The Molding Process

LESSON 1: Injection End Parts and Their Functions - II

Lesson 2: Injection End Parts and Their Functions - II

This lesson is a continuation of Lesson One. It begins with a discussion of the basic steps involved in the molding of a plastic part. Each sequence in the machine cycle is discussed in this lesson, as well as the function of each part of the injection system of the machine. This lesson also discusses how molding machines are rated for part size capacity.

Objectives of Lesson Two

1. Begin to understand the functions of the machine's basic molding cycle.
2. Learn the names of the external components on the injection end of the machine.
3. Learn how the machine is rated for its part size capacity.

Objective One

The Basic Molding Cycle

There are two areas on an injection molding machine where most of the important action takes place: one is the injection system of the machine, the other is in the mold. The following molding cycle diagram (Figure 1) shows what happens in each of these two areas of the machine as it goes through one complete cycle. Each horizontal line represents a portion of time. The total time from left to right is called the cycle time.

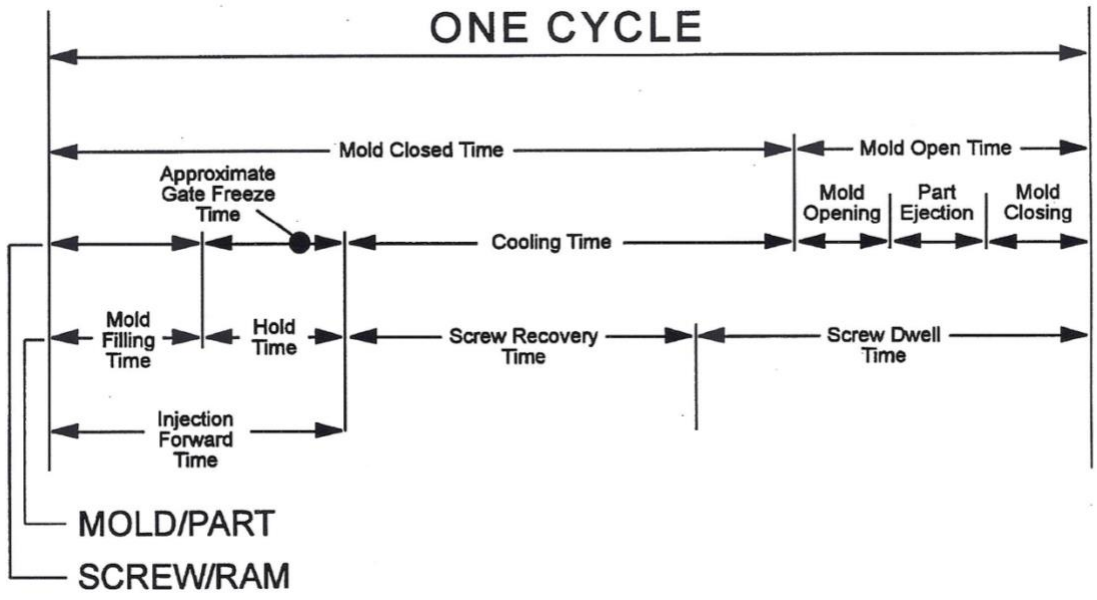

Figure 1 - Diagram of the Molding Cycle

Fill Time

The molding cycle begins with the mold in the closed position. The cycle time then starts with the forward movement of the screw as it injects plastic into the cavity (Figure 2).

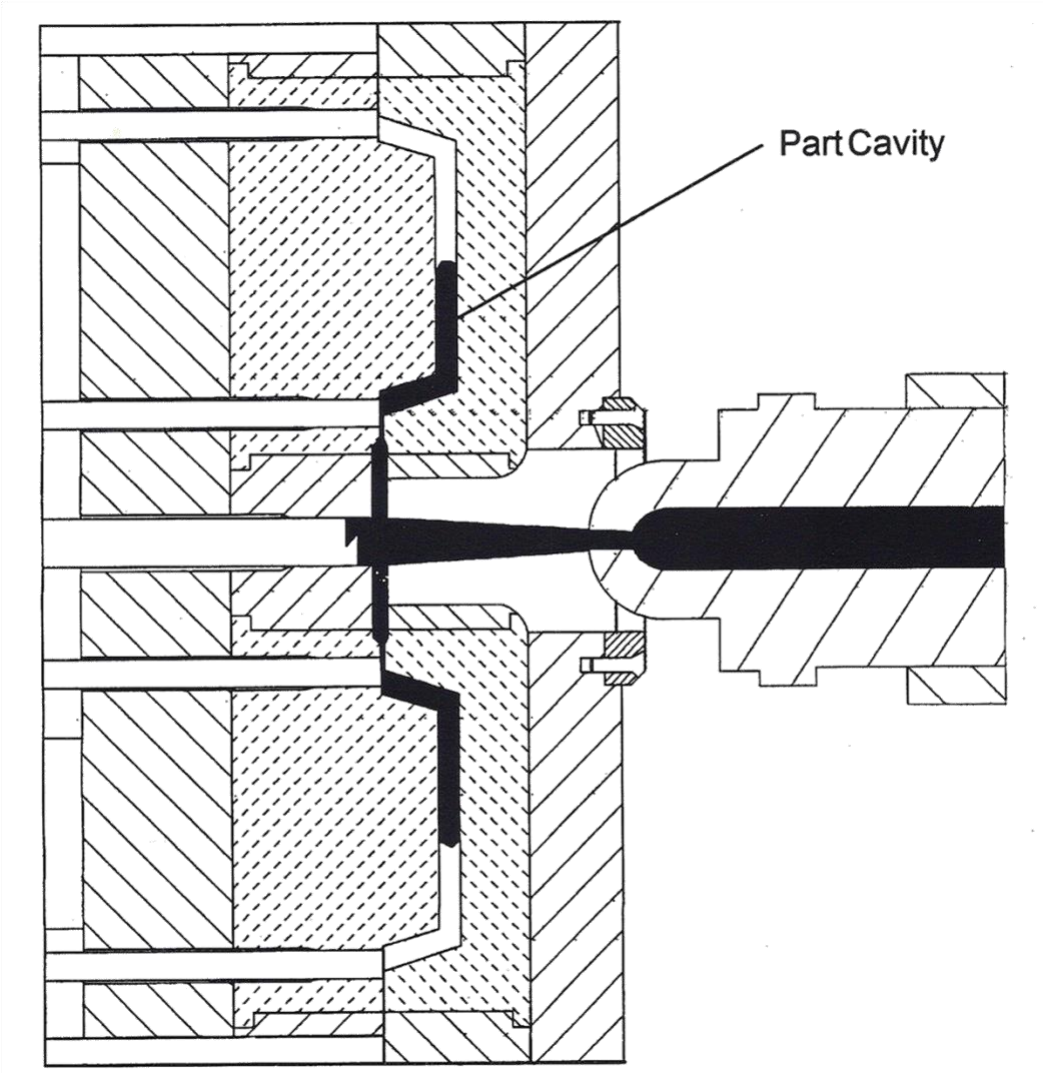

Figure 2 - Mold Cavity Filling

The screw stops moving forward when the cavity is full, as shown in Figure 3. The amount of time it takes to fill the cavity is called the fill time.

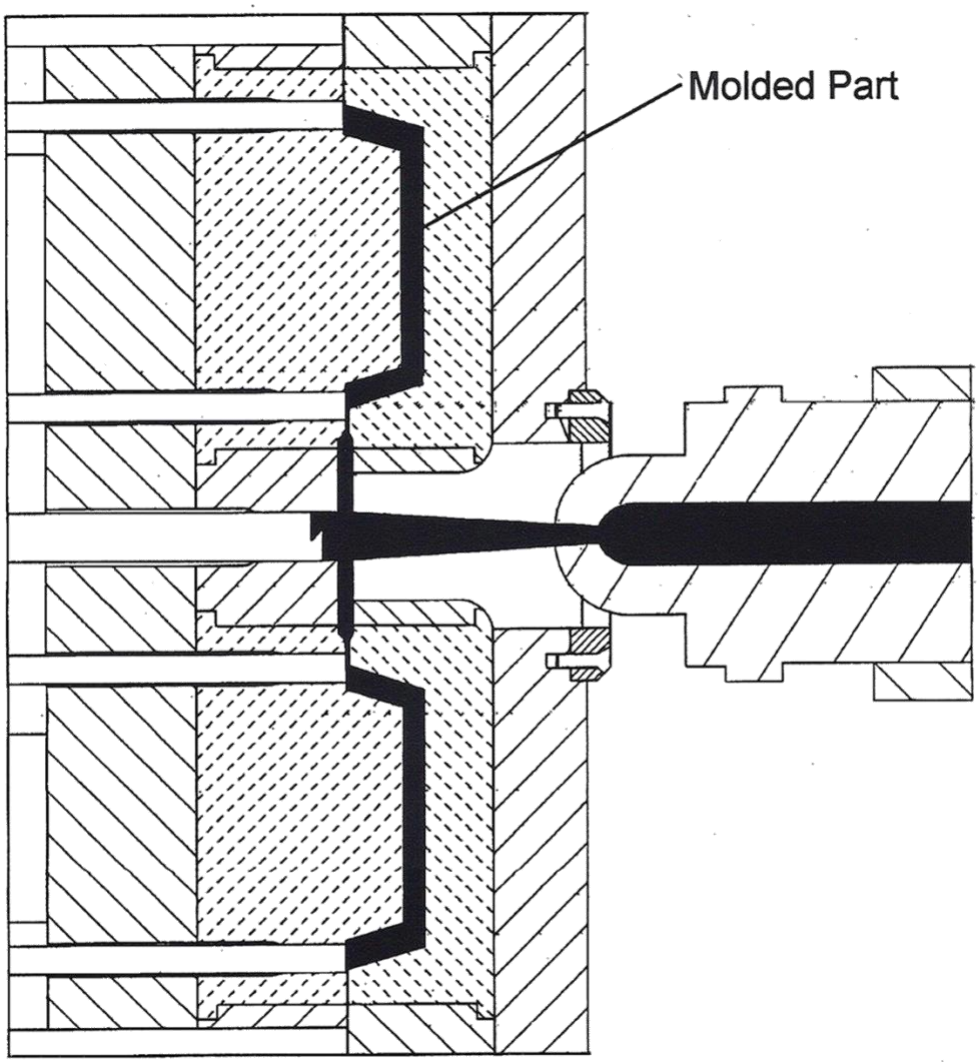

Figure 3 - Mold Cavity Full

The fill time can be as short as a fraction of a second for small parts, or as long as ten seconds for large, heavy parts. An average part takes one to two seconds to fill.

Exercise One

Unplanned Shutdowns

Find several machines in your shop that are running completely different parts. Record the fill time for each part. Write your results, and a brief description of the part you timed, in the table below:

Machine Number	Fill Time (s)	Part Characteristics

In the space below, express why fill times vary based on what you know about the parts that are being molded:

Instructor Date

Holding Time

After the cavity has been filled, the screw must remain in the forward position until the gate freezes. The gate is the thin section of the mold that attaches the runner system to the actual part. When the gate is frozen it prevents the molten plastic in the cavity from flowing back out through the runner. The time that the screw is in this forward position is called the holding time. Together, the injection forward movement and the holding time are called the injection forward time.

Cooling Time

The plastic part must be sufficiently cooled within the mold before it can be removed. It must be solidified enough so that it does not warp or distort when it is ejected and handled. This portion of the cycle is usually the longest of the whole process, and is largely dependent on the thickness of the part. Thin parts may take only a few seconds to cool, while very thick parts can take over a minute. Most parts take five to twenty seconds for the solidification portion of their cycle.

Exercise Two

On the same machines you used in the previous exercise, record the injection forward time (to the nearest tenth of a second). Remember that the injection forward time starts with the initial forward movement of the screw, and ends when holding time is complete.

Machine Number	Injection Forward Time	Relative Gate Size
Does the gate size affect the injection forward time?		
Do any of the parts seem to have excessive sink marks on them?		

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Like most materials, plastics expand when they are heated and shrink when they are cooled. Figure 4 shows plastic shrinking as it cools in the cavity. This topic will be covered in much more detail in another lesson.

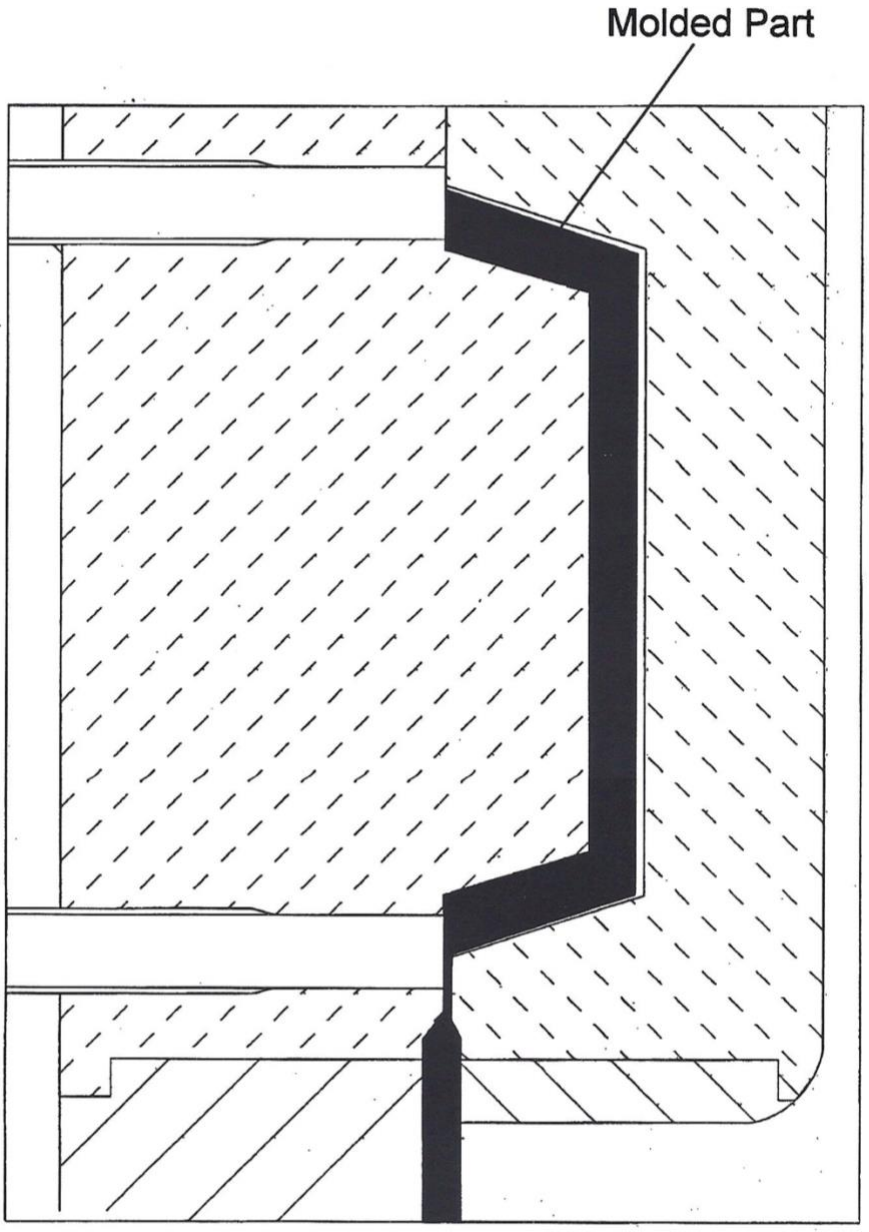

Figure 4 - Shrinkage

Exercise Three

On the same four machines that you used in the previous exercises, measure and record the overall cycle time to the nearest second. The overall cycle time reflects the amount of time the part needs to cool.

Machine Number	Cycle Time (s)	Part Size or Thickness

How did the size or thickness of the part change the cooling time, and therefore the overall cycle time, of the different parts?

Instructor Date

Ejection

As shown in the previous figure, the plastic part shrinks away from the cavity half (female side) and onto the core half (male side) of the mold. Therefore, when the mold opens, the part generally stays on the core, as shown in Figure 5. As a result, the ejection system is usually designed into the core half of the mold, since this is where the part will be.

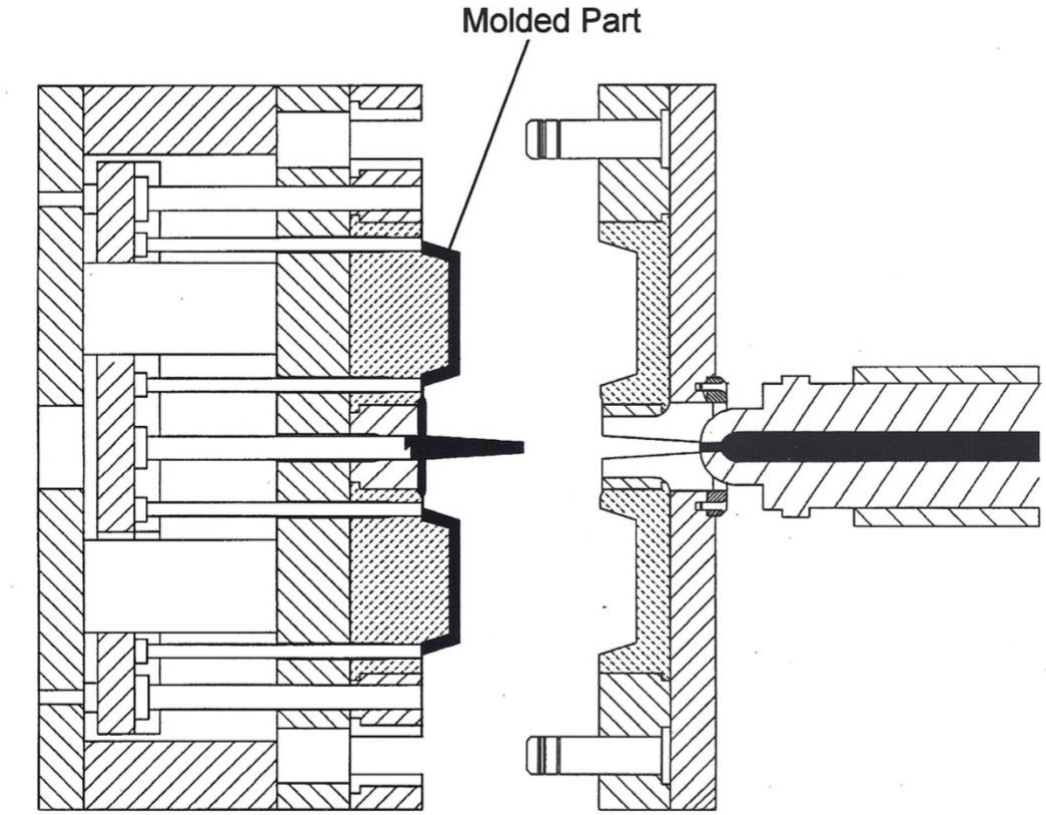

Figure 5 - Mold Open Position

Figure 6 shows the ejection system being activated forward, pushing the part off the core. It may be removed by hand or allowed to drop into a bin. After a sufficient time has been allowed to ensure that the part is completely out of the mold halves, the mold shuts and the cycle can be repeated.

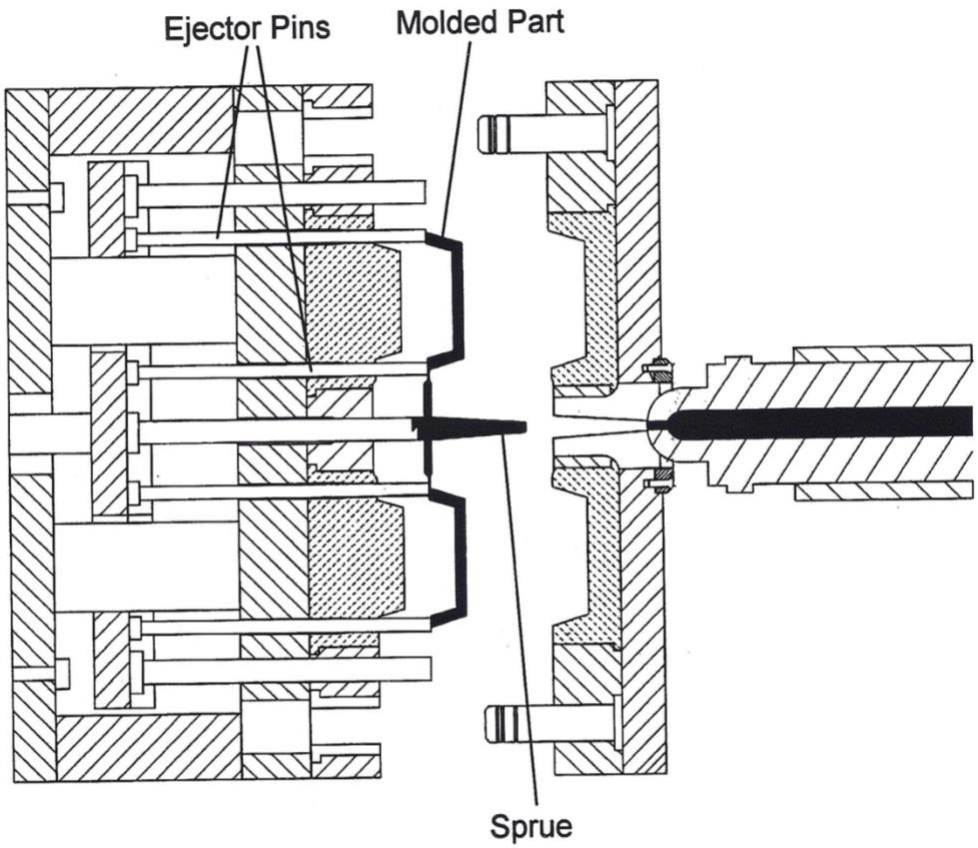

Figure 6 - Mold Ejection Position

Objective Two

Injection End External Components

Figure 7 illustrates the injection end of a molding machine.

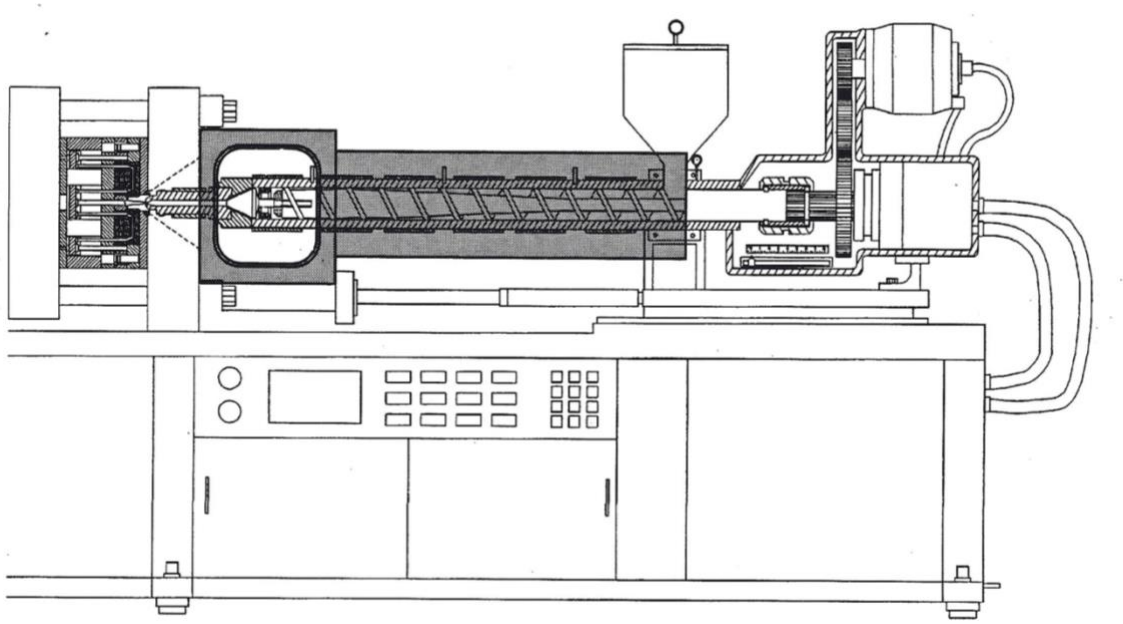

Figure 7 -External Machine Components

Purge Guard

Purging is the process of ejecting the remaining plastic out of the barrel after molding has been completed. Since the hot plastic could splatter on operators, this hinged guard is placed around the area where the plastic is purged out of the nozzle. There is a purging tray under the nozzle to collect the molten plastic.

The Barrel Shield

The barrel shield covers the barrel and heater bands. It may be hot, but it is much cooler than the actual barrel heater bands. The barrel shield reduces the risk of operators being seriously burned. The shield also keeps foreign objects and molten plastic off the heater bands where electrical shorting or other damage could shorten their operating lives.

The Carriage

The complete barrel and drive assembly together make up the carriage. It is a moveable unit that retracts to pull the nozzle away from the mold for purging or shutdown (Figure 8). It is brought forward to seat the nozzle against the mold for injection (Figure 9). In many machines it can also be pivoted outward to allow the screw to be removed.

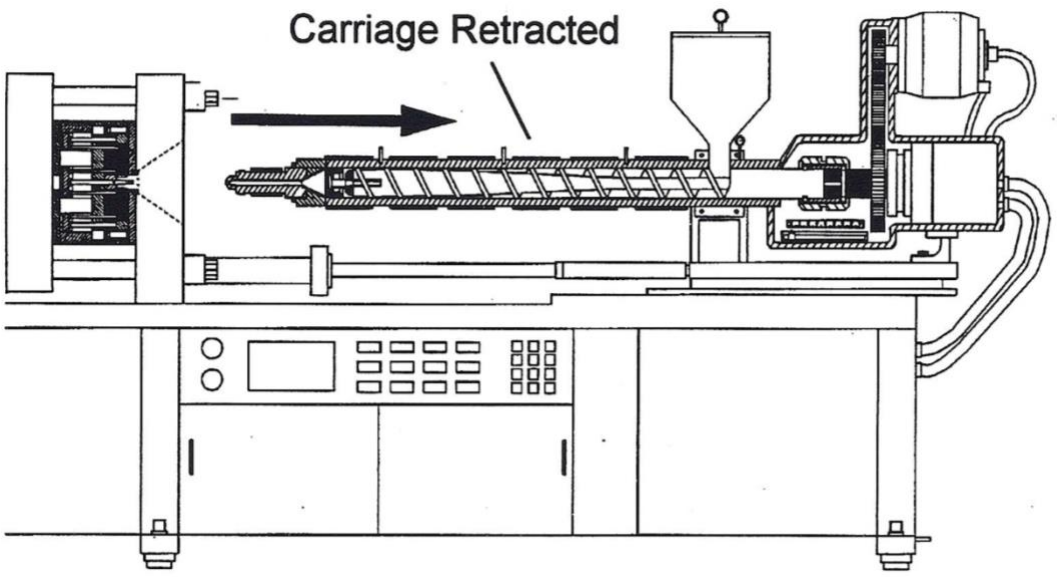

Figure 8 - Carriage Retracted Position

The Carriage Position Cylinder

This hydraulic cylinder, located under the barrel, is used to move the carriage toward and away from the mold as described in the previous paragraph. When plastic is being injected into the mold, hydraulic oil must be continually pumped to this cylinder to keep the nozzle seated against the mold, otherwise the injection forces would push the nozzle away from the mold causing the plastic to spit out of the nozzle.

Shot Size Indicator

Located on the outside of the injection cylinder housing is the shot size indicator. It is usually a scale, measuring in inches or centimeters, that shows the position of the screw inside the barrel. By looking at this indicator the operator can determine whether the barrel is full of plastic, the plastic has just been shot, or the screw is rotating and moving backwards.

Control Panel

The control panel is commonly located on the front of the machine. On some machines it stands by itself next to the machine. On machines that are computer controlled, virtually all of the controls are located in the control panel. On older machines with solid state controls, the control panel contains the timers and temperature controllers while the hydraulic controls are in a separate location by themselves.

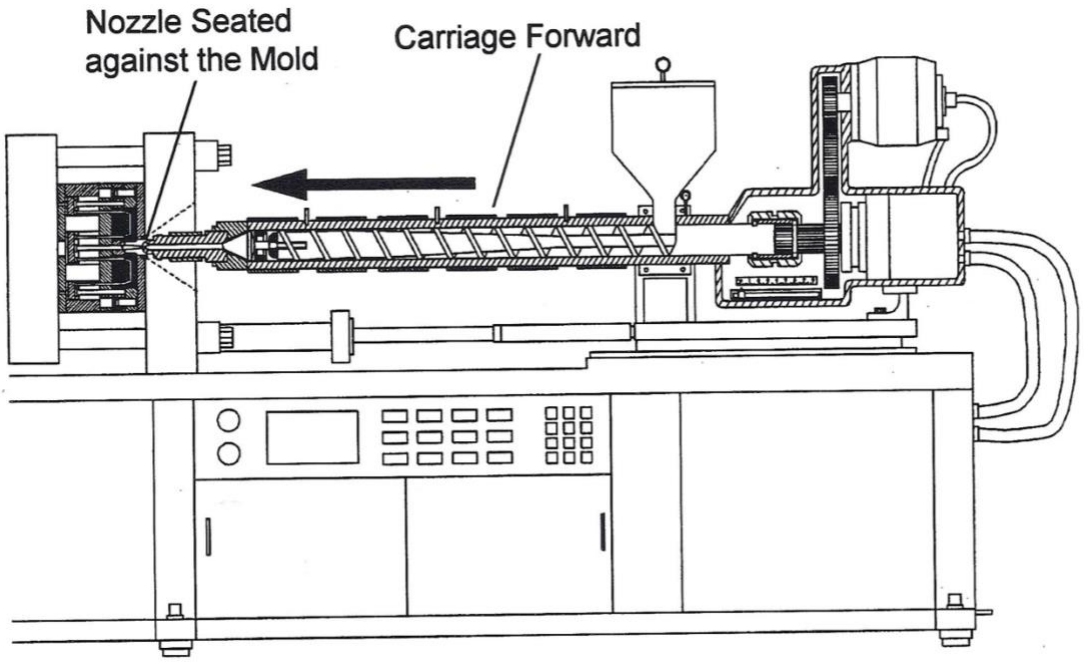

Figure 9 - Carriage Forward Position

Exercise Four

In your shop, go to a machine and identify for your supervisor or instructor the following machine com-ponents:

Machine Number			
Machine Mfg.			
Carriage Cylinder			
Hydraulic Controls			
Carriage Slides			
Nozzle Thermocouple			
Rear Heater Band			
Screw Spline			

Instructor Date

Objective Three

Injection End Machine Ratings

Shot Size

The size of the injection end of a molding machine is measured by its shot size capacity. The shot size is the maximum amount of material that can be shot at one time from a full barrel (Figure 10). This is what determines the size of part that can be molded in a particular machine. The shot size capacity is typically given as the weight of the largest shot the machine can make.

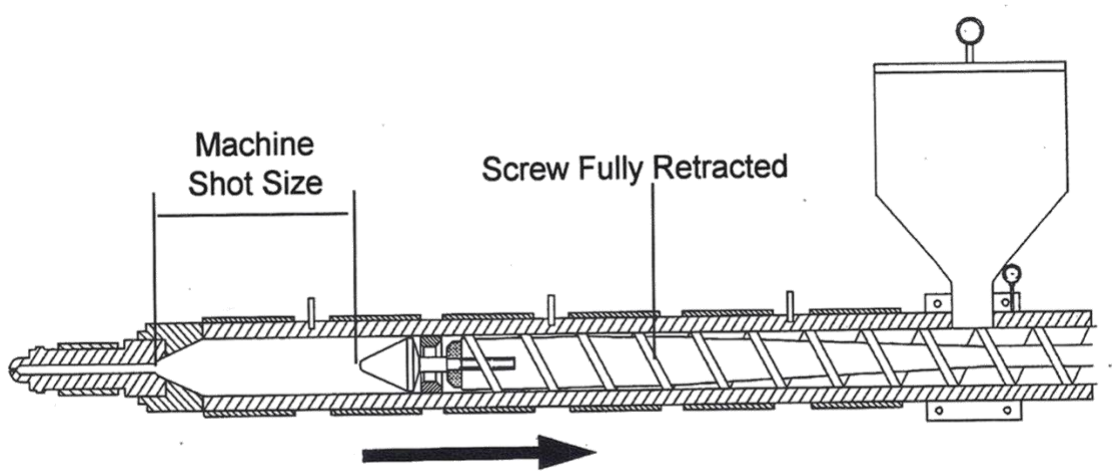

Figure 10 - Shot Size

The shot size can also be converted to, or represented by, volume (cubic inches). This method is often more practical since it is not dependent on the density of the plastic being used.

Maximum Injection Rate

The maximum injection rate is the maximum amount of plastic that the machine is capable of injecting in one second. To obtain extremely fast injection rates for specialty applications, machines must be built with additional equipment to generate the high speeds. The maximum injection rate is another way to rate the injection end of the machine.

Maximum Injection Pressure

Plastics require very high pressures to fill and pack the cavity. Most molding machines are capable of about 20,000 psi maximum injection pressure. The maximum injection pressure is another specification used to rate the molding machine.

Molding machines are also identified by their screw rpm, screw diameter, and recovery rate. These machine specifications are mainly used by engineering and production scheduling departments.

Exercise Five

Determine the shot size capacity of three different sized molding machines in your shop. You may not be able to find the information on the machine. In that case you will need to find a machine manual, or consult a supervisor or engineer.

Machine Number	Machine Manufacturer	Shot Size

Instructor Date

Example

Injection end specifications for a typical 400 ton molding machine:

- Shot size (by weight) 50 ounces
- Shot size (by volume) 82 cubic inches
- Injection Rate (max.) 28 cubic inches per second
- Screw Diameter 3 inches
- Screw Speed (max.) 200 rpm
- Injection Stroke (max.) 11.5 inches
- Injection Pressure (max.) 22,000 psi
- Recovery Rate (max.) 3.2 ounces per second

Self-Test

1. The fill time plus the hold time make up the:
    a. Recovery time
    b. Cooling time
    c. Injection forward time
2. Fill time is a very short segment of the total cycle time.
    a. True
    b. False
3. Holding time should normally be set long enough to allow:
    a. The parts to solidify completely
    b. The cavity to fill completely
    c. The gates to freeze
4. The screw rotates during which part of the cycle?
    a. During the mold open time
    b. During the cooling time
    c. During the dwell time
5. When the mold opens, to which half of the mold does the plastic part usually stick?
    a. Cavity half
    b. Core half

6. What machine component reduces this risk of a technician being 'splashed' with molten plastic?
    a. Purge guard
    b. Mold platen
    c. Barrel shield
7. The nozzle is separated from the mold by moving the whole:
    a. Platen
    b. Carriage
    c. Barrel
8. The output for shot size displays the position of the screw inside the barrel.
    a. True
    b. False
9. Molding machines are capable of generating high injection pressures. A typical machine can generate:
    a. 5,000 psi
    b. 20,000 psi
    c. 50,000 psi
10. The way that machine shot capacity is normally stated is based on:
    a. Weight
    b. Volume

Glossary

Carriage - the moveable unit that incorporates the whole barrel and drive assembly of the machine.

Ejection - the process of removing molded parts from the mold.

Holding Time - the time that the screw stays forward after injection has taken place.

Hydraulic Accumulator - a large hydraulic cylinder that provides stored hydraulic energy required for high flow rates.

Injection End - the end of the molding machine that contains the plastic injection cylinder.

Injection Forward Time - the total time that the screw both moves forward and stays forward.

Reciprocating Screw - another term for the injection screw. Reciprocating screws are capable of turning as they move back and forth.

Screw Recovery - the rearward motion of the screw as it rotates and pushes plastic forward in the barrel.

Shot Size - the maximum amount of plastic that can be injected from the barrel at one time.