

## Training Objective

After watching this video and reviewing the printed material, the student/trainee will understand the principles and physical operations of the plastic injection molding process.

- An overview of the process is presented.
- Aspects of plastic materials is reviewed.
- Descriptions of the injection machine are detailed.
- Mold types and design are explained.

## Injection Molding

This is the most common method of producing parts made of plastic. The process includes the injection or forcing of heated molten plastic into a mold which is in the form of the part to be made. Upon cooling and solidification, the part is ejected and the process continues.

The injection molding process is capable of producing an infinite variety of part designs containing an equally infinite variety of details such as threads, springs, and hinges, and all in a single molding operation.

A plastic is defined as any natural or synthetic polymer that has a high molecular weight. There are two types of plastics, thermoplastics and thermosets. Thermosets will undergo a chemical reaction when heated and once formed cannot be resoftened. The thermoplastics, once cooled, can be ground up and reheated repeatedly. Thus, the thermoplastics are used primarily in injection molding.

There are four major elements that influence the process. They are:

- the molder
- the material
- the injection machine
- the mold

Of these four, the injection machine and the mold are the most varied and mechanically diverse. Most injection machines have three platens. Newer models use just two platens and may be electrically operated as opposed to the traditional hydraulic models. They can range in size from table top models to some the size of a small house. Most function horizontally, but there are vertical models in use. All injection machines are built around an injection system and a clamping system.

The injection system mechanism may be of the reciprocating screw type or, less frequently, the two-stage screw type. Also included is a hopper, a heated injection barrel encasing the screw, a hydraulic motor, and an injection cylinder. The system's function is to heat the thermoplastic to the proper viscosity and inject it into the mold. As the resin enters the injection barrel, it is moved forward by the rotation of the screw. As this movement occurs, the resin is melted by frictional heat and supplementary heating of the barrel encasing the screw. The screw has three distinct zones which further processes the resin prior to actual injection.

Injection is accomplished through an arrangement of valves and a nozzle, all acted upon by the screw and the hydraulic pump that pushes the resin into the mold. This so-called "packing action" occurs at pressures from 20,000 to 30,000 psi and higher. The temperature of the resin at this time is between 320° and 600° F.

The clamping system's function is to keep the plastic from leaking out or "flashing" at the mold's parting line. The clamping system consists of a main hydraulic pressure acting on the mold platens and a secondary toggle action to maximize the total clamping pressure.

The platens are heavy steel blocks that actually hold the mold tightly closed during the injection phase. Most injection machines have three platens. The "stationary" platen has a center hole that receives the injection nozzle and holds the cavity half of the mold. This platen also anchors the machine's four horizontal tie bars. The "movable" platen holds the core half of the mold. This platen moves back and forth on the tie bars and as the mold opens, the mold's ejection system of pins and posts expel the finished part. The "rear stationary" platen holds the opposite ends of the tie bars and anchors the whole clamping system.

All injection machines have some sort of safety interlock system that prevent access to the molds during the clamping and injection phases when the machine is operating semi-automatically. The operator removes the finished part, closes the door or gate, which sets in motion the next molding cycle. In full automatic operation, finished parts fall into a container, conveyor, or are removed by robot mechanisms.

## Injection Molds

The mold determines the part's shape, acts as a heat sink to cool the part, is made to vent trapped air and gases, and, finally, ejects the finished part. Molds are most often made of special molding steel. Other mold materials include beryllium copper, stainless steel, aluminum, brass, and kirksite. Molds are manufactured by machining, EDM, or casting. The finished mold surfaces are often polished and coated to resist wear and aid in part ejection. The accurate mounting of each half of the mold is accomplished with leader pins and dowels and ensures proper mold alignment. The injection nozzle is seated on the molds "sprue bushing." The sprue's tapered center hole directs the molten resin into either the molds runner system or directly into the mold cavity.

A mold may have several and varied types of runners and gates. The function of the runners is to channel the flowing resin to the mold's gates, which in turn lead to the cavity itself. In some cases where resin goes directly into the cavity, it goes through a "sprue gate."

Vents are ground on the molds parting line to allow the escape of air and gasses as the mold fills. The "molder" determines the size, number, and location of the vents according to the parts geometry, gate locations, type and viscosity of the resin, and the injection rate. The mold also has an internal water cooling network. Cooling is the most critical part of the whole process, contributing to controlled shrinkage, part strength, and process speed. When the mold opens, part ejection is accomplished by pins and

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bushings pneumatically or hydraulically actuated. Older machines use mechanical systems while still others use a stripper plate arrangement.

Many different mold designs are in use. They include:

- cold runner, two plate mold
- cold runner, three plate mold
- hot runner mold
- insulated runner mold

Each has its own distinct advantages which influence process speed, ejection efficiency, automation potential, and part cleanliness.

## Machine Control

Machine controls range from electromagnetic relays and timers to computer driven solid state devices. Computers not only control the process sequences, but also perform quality control functions, real-time reject recognition, fault analysis, record keeping, and instant set up procedures. Additionally, computer systems aid in the design and construction of the molds.

## Review Questions

1. A "plastic" is defined as a:
  - a. resin
  - b. composite
  - c. polymer
  - d. nonmetallic
  
2. A thermoplastic is one that:
  - a. can be reused
  - b. can be processed just once
  - c. is the most light weight
  - d. is the strongest
  
3. The most common type of injection machines are:
  - a. vertical
  - b. horizontal
  - c. a combination of the two
  - d. electrically operated
  
4. Movement of the plastic material is caused by:
  - a. a ram
  - b. compression in a cylinder
  - c. gravity
  - d. a rotating screw
  
5. The movement of the material into the mold is called:
  - a. filling
  - b. packing
  - c. squirting
  - d. flowing
  
6. Leaking out or flashing occurs at the:
  - a. mold gate
  - b. mold runner
  - c. sprue hole
  - d. parting line
  
7. The temperature of the material upon entering the mold is:
  - a. 800 to 1000 degrees
  - b. over 1000 degrees
  - c. 100-200 degrees
  - d. 320-600 degrees
  
8. Most molds are made of:
  - a. a special steel
  - b. aluminum
  - c. copper
  - d. brass
  
9. The function of the mold runners is to:
  - a. vent trapped air
  - b. provide entry into the mold cavity
  - c. provide a path to the mold gates
  - d. define the mold parting line

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10. The most critical process function is:
- a. speed
  - b. clamping pressure
  - c. mold cooling
  - d. ejection speed

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## Answer Key

1. a
2. a
3. b
4. d
5. b
6. d
7. d
8. a
9. c
10. c