Polymer
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SYSTEMS FOR PRODUCTIVITY

New Employee Orientation Program

Training in Injection Molding

Student's Manual

SAMPLE

Polymer Training Resources®
SYSTEMS FOR PRODUCTIVITY
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Practical Technology Training SM

A Complete Training System for Quality and Productivity in Injection Molding

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SYSTEMS FOR PRODUCTIVITY

Please review this sample of our New Employee Orientation Program Student's Manual

(Injection Molding Overview)

This program will give your new employees a clear understanding of the injection molding process...

Program includes:

1. One Instructor's Manual and One Student's Manual in our Special 3-Ringed Binder
2. CD-ROM Instructor's Presentation and Animation of Major Machine Functions
3. 15 Student's Manuals

Instructor's Materials:

1. Instructor's Manual - tells what to discuss in class and how to use the CD-ROM presentation and machine animation.
2. Student's Manual
3. CD-ROM Instructor Presentation and Animation of Major Machine Functions

Options for an additional charge: Transparencies or Hardcopy of Transparencies for those who do not have access to a computer for training.

Student's Materials:

1. Each student receives a student's manual. The manuals are written in an easy to understand format.
2. Each lesson has detailed technical illustrations.

Special Features for Learning:

1. Can be taught in your plant, by your instructors.
2. Classroom setting for maximum learning.
3. Animated graphics.
4. Quick, effective and consistent training in injection molding, regardless of job function.
5. A cost-effective tool targeting part defects, safety and part handling.
6. Student self-tests and exercises providing customized learning rates.
7. Meets companies ISO training requirements.

Table of Contents

Page #

Section 1-
Machine Parts
and Their Functions

Introduction to the Process

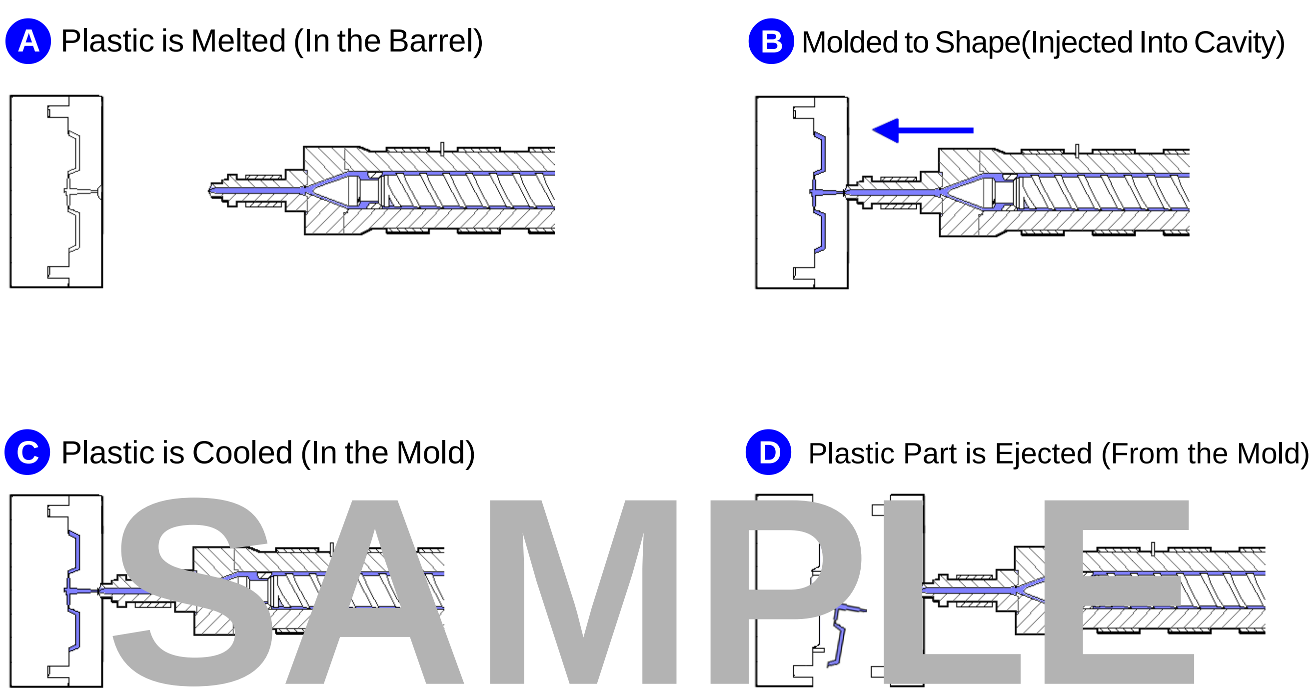
The first half of this introduction provides an overview of the significant features of the injection molding process. The objective is to convey the importance of injection molding and how it fits into the manufacturing world. It helps to have an under-standing of the quality and productivity capabilities and expectations of this high-volume molding process. The injection molding process has evolved over the last 50 years into a mature and highly competitive industry.

Process Overview

The injection molding process is often described as a "thermal conversion process" as shown in Figure 1-1. The plastic material is 1) melted, 2) molded into shape, 3) cooled. and 4) after the parts solidify, the mold opens and the parts are ejected. The mold then recloses to begin the next cycle.

The sequence for molding one series of parts is known as the molding cycle. Each mold and material combination has an optimal cycle time. It is imperative that molding personnel maintain the most efficient cycle time in order to keep productivity high. Maintaining productivity and minimizing scrap are two major ways to sustain profitability.

Figure 1-1 **Process Overview**



High Volume Manufacturing Process

The injection molding process is a high-volume, mass production process used by tens of thousands of molders around the world. Some advantages of the process are shown in the chart in Figure 1-2.

The high productivity of this process is largely due to the fact that plastic can be melted and resolidified relatively quickly. Thin-walled parts are commonly molded in less than 10 seconds. More typical parts tend to be in 20 to 30 second cycles.

Another advantage of injection molding is the capability to mold numerous identical parts in one cycle. This is done by using multi-cavity molds. The cavity is the impression built into the mold, which is filled with molten plastic to form the parts.

A multi-cavity mold can have any number from two to over 100 cavities. Each time plastic is injected into the mold (referred to as one "shot"), a part forms in each cavity. The production economics of multi-cavity molds are easy to calculate. For example: A 10-cavity mold running at a 10-second cycle would produce 3600 parts in one hour.

Figure 1-2 **Advantages of the Injection Molding Process**

Process Advantages	Explanations and Examples
1 High Volume Process	
• Fast thermal process	• Melt, mold, and cool
• Multi-cavity molds	• Up to 100 cavities per mold
• High machine output	• Thousands of parts per hour
2 Complex Part Capability	
• Complex parts molded in one shot	• Parts with over 100 dimensions
• Multiple functions in each part	• Holes, hinges, springs, snap fits, etc.
3 High Part Quality Potential	
• Dimensional accuracy	• Plus/minus .001 inches
• High quality surfaces	• High gloss surfaces
• Molded-in color	• No painting required
4 Wide Range of Plastic Materials	
• 20 to 30 plastics types	• Each with different set of characteristics
• Unique properties	• Transparent, insulating, lightweight, etc.

Complex Part Capability

The mold is the heart of the process. Molds are generally made of hardened steel and contain the cavity or cavities in which the parts are formed. Molds are expensive precision tools that can cost tens or hundreds of thousands of dollars each. The cavities can take almost unlimited shape, which allows complex or large parts to be molded in one shot. Parts are commonly designed with multiple holes, ribs and intersecting walls. More complex features include springs, molded-in hinges and snap fit sections. Molded parts often contain hundreds of measurable dimensions. The responsibility of measuring and monitoring the key part dimensions is different in each organization. However, it is everyone's responsibility to help maintain part integrity by not allowing parts to warp or otherwise become dimensionally unacceptable during molding and handling.

High Part Quality Potential

Plastic materials are capable of precisely duplicating the shape and surface features of the mold cavity. This means that a properly molded part is able to reproduce a high quality polished or leather grain cavity surface. Parts that do not adequately duplicate the surface condition of the mold are often deemed unacceptable. Proper duplication also means that the plastic is able to completely fill each cavity extremity, forming a fully shaped part. Parts that are not fully formed are classified as scrap and must either be discarded or reprocessed by regrinding the defective parts.

One major contribution that all plant floor personnel can make is to help maintain the quality of the molded parts. This includes everything from optimizing the molding machine conditions by the technicians to part inspection by the machine operators and quality control personnel. Molded plastics derive much of their value from their ability to be made into high-quality, as-molded finished parts. Injection molding companies that cannot maintain adequate part quality, and end up shipping bad parts, will ultimately lose business.

Wide Range of Plastic Materials

Plastics are unique materials. They have physical property combinations that are not available in any other material. Plastic can be transparent or opaque. It can be rigid or flexible like rubber. It can be inexpensive or cost more than stainless steel.

Each major type of plastic has its own particular set of processing conditions: some plastics come out of the mold too hot to handle without gloves, others shrink or warp after they have been molded, some plastics will crack if dropped, and others are so tough that they are difficult to trim.

Machine operators and parts handlers should be familiar with the basic types of plastics in order to handle the finished parts properly. It is also important to be able to distinguish different plastic materials since most plastic types are incompatible with each other. Raw plastic pellets or defective parts from dissimilar materials should never be put into the same container.

Molding Personnel Responsibilities

As a summary to this section, a listing of operating personnel responsibilities is shown in Figure 1-3. Operators who remove parts directly from the mold can affect productivity by maintaining the optimal cycle time. The other items in the chart all reflect the responsibilities of monitoring product quality.

Figure 1-3 **Molding Requirements**

Molding Personnel Responsibilities

The responsibility of the molding personnel is to maintain:

1. The optimal cycle time for maximum productivity
2. The dimensional control of the parts
3. The aesthetic quality of the parts

Clamp End Parts and Their Functions

As stated earlier, the mold is the heart of the process. The standard mold has two halves which must be closed in order to mold the part and then opened to remove it. The mold must be held together under high pressure to keep the molten plastic from squeezing out at the parting line as it is injected into the cavity. The mold movement and pressure containment requirements are handled by the clamp end of the machine.

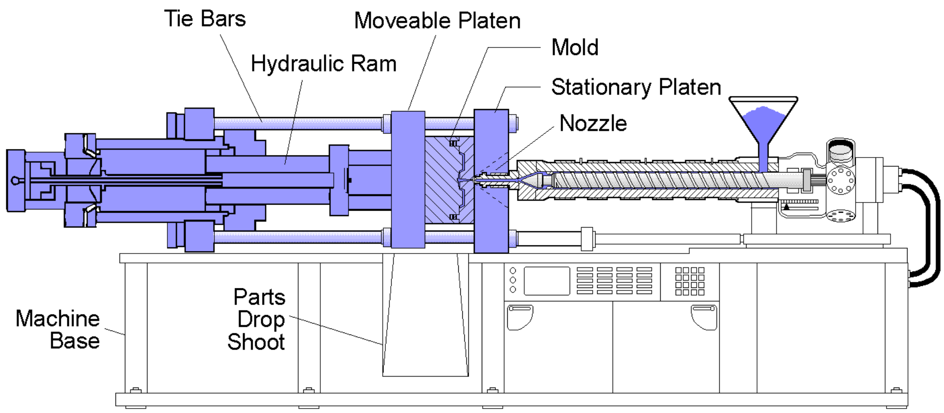
There are two basic mechanisms that can be used to close and clamp the mold. They are 1) the hydraulic clamp and 2) the toggle clamp, as shown in Figure 1-4 and Figure 1-5. Both are commonly used, although your plant may have just one or the other.

Hydraulic Clamping System

The hydraulic clamp illustration shows a few major parts of the clamp end of the machine. The hydraulic clamp system uses a direct hydraulic cylinder to move one of two large steel platens. The two halves of the mold are bolted respectively to these two platens which are called the stationary platen and the moveable platen. The nozzle from the injection unit protrudes through the opening in the stationary platen, and then it is butted up against the stationary mold half. The nozzle is generally left in this position, and it maintains constant contact with the mold from cycle to cycle.

The mold is opened and closed by moving only the mold half that is attached to the moveable platen. The parts are designed to stick in the moveable half of the mold. The ejection system, which removes the parts from the mold, is also located on this moveable half of the mold. The hydraulic ejection cylinder, see Figure 1-4, is mounted on the back of the moveable platen. The ejection cylinder is activated forward after the mold is opened to eject the part from the movable half of the mold.

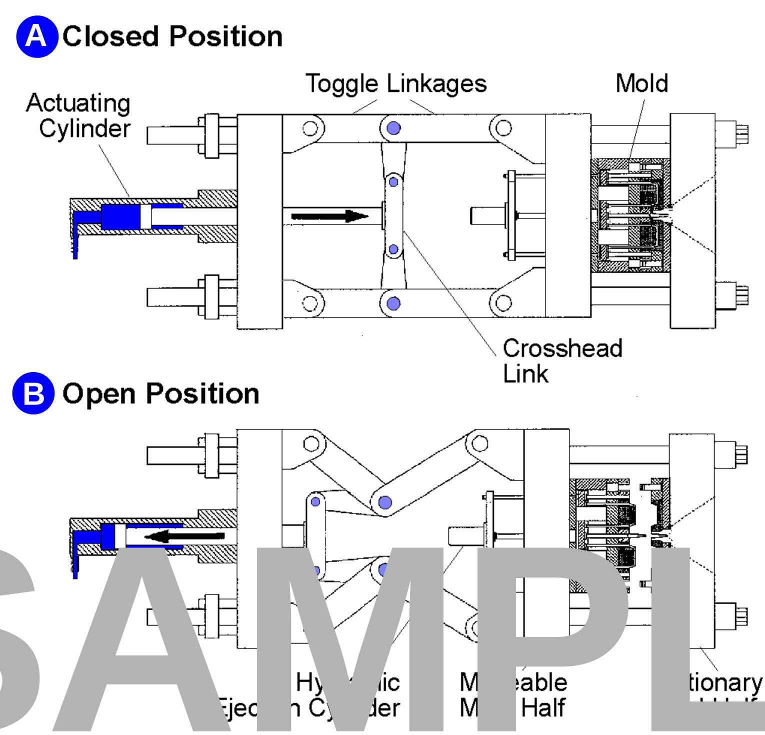
Figure 1-4 **Hydraulic Clamping System**



Toggle Clamping System

The toggle mechanism uses a series of toggle linkages that collapse to open the mold and straighten to close the mold. The toggle clamp also uses hydraulic force to move the platen. In this case, a smaller hydraulic actuation cylinder moves a component called a crosshead. Notice how the main toggle links are locked in a straight position when the mold is closed. The mechanical advantage designed into this system is the way that the toggle clamp generates enough force to hold the mold shut. The clamping mechanisms are always encased with housings and safety guards, which have been left out of these illustrations in order for the internal parts to be shown.

Figure 1-5 **Toggle Clamping System**



Molded parts are commonly allowed to fall down the parts drop chute when the mold opens. Larger parts often must be manually removed from the stationary half of the mold in order to prevent damage. To remove the parts the operator must first open the safety gate (not shown in these illustrations) in front of the mold.

The most common method for rating the size of a molding machine is to identify the amount of clamp force (tonnage) it is capable of producing. Small molding machines have been built with a clamp force (tonnage) rating of 25 tons or less. They may only be 5 or 6 feet long. The largest machines have clamp force (tonnage) ratings of over 5,000 tons and may be over 50 feet long. Most molding machines fall in the middle range of about 100 to 500 tons. A chart showing the relative clamp tonnage ranges is shown in Figure 1-6.

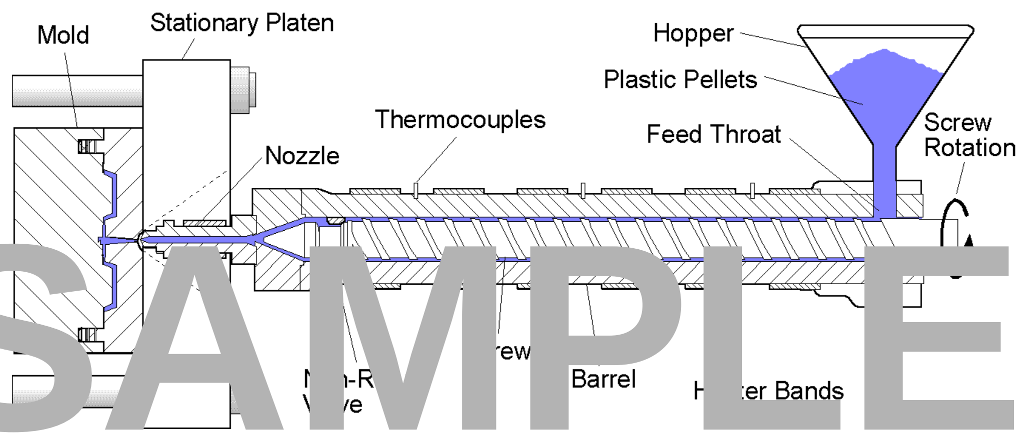
Figure 1-6 **Machine Size Ratings**

Clamp Tonnage	Relative Size
25 to 100 tons	Small
100 to 500 tons	Medium
500 to 1,000 tons	Large
over 1,000 tons	Very Large

Injection End Parts and Their Functions

The injection end of the machine is where the plastic pellets are melted and injected into the mold. The key mechanical parts of the injection end of the machine are shown in Figure 1-7. The remaining parts of the injection end are shown in the next figure.

Figure 1-7 **Screw and Barrel**



The Hopper

The process begins by loading plastic pellets into the hopper. The hopper is simply a holding chamber which feeds plastic material into the screw and barrel. The hopper is mounted on top of the barrel and often contains a shut-off slide plate. The pellets fall through an opening in the barrel called the feed throat.

The Screw

The central mechanical component of the injection system is the screw. It is also known as the feed screw. It has two different modes of operation: rotation and forward injection. When the screw is in its rotation mode, it acts like a meat grinder. As the plastic melts, it is fed forward in the barrel by the rotation of the screw. The machine then injects the molten plastic into the mold once the barrel has been filled with the proper amount of material for the mold being run.

The main function of the screw is to inject plastic into the mold. In the injection mode, the screw acts solely as a ram (or piston) to inject the molten plastic into the mold cavity. The screw does not rotate during the injection mode. During injection, the molten plastic is forced through the nozzle into the mold where it cools. The nozzle is attached to the end of the barrel. It has a small orifice at its tip which seats against the mold.

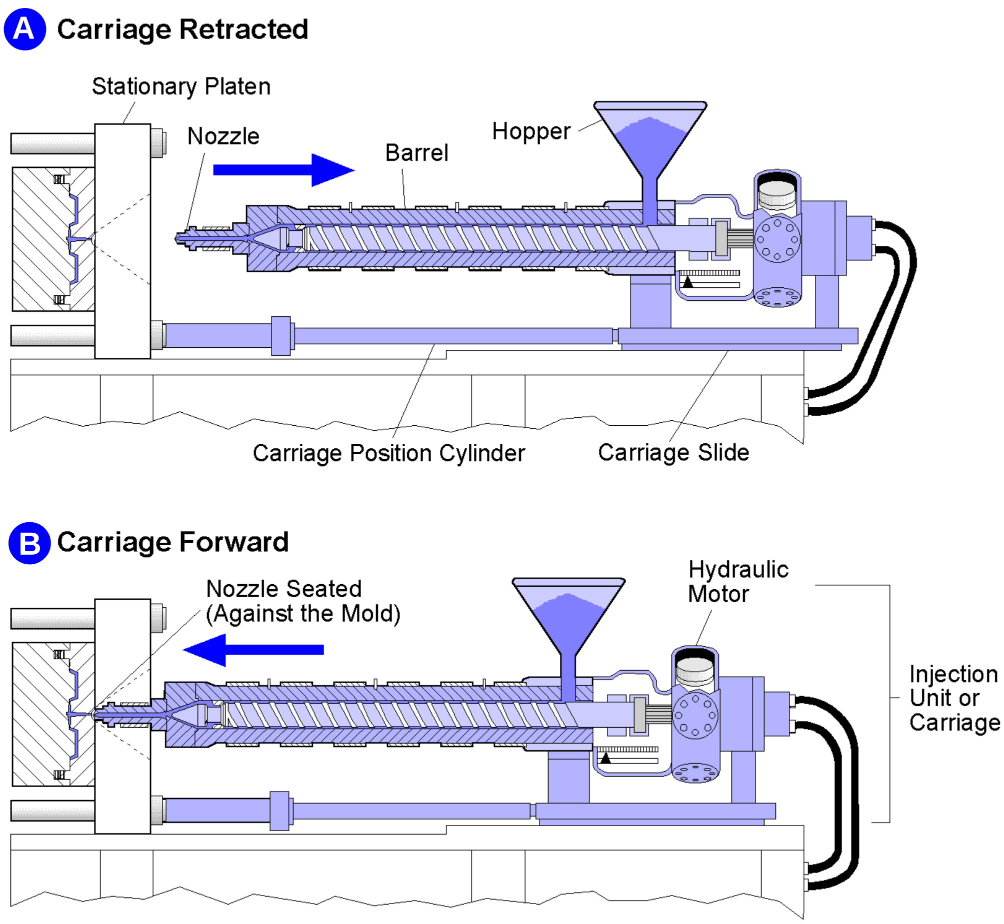
The Barrel

The screw is located and moves inside the barrel (or cylinder) which has thick steel walls to contain the high pressures that develop during injection. The barrel is wrapped lengthwise with heater bands. The heater bands are connected to an electrical source and are capable of reaching over 800° F. The actual temperature reading for each heater band zone is measured by a thermocouple. The thermocouple and electrical wires all go back to the temperature controller. It is important that these wires are not damaged, bent or covered with molten plastic. The whole barrel is surrounded with a sheet metal heat shield (not shown) to reduce the chances of serious burns.

The Carriage

The carriage, as shown in Figure 1-8, incorporates most of the injection unit components. The carriage is usually left in the retracted position during shut-down as seen in Figure 1-8A. When the barrel is hot and the machine is ready to run, the carriage is moved forward so that the nozzle seats against the mold. The carriage position cylinder moves the carriage toward or away from the mold. The whole carriage slides in a guided and lubricated track. The carriage assembly includes all of the hydraulic drive system located behind the screw.

Figure 1-8 **Carriage**



The Hydraulic Injection System

The injection function is controlled by the hydraulic injection cylinder located directly behind the screw. When oil is pumped into this cylinder, the piston (which is connected to the end of the screw) is moved forward injecting plastic into the mold.

The screw is usually driven by a hydraulic motor. The illustration in Figure 1-8 shows a simplified machine design where the hydraulic motor is connected to the drive end of the screw. The hydraulic pump and oil reservoir are usually located under the machine.

Some newer machines use electric drives. The function and movement of key mechanical components is essentially the same in these newer machines.

EXERCISE 1:

Shop Floor Machine Listing

DIRECTIONS:

With your supervisor's permission, go out onto the shop floor and complete the following Machine Listing. Identify the clamp force (tonnage) ratings and the type of clamp for each machine. If the machines are arranged in rows (banks) or by department, identify their specific location.

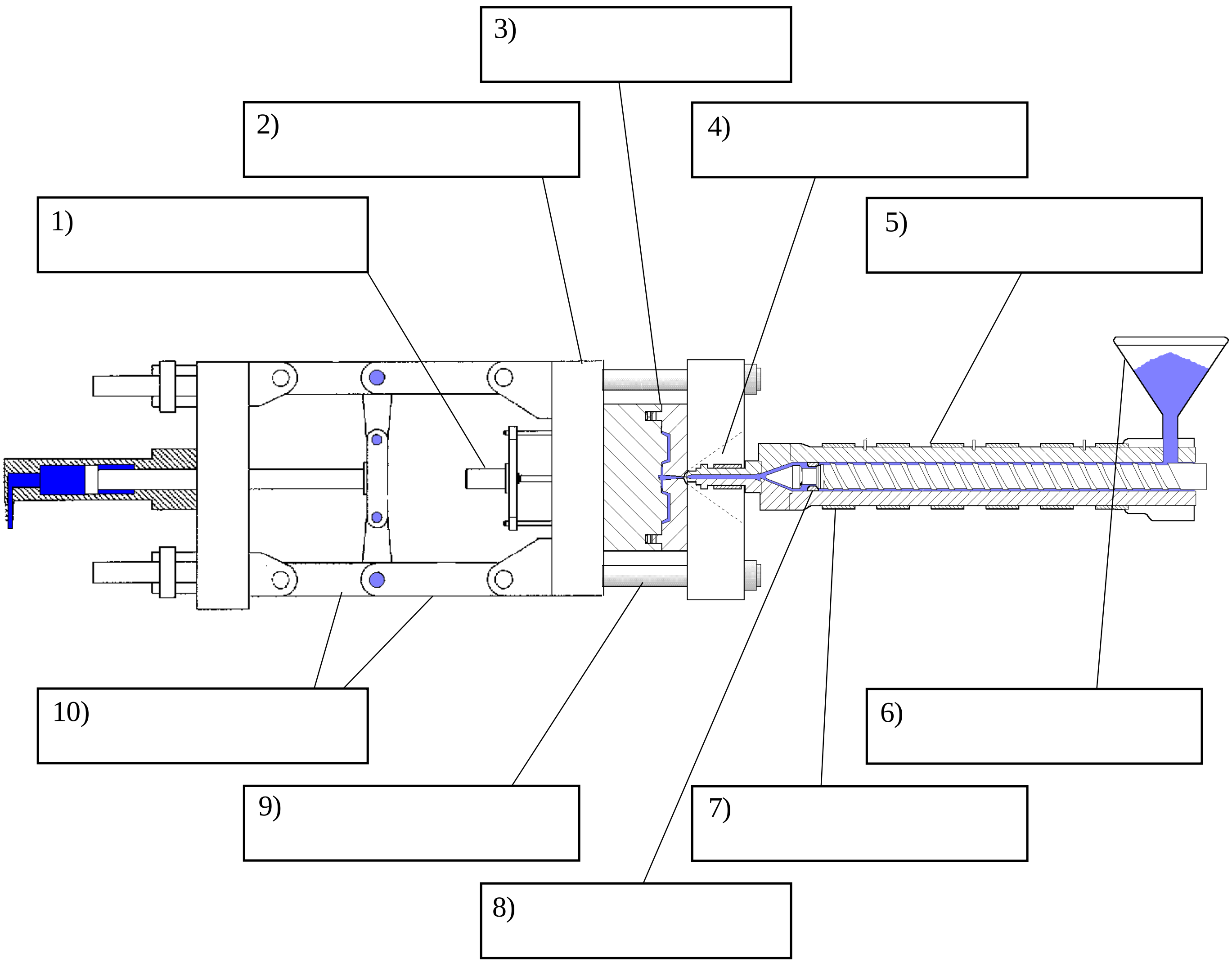
Machine Number	Machine Manufacturer	Clamp Tonnage	Clamp Type Toggle (T) or Hydraulic (H)	Machine Location Dept. or Machine Bank

EXERCISE 1a:

Machine Part Identification

DIRECTIONS:

Write the correct machine component name in each of the ten label boxes.



Self Test

1. What is the machine processing sequence in which one set of parts is made from the mold?
   ____ a. the machine operation
   ____ b. the molding cycle
   ____ c. cavity duplication

2. One major contribution that an operator can make to the company is to help maintain the quality of the molded parts.
   ____ a. true
   ____ b. false

3. What is the name used for a mold that can make eight identical parts at one time?
   ____ a. a multi-cavity mold
   ____ b. a sequential mold
   ____ c. a family mold
   ____ d. a hot runner mold

4. What is the name of the molding machine mechanism that holds the mold halves together during injection?
   ____ a. the platen attachment
   ____ b. the tie bar system
   ____ c. the hydraulic pump
   ____ d. the clamping system

5. What is the most common way to rate the size of a molding machine?
   ____ a. by length
   ____ b. by clamp tonnage
   ____ c. by weight
   ____ d. by platen size

6. On which machine component is the hydraulic ejection system mounted?
   ____ a. the clamp cylinder
   ____ b. the machine base
   ____ c. the moveable platen

7. In which phase of the cycle does the screw rotate?
   ____ a. the injection phase
   ____ b. the holding phase
   ____ c. the screw recovery phase

8. Where within the molding machine does most of the melting take place?
   ____ a. the barrel
   ____ b. the nozzle
   ____ c. the feed throat

9. What major machine component is moved forward in order to set the nozzle against the mold?
   ____ a. the slide
   ____ b. the carriage
   ____ c. the barrel

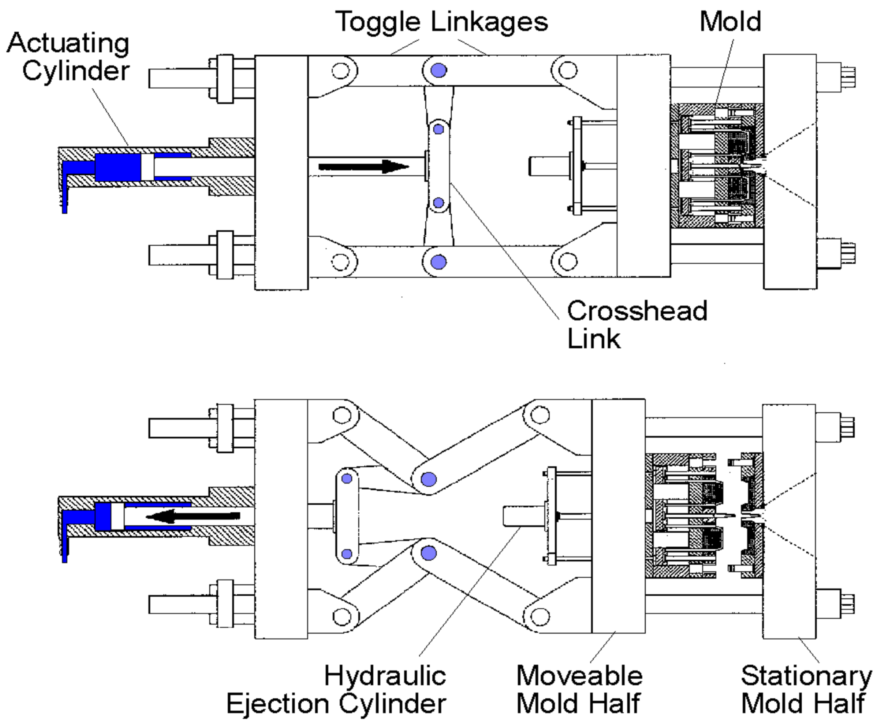
10. Most of the clamp system movements of traditional molding machines are driven by:
   ____ a. hydraulic pressure
   ____ b. electric motors

Sample of CD-ROM Slide Presentation

Toggle Clamping System

A) Closed Position

B) Open Position



Play Animation