section briefly describes some of the typical job titles in the plastics industry.

Machine Operators

The role of Machine Operators varies from plant to plant. It's common for Machine Operators to handle parts and be responsible for inspecting, packing, and organizing product that's being produced from a machine or multiple machines.







In some plants, machine operators perform secondary operations, such as trimming and assembly, and may also be responsible for making changes to the process. Ask your supervisor about the exact role that's expected of Machine Operators at your facility.



Quality Personnel

Quality personnel conduct regular inspections to confirm that parts are meeting the customer's specifications. Their duties include; measuring, weighing, and visually inspecting the parts. This information is entered into a computer, so that data can be analyzed.

Material Handlers

Material Handlers maintain the integrity of the plastic material and the feed system of the facility. This is verified by updating all material-related documentation. These personnel must ensure that each machine is receiving the correct type and lot of material – and that the material is free of contamination.

Most materials require additional preparation including; mixing, drying, or preheating - which material handlers must oversee.

In many plants, material handlers may also be responsible for grinding rejected parts into regrind and incorporating the correct percentage back into the cycle.







Mold Setters

Mold Setters – often called Die Setters, are responsible for installing and removing molds from the machine.

The mold halves must be strapped together while being transported. Molds typically weigh between 500 and 5000 pounds, so die setters need to be comfortable using cranes and other heavy equipment.

Molds are also very expensive to build – costing up to $200,000 or more. For these reasons mold must be handled with extreme care.

It is also a die setter's responsibility to start up the machine and check that the mold has been properly installed, aligned and leveled.





Process Technicians

Once the Die Setter has verified proper mold installation, a Technician must set up the process, troubleshoot any problems that come up and, whenever possible, optimize the process.

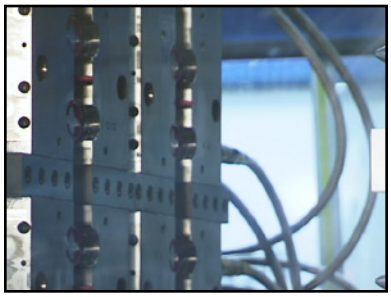






Maintenance Personnel

Maintenance Personnel are on hand to repair the molding machines, molds and other equipment in case of damage or failure. In addition, they perform scheduled preventative maintenance to keep the machines functioning properly.



Managers & Supervisors

It is the responsibility of the Managers and Supervisors to ensure all equipment, materials, and personnel are functioning properly.

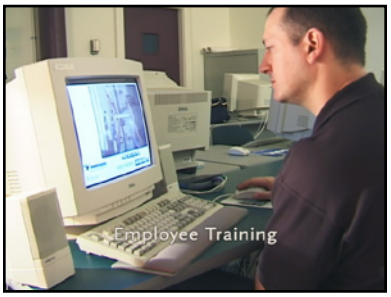


Training

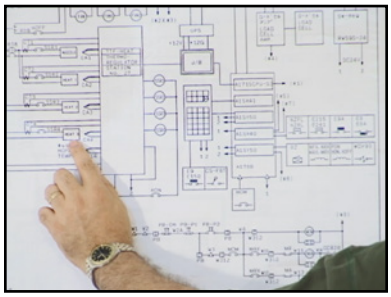
The different jobs at a plastics processing facility require a variety of skills. A given position may require candidates to demonstrate proficiency in some or all of the following areas:

- Reading
- Writing
- Math
- Communication
- Computer Skills
- Problem Solving

Training plays an important role in the success of any molding facility, and provides benefits to both the employee and employer. It is important that personnel at all levels participate in a structured in-house training program. Employees increase their knowledge base and learn applicable skills to enhance their performance in a production environment.







Training also helps the employer satisfy their customers – and ensures future customers that they'll be able to handle new challenges.

- Common training methods include:
- On-the-job training
- Documentation – in the form of books and manuals
- Computer-based interactive training
- Instructor-led training
- Higher education – such as a degree, diploma, or certificate from a college, university or technical school

Such training is essential to performing your job correctly. In addition, training can help achieve your professional and financial goals by providing job advancement opportunities.

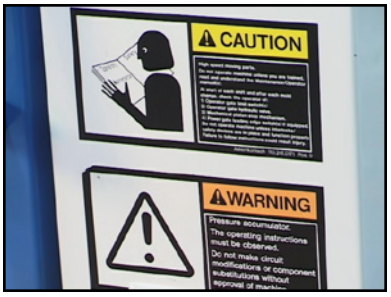
Safety

Never be afraid to ask your supervisor questions regarding safety. Everyone, including you, is responsible for keeping the workplace safe and hazard free.



General Plant Safety

Since an injection molding environment contains many dangers, all safety rules and regulations at your plant should be taken very seriously and must be followed by all personnel at all times.



Governmental Regulation

Also be aware that each state, region, or country has governing bodies that determine which specific safety precautions are necessary.

One example of this is OSHA in the United States. OSHA stands for Occupational Safety and Health Administration. Safety regulation materials and material safety data information should be readily available for your review.



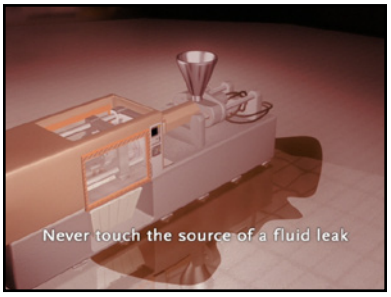
Safety Precautions

Here are some general safety precautions that apply to all injection molding facilities:



Pay strict attention to designated areas that require Personal Protective Equipment, such as safety glasses and ear plugs. Most molding operations plants provide personnel with hearing and eye protection.

Always ensure that the area around the molding machine is clean and free of obstructions. Leaking oil or water, as well as spilled plastic pellets, are severe hazards and should be cleaned up immediately.

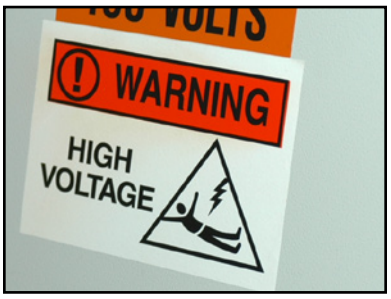


Never touch the source of a fluid leak. High pressures can inject fluid under the skin — creating a serious health problem.

Warning Signs

Stay alert and be aware of all warning signs; they are there for your protection. Here are some of the warning signs that you'll see throughout a molding facility:

- Shock Hazard
- Crush Hazard
- Cutting Hazard
- Burn Hazard
- Purge Hazard
- Eye Protection Required
- Ear Protection Required
- Head Protection Required
- Hand Protection Required













Also be familiar with where forklifts and other moving equipment travel. These vehicles travel in areas that are usually marked with yellow line and have the right of way – so pay attention to their signals that inform their presence.

It is important that all plant personnel are prepared to handle an emergency situation. This includes knowing the location of all emergency exits, eyewash stations, and first aid kits – as well as whom to contact in case of an emergency.

Injection Molding Safety

Injection molding machines produce plastic parts using extraordinary pressures, speeds and temperatures. To protect personnel from these risks, each machine is equipped with several safety features.

Safety guards should cover both the machine and any auxiliary equipment being used and must not be operated if any guard has been removed.

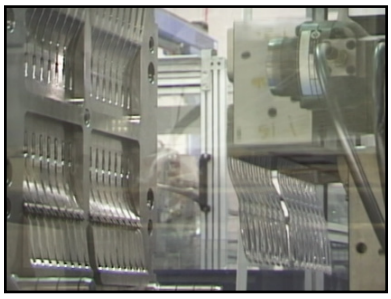
Both front and rear safety gates are located on the machine to protect against the extreme forces used to open and close the injection mold.

Never reach under or around a machine guard or gate.

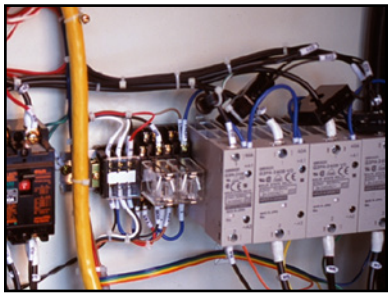
Be sure to follow your plant's safety procedures when removing plastic parts that are jammed or stuck in a mold.













Emergency Stop Buttons

You should also be familiar with emergency stop buttons for all of the equipment in the plant. These buttons should be labeled and are colored red. Be sure to press the button firmly to stop the equipment. To allow the machine to function again, turn and pull the button.

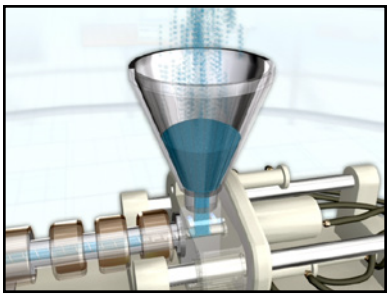
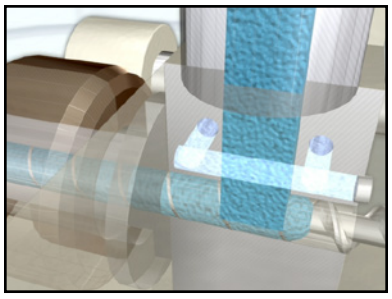
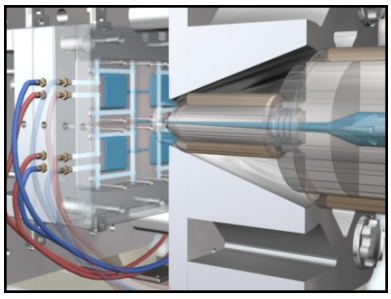
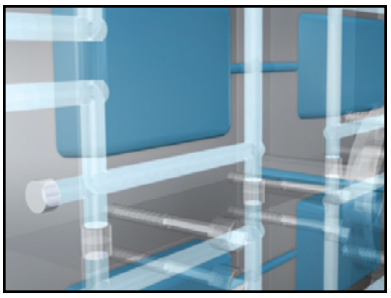
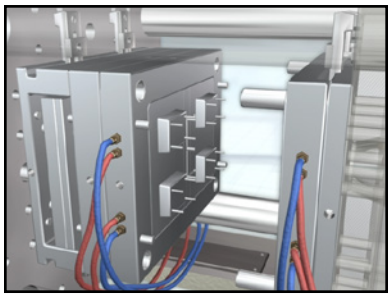
Lock-out/Tag-out

Be aware that some equipment may require Lock-out/Tag-out procedures in order to restart. These procedures are only conducted by trained personnel and tagged equipment should not be tampered with under any circumstances. Lock-out/Tag-out signs indicate hazards for electricity, pressure release, and movement.

Introduction to the Molding Process

The following sequence illustrates the basic functions of an injection molding machine and the process by which plastic pellets are transformed into molded parts:

- Pellets are fed into the hopper
- A screw conveys and melts the pellets within the barrel
- Melted polymer is forced into the closed mold
- The parts are formed
- The polymer is cooled within the mold
- The mold is opened
- The part is ejected or removed from the mold
- The cycle repeats


INDUSTRY TIP

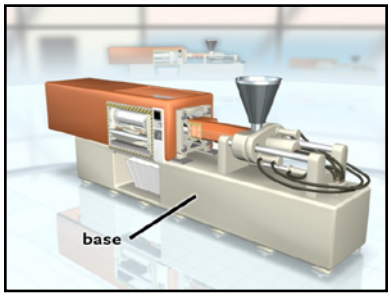
Any changes made to the process will affect the final product. Personnel such as Process Technicians or Engineers are responsible for understanding how adjustments can be used to improve part quality and consistency.

Molding Machine Components

In this section we will cover some of the basic components of an injection molding machine.

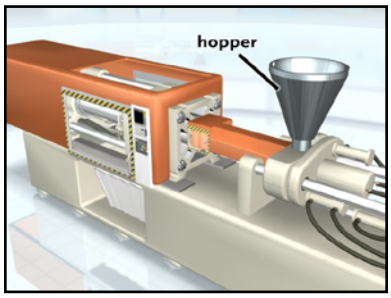
Machine Base

The base supports the molding machine and houses many of the machine components.



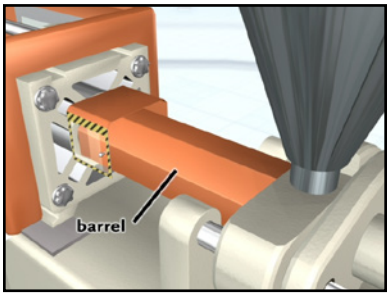
Hopper

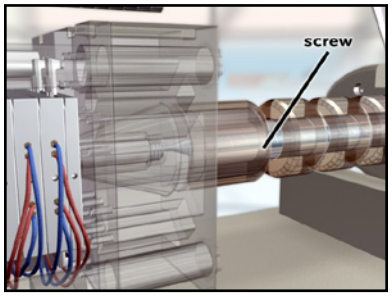
The hopper holds and funnels the plastic material into the barrel.

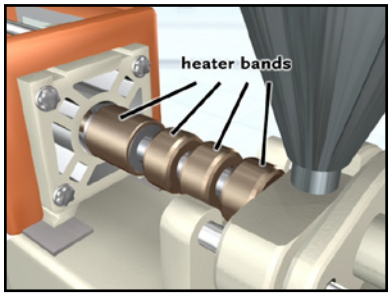


Barrel

The barrel houses the screw – which melts the pellets and forces the plastic into the mold. The barrel is surrounded by heater bands which help maintain the barrel temperature.





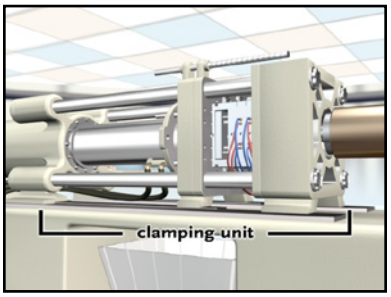


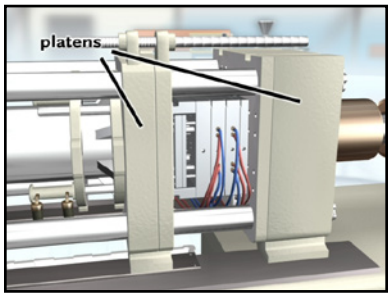
Clamping Unit

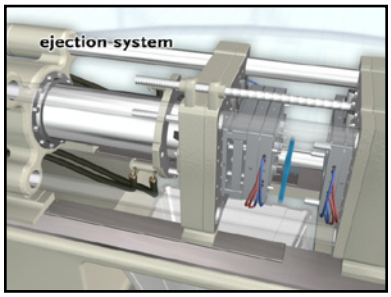
The clamping unit contains two large steel plates called platens, on which the two halves of the mold are mounted.

The machine clamp is used to open and close the mold.

An ejection system is used to remove the part from the mold after it is formed.







Control Panel

The control panel is used to setup, monitor and manage machine functions including; speeds, pressures, times, mold open and close, part ejection and the temperature of the plastic material.



Material Handling

Plastics, or resins, are most commonly provided as pellets, yet may also be in the form of powder or flakes. Resin costs typically range from fifty cents to seven U.S. dollars a pound. To reduce material costs, some processes use plastics that have already been processed. This is called regrind. It consists of ground up 'scrapped' plastic from sprues, runners, and rejected parts.

The material can be supplied in many different manners: in bags, or in large boxes – called gaylords, or loaded directly into material silos from a railcar or truck.







Bags are often poured directly into the hopper or loaded via a vacuum loader.

Material shipped in gaylords is typically vacuum-loaded directly to a machine's hopper.

Companies that use material silos transfer resin throughout the plant using a centralized material conveyance system.

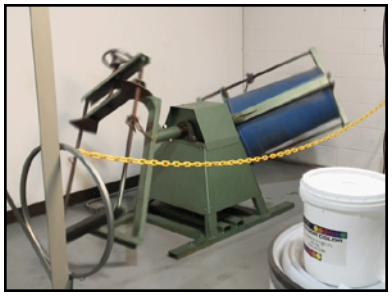
Materials can be mixed by hand, in a batch mixer, or by a continuous mixer.

Hand mixing is relatively easy, but it's often inconsistent and is only practical for mixing small quantities for short production runs.

Batch mixers, or tumblers, are used to thoroughly mix materials with specified additives. Materials are removed from their original containers and placed into mixing drums. Although more consistent than hand mixing, a particular blend may vary from batch to batch.

Continuous mixers are built into a facility's material feed system and blend the material and additives as needed. These systems are completed automated, can be adjusted at any time, and provide absolute consistency.



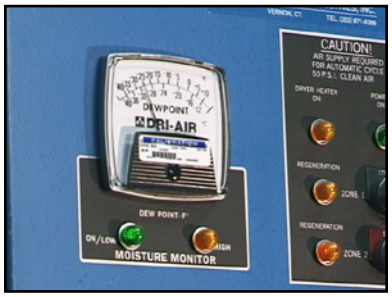




Many materials used in injection molding are hygroscopic, meaning that they absorb moisture from the atmosphere.

These pellets must be placed in a material dryer before they are blended or processed. Moisture in the material can change its processing characteristics and may cause molded part defects.







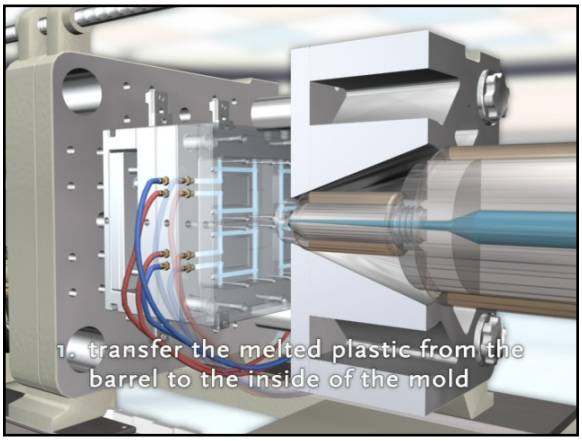
INDUSTRY TIP

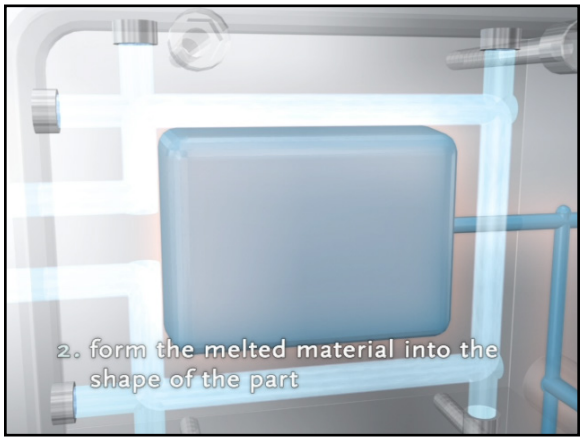
Plastics materials can cost a lot of money; an ounce or gram of resin can be more expensive than an equal amount of silver or gold. For this reason, you should take great care in not wasting the material and recycling scrap whenever possible.

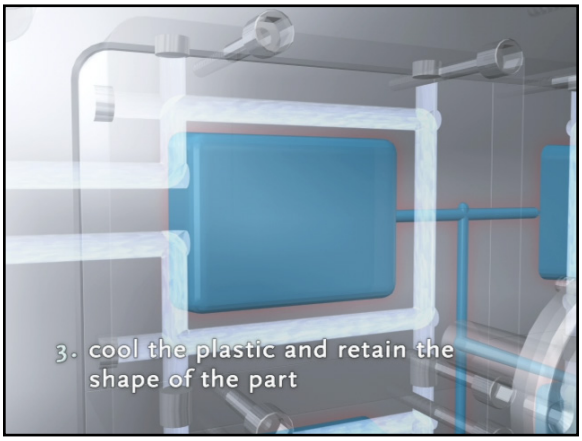
Functions of an Injection Mold

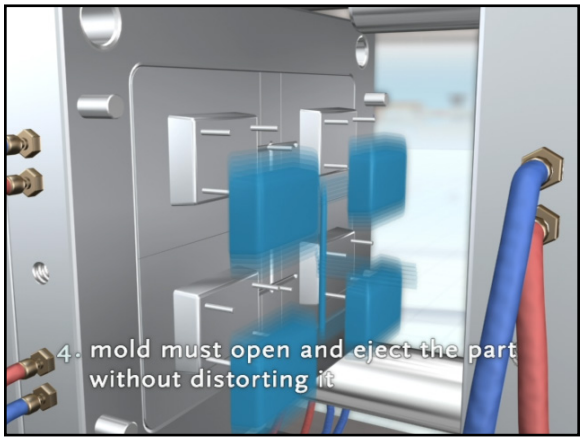
An injection mold performs several major functions:

- First, the injection mold must transfer the melted plastic from the machine's barrel to the inside of the mold.
- Once the plastic reaches the inside of the mold, it must successfully form the melted material into the shape of the part.
- Next, the mold must cool the plastic so that it can retain its shape.
- Lastly, the mold must open and eject the part without distorting it.









INDUSTRY TIP

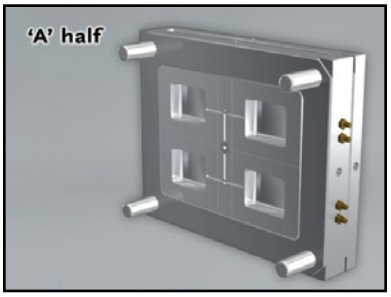
Because injection molds are clamped under high forces, have many moving components, and can produce millions of parts – they need to be serviced on a regular basis. The more often molds are cleaned, lubricated, and inspected, the less chance they will break or need repairs.

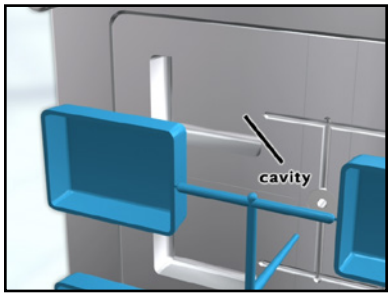
Injection Mold Terminology

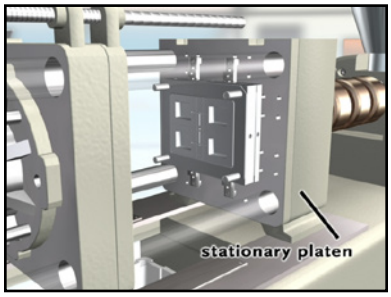
An injection mold consists of a series of metal plates grouped together to create two halves: the ‘A’ half and the ‘B’ half.

The part detail is split into the cavity and core.

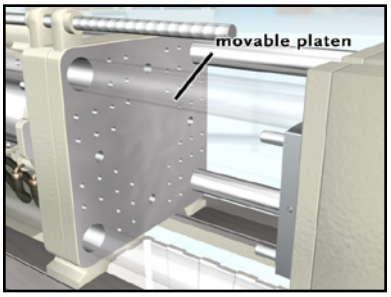
The A half of the mold is attached to the stationary platen and contains the mold cavity.

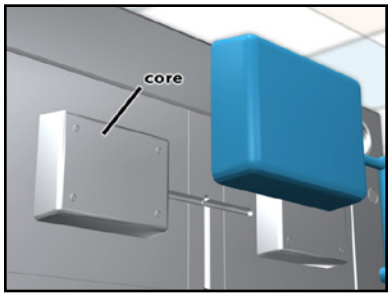


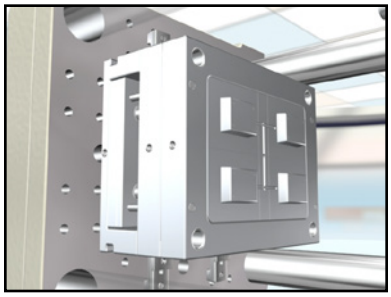




The B half is attached to the movable platen and contains the core. The B half of the mold typically contains an ejection system to remove the part from the mold.







These halves are clamped together to allow the melted plastic to be injected into the core and cavity and form the part.

The injected plastic cools and the mold is opened – allowing the final part to be ejected.

Most applications produce multiple parts during each cycle. These molds are referred to as multi-cavity or family molds.

Common Part Defects

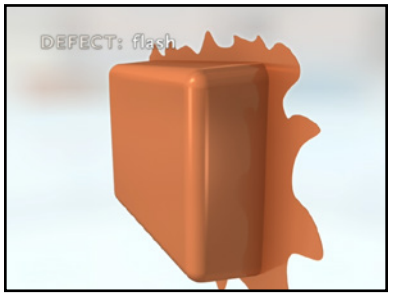
It is important that production personnel are able to recognize common molding defects so that they can discuss problems that may arise.

Every part should pass a basic visual inspection before being shipped. To do so, a part must free of contaminants, and should match all criteria set by the customer – including color, clarity, and surface finish.

Here are some part defects that you may encounter.

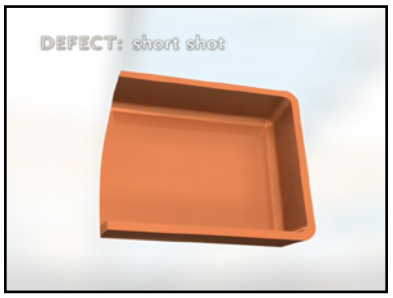
Flash

Excessive, unwanted material located on the edge of a part is referred to as flash. In some cases, this flash is removed by pulling, cutting, or burning it off.



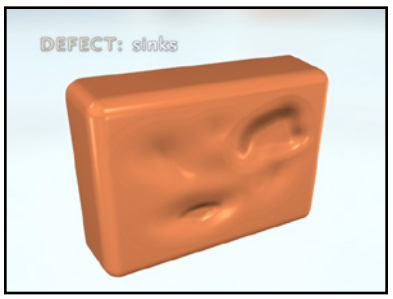
Short Shot

The incomplete filling of a mold cavity is called a short shot. Short shots can often be detected visually. In other cases, parts must be weighed to determine if they have been filled completely.



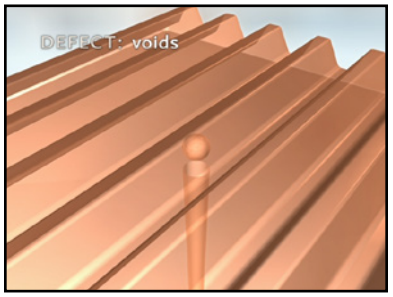
Sink Marks

Sinks are indentations on the part surface, and are often located near the gate. Sink marks are also commonly found on the opposite side of thick part features, such as ribs.



Voids

Voids appear as bubble-like sections in the center of a part. While they are easily noticed in translucent parts, solid parts usually have to be cut apart to reveal the defect.



Splay

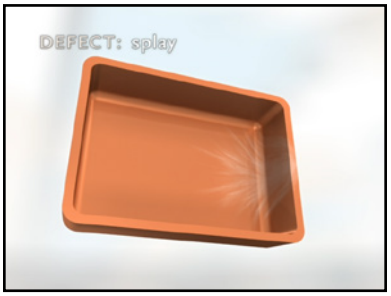
Streaks on the surface that spread outward from the gate area of a part are referred to as splay.

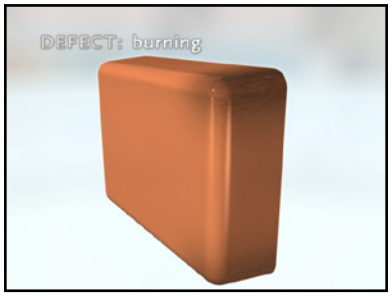
Burning

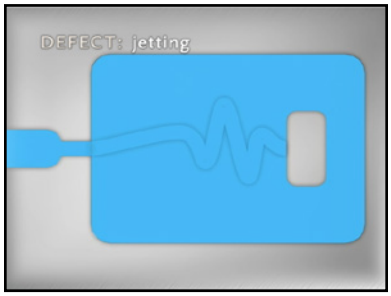
Black or charred material on the part surface is called burning or ‘dieseling’.

Jetting

Jetting, or worming, is a snake-like pattern on the part surface – most often originating at the gate.







Brittleness

Brittleness is the reduced strength or toughness of a molded part. This is most often found in parts exhibiting other defects, such as splay and burning.

Dimensional Variations

Dimensional variations exist when parts are ‘out-of-spec’ and do meet the customer’s requirements. Part dimensions are often measured using devices such as calipers, micrometers, and fit gauges.

INDUSTRY TIP

Sometimes an imperfection is acceptable to the customer — it all depends on the part and how it is being used. Examples of both acceptable and unacceptable parts should be located at each machine or inspection station to help you determine which parts are OK.

Conclusion

After completing this course, participants should be familiar with:

- An Overview of Plastics & the Industry
- A Typical Molding Facility
- General Plant Safety
- An Introduction to the Molding Process
- Molding Machine Components
- Material Handling
- Injection Mold Terminology
- Common Part Defects