Working with the Machine

LESSON 1: Setting up the Machine

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Productivity in injection molding means keeping the machines running making good parts, hour after hour. A good setup can save hours of process troubleshooting later. In this lesson, we will look at some of the devices and techniques you should use to set up the machine quickly and correctly.

Objectives of Lesson One

1. Learn how to record the setup information
2. Learn how to set the clamp controls
3. Learn how to set the heats
4. Learn how to set the pressures, strokes, and process timers

Objective One

Recording Setup Information

Sampling

When a new injection mold arrives at a molding shop, there is no detailed information available on how it should be run. The first time that a mold is tried out is called sampling.

Sampling is done to determine how well the mold runs, how close the parts can be made to the design specifications, and what machine control settings are needed to run the job well. Sampling requires the molding technician to work from scratch to adjust and set all of the machine controls slowly, refining the process, until a quality part is made.

Setup Sheets

Sampling can take a long time. It may take many adjustments to develop settings that produce a quality part in a new mold. When these settings are found, they need to be saved. This way, the next time the mold is run, the previous settings can be used to make it easier to set up the machine.

Most shops use a setup sheet or process control sheet to record and save sampling information. Figure 1 shows an example of a setup sheet.

Item	Part No.	Mold No.	Mold Type	Pcs./Mold	Mold Drawing #
Material	Pc. Wt.	Shot Wt.	Overall Cycle Pcs/Hr.	Clamp & Shot Size	Make & # of Press

Set	Clamp Fwd. Slow LS-2 Mold Protection		Timers in Sec.	Injection High or Total Injection		Mold Mounting Data	Eye Bolts Size & No.				
	Pressure Buildup LS-3 Prefill Closed			Injection Low			Mold Shot Height (in.)		Water Data		
Clamp Cycle	LS-5 Clamp Fast Reverse			Cooling - Cure			Horizontal-in(eye Bolt Side)			Water Temp - Cavity	
	LS-6 Clamp Slow Down			Melt - Decompress			Vertical-In.			Water Temp - Core	
	LS-7 Clamp Rev. Stop			Clamp - Open			Spacer Size		Temp. Cavity Position	1	
	LS-8 Clamp Overstroke			Air Ejection - on/off			Pull Backs or K.O. Rods Size and No.			2	
	LS-20 Hyd. Eject		Temp. Cylinder, Nozzle, and Nozzle Valve	Front, Zone #1			Mold Weight			3	
Clamp Data	Press Daylight			Middle, Zone #2			Time to Place Mold			4	
	Clamp High/Clamp Low			Rear, Zone #3		Mold Placement	Sling Type Size & No.		Temp. Core Position	1	
	Clamp Open-Slow/Fast			Rear, Zone #4			Lift Size			2	
Pressures, Feed and Speeds	Injection High			Time to Reach Settings			Type of Hold Down Clamps			3	
	Injection High-Squeeze			Melt Temp.			Heels			4	
	Injection Hold			Nozzle Temp.			No. of Hold Down Clamps		Misc. Columns Needed		
	LS-25 Setting			Nozzle Valve Temp.			Hold Down Clamp Spacing - Cavity				
	Back Pressure			Nozzle V. Actuated			Hold Down Clamp Spacing - Core				
	Injection Feed			Throat Temp.			"Screw Jacks" Bottom Supports				
	Cushion		First Shot	First Shot Feed for Runnerless Mold			Torque on Clamp Bolts				
	Injection Speed Setting			Mold Warm-up Time		Removal	Core & Cavity Temp.				
							Cover with Moldsaver				
	Screw RPM			Hot Runner Warm-Up Time			Time to Remove Mold				

Figure 1- Setup Sheet

Our molding machines have a memory storage device, such as a memory card or a hard drive to save machine settings.

Most of the time, when a mold is installed into a molding machine, it has been run before, the setup sheet or machine controllers memory provides a good starting point for setting the machine controls. The setup data is helpful, but often needs to be adjusted, within the defined process range, to achieve good parts. This is because machine conditions and plastic properties change over time.

If the mold is running in a different machine from the one it ran in before, a new setup sheet should be made. This is true especially if the other machine is from a different manufacturer, or has a different clamp tonnage. Pump outputs, clamping pressures, and control systems can vary greatly from one machine to another.

Log Sheets

Many companies also use a molding parameter log sheet (Figure 2). This sheet records the control adjustments made during each shift. If the same problem occurs on the next shift, the molding technician can check the log sheet to see what solution the previous shift used. Experienced technicians will often spot trends on the log sheet that will help troubleshoot repetitive problems.

Some shops also use a shift logbook. During the shift, any machine problems, part quality problems, or control changes are noted and written into the logbook. This is sometimes accompanied by a verbal report to the personnel on the next shift. Good communication saves time and effort. Logbooks and verbal reports help share the knowledge of the problems that have been occurring, and what adjustments have been used.

Machine #			Mold #					Material				
Date												
Shift	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd
Heats												
Nozzle Front												
Nozzle Rear												
Nozzle Front												
Adapter												
Manifold												
Zone 1												
Zone 2												
Zone 3												
Zone 4												
Melt												
Mold Temp												
Front												
Rear												
Times												
Clamp												
Inj. High												
Inj. Low												
Fill Time												
Screw Rec.												
Total Cycle												
Pressures												
Clamp (tons)												
Inj. High												
Inj. Low												
Back												
Other												
Feed (in.)												
Cushion (in.)												
Shot Weight												

Figure 2 - Log Sheet

Objective Two

Setting the Clamp Controls

During setup, the important thing is to set the mold and ejector movement to protect the mold from damage. Later, when parts are coming out of the mold, it will be possible to refine the clamping strokes. Set mold movements to protect the mold rather than trying to minimize the cycle time.

Clamp Speeds and Pressures

Different machines use different control scales to set the specific speeds and pressures. Some machines use a percentage scale, "1" for the slowest speed or pressure, and "100" for the fastest speed or highest pressure, that the machine can generate. Other machines use different scale increments, you need to become familiar with the clamp speeds and pressure settings on your machines. In this lesson we talk about setting speeds as slow, medium, or fast; and setting pressures as low, medium, or high.

Before attempting to move the clamp, set the high and low clamp pressures. The engineering department will often give a starting point recommendation for the high clamp pressure setting on a new mold. If no data is available, you can get a rough starting point by multiplying the projected area of the parts, times four tons per square inch, to get the clamp tonnage (Figure 3).

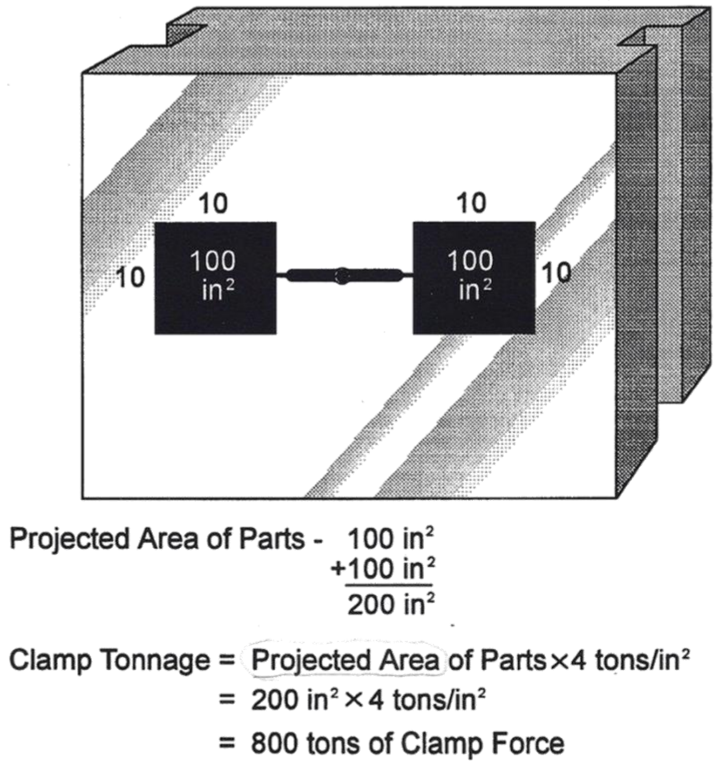

Figure 3 - Clamp Force

Set the low clamp pressure (or safety pressure) as low as possible. This will minimize the potential for mold damage if a part should not fully eject. Use just enough pressure to move the clamp mass and overcome any frictional resistance from the tie bars or leader pins on the mold. If a lower pressure will work, use it. Ideally, the machine would be set with enough sensitivity to alarm when the molds leader pins become too 'dry.'

Mold Open Distance

The first clamp movement that needs to be set is the mold open distance (Figure 4). Once the mold is properly installed, clamped, and aligned, set the initial mold open distance to at least twice the height of the core.

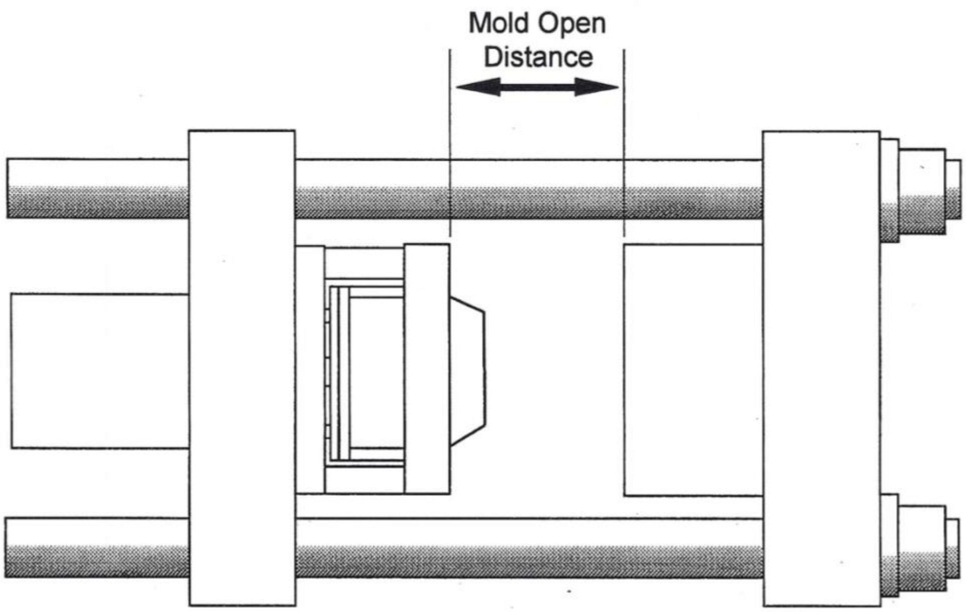

Figure 4 - Mold Open Distance

On molds with cores that are shallower than the sprue height, set the mold open stroke to a distance slightly greater than the core plus the sprue together. This will allow the parts enough room to clear the mold and drop into the bin, or be removed by hand.

On some semi-automatic jobs, the mold will need to be opened further to allow the technician enough room to grasp the part and remove it from the mold. Likewise, if the machine uses a robot to remove the parts, the mold needs to be opened far enough for the robot arm to enter the mold safely.

Mold Opening Stroke

Figure 5 illustrates the mold opening stroke. The first part of the mold opening stroke is the slow mold breakaway. It is used during the initial part of the mold opening stroke.

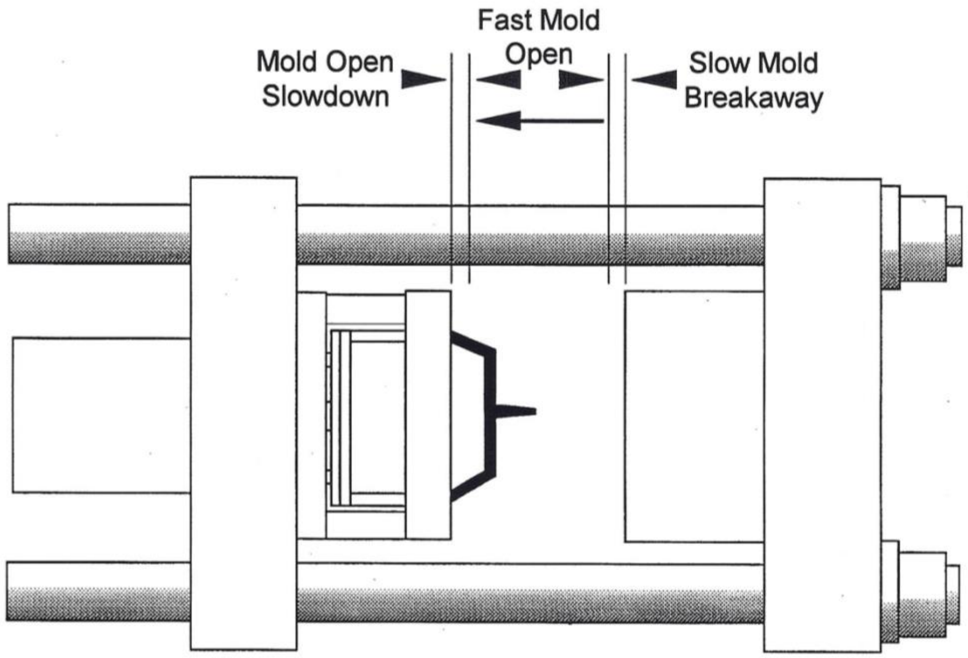

Figure 5 - Mold Opening

The part is packed closely to the walls of the core and cavity. The first opening movement of the mold will break this seal, or vacuum, as the part is released from the cavity half of the mold. The speed is kept slow so the new part is not damaged. Start with a slow mold breakaway distance of about one-half inch.

Most of the mold open distance should be traveled at high speed. Allow the mold to move at high speed, from the end of slow mold breakaway, to the beginning of mold open slowdown.

If the mold opened all the way at full speed, the strain of going from full speed to a dead stop would shock the clamping systems. Slow the mold down to low speed a few inches before the end of the mold opening stroke.

Mold Open Timer

Initially, set plenty of time on the mold open timer. This will ensure that the mold stays open long enough for the part to eject properly. Later, the mold open time will be reduced to minimize the cycle time.

Ejection

Most machines allow parts to fall out of the mold into a bin or onto a conveyor. Generally, the initial ejector plate movement should be set at least as far as the height of the tallest core. This will probably be reduced later. For now, this will ensure that the part is completely ejected and fall freely from the core. Figure 6 shows the clearance needed for the part to be ejected.

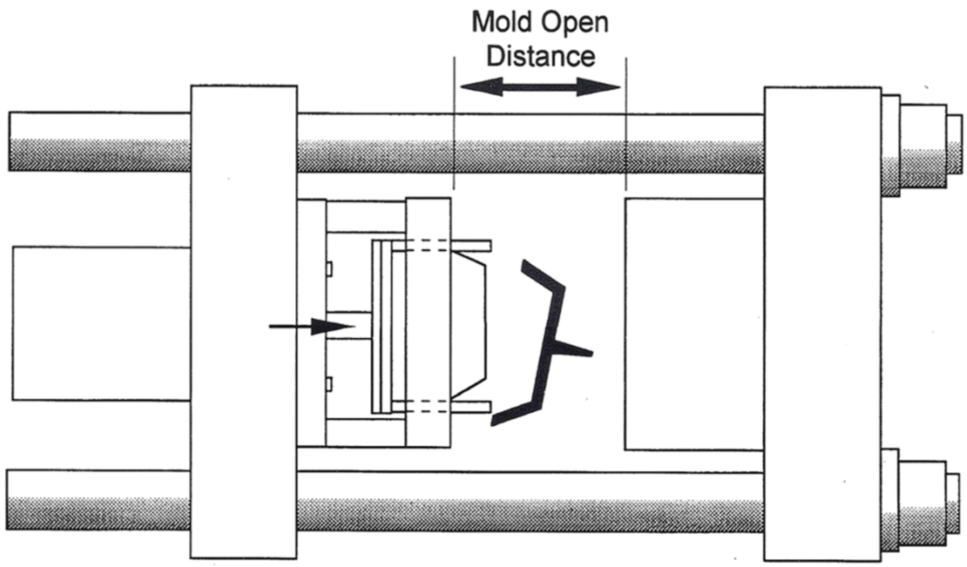

Figure 6 - Part Ejection

If the part is being removed by hand, or if the machine is using a sprue picker or robot arm to remove the part, set the ejector plate movement just large enough to break the seal between the part and the core. The part can then be grasped and lifted off the mold core. Usually, 1/4 of an inch is enough movement to break the seal between the part and the core.

Exercise One

Ejection

On several machines, watch the part as it is ejected. Estimate how much clearance there is between the part and the stationary mold as it is ejected and removed.

Machine Number	Part Being Ejected	Clearance

Instructor Date

Mold Closing

Going from a dead stop to full speed would be a shock to most clamping systems. Start the closing motion at a modest speed for the first inch or two.

Once the mold gets going, you can close most of the rest of the distance at high speed which is called fast mold closed.

If the mold halves contact at high speed, they would smash together, damaging the mold faces. Slow the mold down well before the mold faces come together. For hydraulic presses, It takes time to counteract all the momentum that has been developed. Once a safe slow down distance has been established, the slow down point can be gradually set closer to the stationary mold half until the overall closing stroke is optimized.

Locking up the Mold

The mold has been closing under low pressure. Approximately 0.003" before the mold faces contact, high pressure needs to kick in to lock up the mold fully. If the press goes into high pressure lockup when the moveable mold half is too far away, a stuck part or runner will be crushed with the full clamping pressure, which can easily damage the mold parting line, mold cores or ejector pins.

It is very important to set the mold safety distance just great enough to allow the high pressure to lock up the mold. The position sensor should initially be set so the clamp will not go into high pressure upon closing. Then the distance should slowly be increased until the clamp just locks up. It is usually easy to hear when high pressure kicks in. Then, another slight increase in the mold safety distance will ensure that the clamp will lock up every cycle. This procedure should be completed after the mold has come up to heat otherwise the mold expansion can throw off this setting. Likewise, if the press has been running and is now alarming out for mold protect alarms AND you find nothing in the mold, verify that your temperature control unit (TCU) has not shut off.

Objective Three

Setting the Heats

The temperatures used on the molding machine are set according to the type of plastic being used. Plastics such as polyethylene can be run anywhere from 350° to 600°F. High temperature plastics may require over 700°F to process properly. It is important to know the maximum and minimum temperatures that are safe to use with each plastic. Temperature charts or processing manuals from the plastic supplier are the best place to find accurate barrel temperatures for the specific plastic material being used.

On a new molding job, the initial heats are normally set in the lower to middle section of the safe melt processing range. They can be adjusted later as needed. Lower temperatures usually mean less energy input into the plastic and shorter cycle times.

Starting in the higher temperature range can sometimes cause discoloration if the plastic has a long residence time in the barrel. Temperatures in the upper range are typically used when thin walled parts are being made. The plastic can cool and solidify so quickly in a thin walled part that the higher heats are needed just to be able to fill the cavity.

Starting with excessively low temperatures can increase the risk of screw damage if the plastic is too cold to move. It is safer to jog (suck back) the screw slowly during startup to make sure that it will turn easily if low initial barrel temperatures are used.

Once a job has been run, the heat settings can be recorded on the setup sheet for future use. Figure 7 shows an example of the different heat settings and heat soak times from a setup sheet for a polystyrene molding job.

Part: Cassette Case					Material: Polystyrene							
Barrel and Nozzle Temperatures								Mold Temp.			First Shot	
Front Zone	Middle Zone	Rear Zone	Nozzle Temp.	Nozzle Valve Temp.	Melt Temp.	Throat Temp.	Heat Soak Time	Front Half	Floating Half of Cores	Back Half	Mold Warm-up Time	Hot Runner Warm-up Time
450°F	430°F	400°F	450°F	N.A.	460°F	90°F	1 hr.	100°F	N.A.	120°F	30 min.	1 hr.

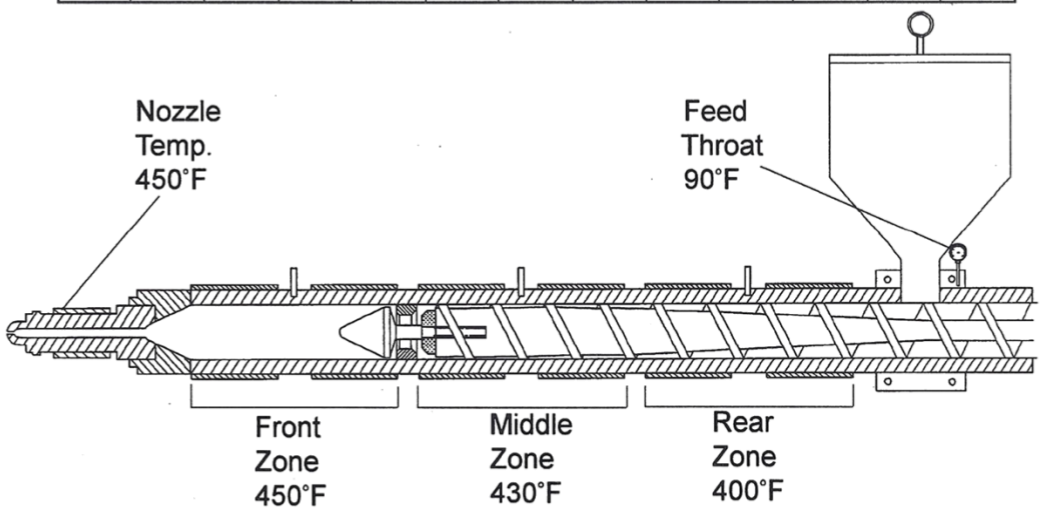

Figure 7 - Heat Settings & Soak Times

Barrel Temperatures

Each zone of the barrel is heated by a separate electric heater band and controller. The different temperature settings along the barrel are referred to as the heat profile. In the previous example, the front zone temperature was set close to the desired melt temperature. The temperature settings decrease 20° to 30°F per zone toward the rear of the barrel. The rear zone temperatures are set lower so that the plastic heats more gradually. Keeping the rear of the barrel cooler also decreases the chances of melting the plastic in the feed throat. There are times or materials that will require a reverse profile, it is good to refer to the material suppliers manual for temperature and profile recommendations.

Nozzle Temperatures

Since the nozzle is relatively small, its temperature setting does not have much effect upon the overall melt temperature. Set the initial nozzle temperature close to the front barrel temperature. Nozzle temperature can be raised later to avoid freeze off or lowered to minimize drooling.

Melt Temperature

Parts with very fine tolerances require accurate and consistent melt temperatures. Today's designers are specifying tighter part tolerances. As a result, it is important to know the actual temperature of the melt. In cases where a lot of back pressure is used, the melt temperature may be much higher then the temperatures set on the temperature controllers. On a job where a lot of material is being processed, the actual material temperature may be much lower than the set points.

One way to measure the melt temperature is with a thermocouple sticking into the melt stream inside the nozzle. Another way to determine the actual melt temperature is to purge out a shot of material and check it with a hand held thermometer with a probe tip.

Mold Temperatures

The mold must be maintained at a stable temperature cycle after cycle. Mold temperature is controlled by coolant, water or oil running through internal mold channels. The coolant may be heated or chilled. Either way, the mold is still much cooler than the plastic being injected into it. Most setups start with a mold temperature in the middle of the recommended range. It may be raised later to improve flow, or decreased to improve cycle time. The two halves of the mold may even be set at different temperatures to cure problems such as parts sticking in the mold, or part warpage.

Heat Soaking

There are three areas in the system where a sizeable mass of steel needs to be heated. In these areas, the temperatures must be allowed extra time to stabilize after the set points have been reached. The three areas are the barrel, the mold, and the hot-runner manifold (on hot-runner molds). Each one needs additional time for the total mass to come up to temperature, this process is called heat soaking (Figure 8).

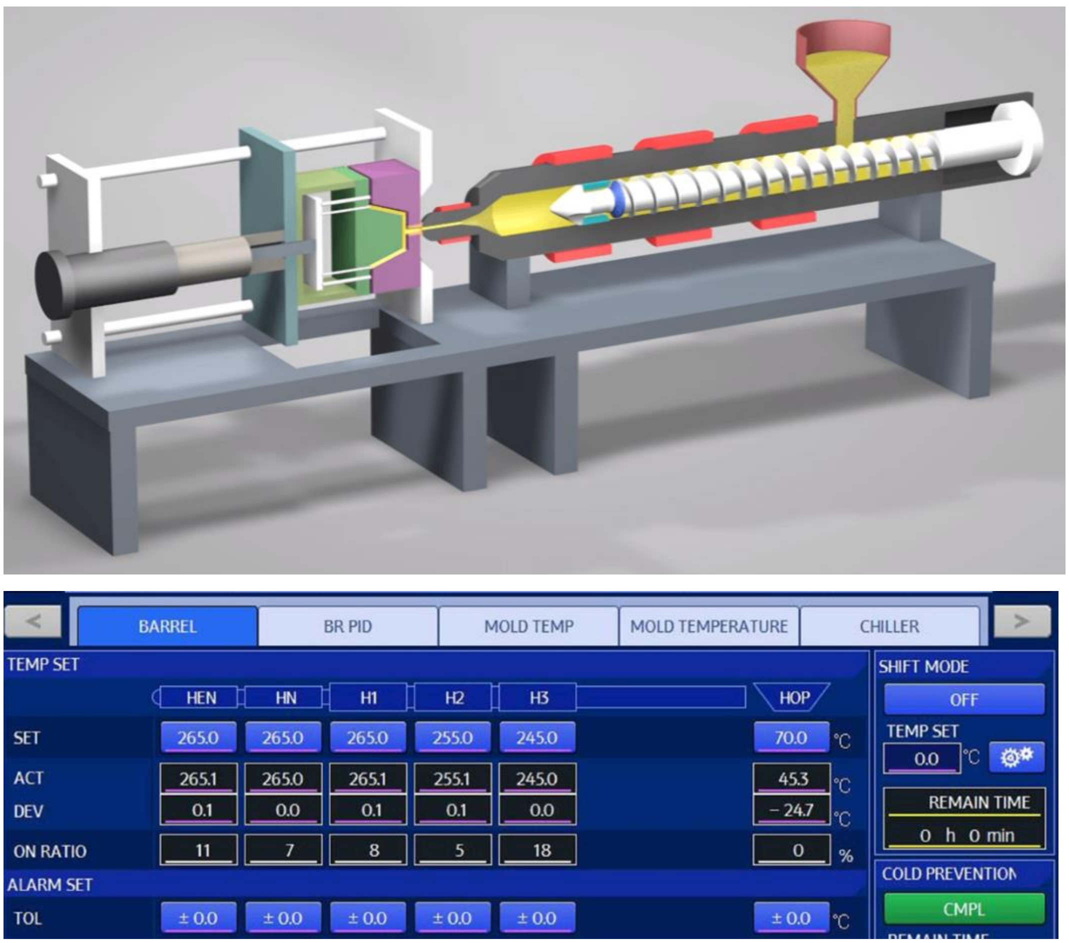

Figure 8 - Heat Soaking

Mold and barrel temperatures directly influence the machine control parameters. Wait until the mold and barrel are at their equilibrium temperatures before setting injection speed or pressure. If injection speed and pressure are set first, they will need to be changed as temperatures continue to rise.

Some setup sheets have spaces where the minimum recommended heat soak times can be listed. Small machines might only need twenty to thirty minutes while larger machines are often allowed to heat soak an hour or two after the set points have been reached.

Exercise Two

Temperature Settings

On several machines, record the following temperature settings.

Machine Number	Barrel Temperature			Nozzle Temperature	Mold Temperature
	Zone 1	Zone 2	Zone 3		

Instructor Date

Objective Four

Pressures, Strokes, and Cycle Timers

Setting up for Sampling

When preparing to sample a mold, many of the remaining machine controls must be preset to some starting values in order to be able to run the machine. Many of these starting point settings must be estimated. The following guidelines can be used as a preliminary setting for the machine controls. Again, check the material supplier's processing guide first for suggested processing conditions. A detailed set of sampling procedures will be covered in a later lesson.

Initially, the timers should all be set longer than anticipated. This generally removes "time" as a potential factor in the trouble-shooting process. Times that are too short can cause confusion during startup as they can create short shots, sink marks, or warpage even if the pressure and speed controls are set properly. Excessively long cycle times generally will only affect dimensional accuracy. The cycle times can be reduced later once a relatively good part is coming out of the mold.

Initial Machine Settings for Sampling

Shot Size.................................. Large

Back Pressure .... Low

Screw Speed .... Medium

Injection Speed .... Medium

Hold Pressure .... Low

Hold Time .... Long

Mold Open Time .... Long

Use a large enough initial shot size setting to ensure that enough material is available to fill the cavity. A standard 1/4 inch of decompression may also be added. Later, when the first shot is made, if the screw bottoms out and the cavities do not fill, significantly increase the shot size. It is important to turn on a "max pressure" or "fill time" monitor to make sure you are not overpacking the mold by putting too much material in the mold.

It is usually safer to set back pressure low and to raise it later if necessary. A typical low back pressure setting is 500 ppsi. There are a few exceptions, such as when you are dealing with PVC.

Screw rpm and injection speed can usually be set safely in the middle of the available machine range. Again, exceptions exist, such as for polycarbonate, where slow screw speeds are called for.

Injection pressures should initially be set low so that short shots will be produced first and then filled out as the sampling continues. If the first shot flashes the mold, there is more potential for damage or stuck parts. It is preferred fill the cavity under injection velocity and add hold pressure to pack the part out.

Setting Pressures, Feeds, and Speeds from a Setup Sheet

Molding machines use a combination of position sensors and set points on the controller to set the injection parameters. Speeds, or velocities, often have a corresponding pressure and time associated with it. For example, we may have entered our injection velocities at 4 in/s for a stroke of 3 in. With max pressure and time settings, if the molding machine didn't make the stroke position, it would maintain max effort to achieve it. I know, confusing. Think about a clogged nozzle tip. The machine attempts to inject but cannot because nothing can make its way through the clogged tip. If we had a high pressure monitor and fill time monitor set, the machine would attempt to fill but would alarm out due to failing one of the monitors protecting the molding machine.

Exercise Three

Machine Settings

Examine several machines, describe the exact location of each of the following and record the current settings.

Machine Number	Transfer Pressure	Transfer Position	Hold Pressure	Back Pressure	Screw RPM

Instructor Date

Setting Cycle Timers from a Setup Sheet

Most machines only have about four cycle time controls on them. They are almost always set to a tenth or even to one hundredth of a second. The only problem encountered when setting timers from a setup sheet is when a different machine is being set up with a different combination of timing controllers.

Setting up in a Different Machine

The molding technician is often required to run an existing mold in a completely different machine from the one for which the setup sheet had been developed. Depending on the machine differences, some settings may be made almost identical, while others may be impossible to transpose.

Temperatures should be largely interchangeable between presses as are timers.

If the machine tonnage and shot sizes are different, most of the stroke settings will be off for both ends of the machine. This means that clamp settings, shot size, and transition point settings will need to be set up from scratch, again.

Because of a different size screw and barrel, the injection speed and resultant fill times will be different when using the same injection pressures. One of the best ways to duplicate the internal processing conditions is to make sure that the fill time comes out the same on the new machine as it did on the old. Duplicate fill times will maintain the same amount of orientation and balanced cavity packing. Duplicating the fill time will have to take place during actual machine processing. It will mainly be influenced by changing the injection speed .

If the job is being run on a different brand of machine, the control systems may be completely different. Again, temperatures may be transferred directly, but cycle timers may be sequenced differently. The knowledgeable technician can reset the different timer controls so that the overall cycle time will come out pretty close to the original press setup.

Other setup techniques can be used, such as proportioning. For example, if the injection pressure on the first machine was set at 60 (on a 1 to 100 scale) and the second machine used a direct pressure, (from I to 20,000 psi) then a proportion calculation can be made. In this case 60 is to I00 as X is to 20,000. Therefore, X (the desired pressure setting on the new machine) is equal to 12,000 psi.

You should use as much information from the setup sheet as possible. The more often you go back and forth between different machines, the easier the transition becomes. A new setup sheet <u>should always be made for the specific machine</u> in which the mold is being run.

Exercise Four

Timers

On several machines, record the current settings for the following timers.

Machine Number	Hold	Cool	Screw Rotate Delay	Eject Delay	Close Delay

Instructor Date

Self-Test

1. Sampling a new mold:
   a. Can take a long time to do correctly
   b. Is commonly done by new technicians
   c. Is not usually necessary if it is designed well
2. If all the information on the setup sheet is programmed into the machine controls, the first parts molded should be assumed good parts.
   a. True
   b. False
3. What is the common rule for setting clamp tonnage per unit of projected area?
   a. 3-4 tons/in^2
   b. 7-8 tons/in^2
   c. 10-12 tons/in^2
4. Mold open distance should be initially set by using a stroke a little greater than:
   a. The core height
   b. 2x the core height
   c. 4x the core height

5. Slow mold breakaway for the first half inch of travel is important because it:
   a. Gently breaks the vacuum seal on the parts
   b. Saves clamp stroke energy
   c. Greatly reduces shock to the clamping system
6. When closing the mold, how far should the mold halves be apart when the high pressure is activated?
   a. 1.000 inch
   b. 0.125 inch
   c. 0.003 inch
7. The heats on a machine have just reached their startup set points. What will happen if parts are molded immediately?
   a. Good parts will be made and downtime will be minimized
   b. The process will have to be adjusted later since the machine will start making bad parts
8. The recommended melt temperature range for a material is 300°-500°F. Where should the start-up temperature be set?
   a. 300°F., this will save energy
   b. 400°F., this is a safe starting point
   c. 500°F., this will melt the plastic fast so the machine can be started sooner

9. A molding machine has been set according to the set-up sheet data and has heat soaked. The molded parts have sink marks, what should be done first?
   a. Hold pressure slightly
   b. Increase hold time
   c. Check to see if there is a cushion
10. An existing mold is set up in a machine that is larger than the one it ran in before. Which one of the following parameters would be the most important to duplicate from the old set-up sheet?
    a. Fill time
    b. Transfer pressure
    c. Hold time

Glossary

Heat Soaking - the extra time used to heat the barrel or mold completely after the set points have been reached.

Log Sheet - an information sheet containing problems encoun-tered when using the mold, and molding solutions or parameter changes that were used to correct them.

Mold Protection Position - one of the names of the clamp position switches that activates the clamp into high pressure during closing just before the mold faces touch.

Projected Area - the total area of the parts and runners in a mold at the parting line.

Sampling - the trial procedures used to determine the initial molding parameters for a new mold.

Set-up Sheet - the data sheet, in which all of the molding parameters that were used to run the mold successfully, have been recorded.