

X. Determining Hold Stage Parameters

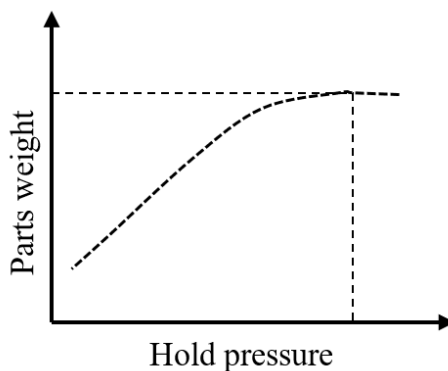
- **Laboratory I - Determining Hold Pressure**
- **Laboratory II - Determining Hold Time**
- **Hold Stage for Molds with Hot Runners and Gate Valves**

Again, remember that before continuing with these *Universal Molding™* labs:

- Auxiliary equipment should be properly installed and correctly operating.
- Temperatures should already be reached.
- Barrel adjustments should have been programmed.
- The required clamping force should have been set.
- The press openings, their movement, speeds, and mold protection should have been carefully and precisely adjusted.
- Extended cooling time should have been set, in order to prevent it from interfering in the determination of other parameters.
- The ideal injection speed should have been determined, adjusted and should be filling about 95% of the required fill for the mold.
- The injection pressure limit should have been determined and adjusted.
- The hold stage should stay off.
- The fill balance should have been verified and adjusted.

Important -- only qualified personnel who have read the operational manuals of the equipment and understand the functionality of the equipment should operate them and/or make adjustments.

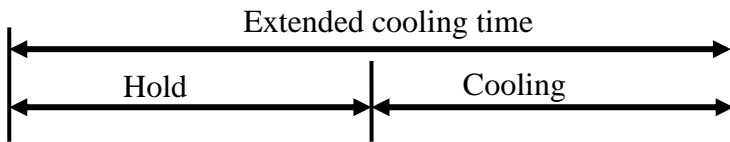
The hold pressure is determined, increasing the hydraulic or melt hold pressure, until the cavities are completely full or have reached the desired weight.



X-1. Graph of the effect of hold pressure on the weight of the parts

Laboratory I - Determining Hold Pressure

1. Set the hold time to a value greater than required. For example, consider half the extended cooling time that was used in previous labs. The goal is to ensure gate freeze; hold time will be optimized later.
2. Write down a cooling time equal to the difference between extended cooling time and hold time. Note that the sum between hold time and cooling time will be equal to extended cooling time.



X-2. Extended cooling time

For example, in a laboratory where the extended cooling time is equal to 12 seconds, half of the extended cooling time was used in order to guarantee gate freeze. The results are the following:

$$\begin{aligned} \text{Hold time} &= 6 \text{ seconds} \\ &\text{and} \\ \text{Cooling time} &= 6 \text{ seconds} \end{aligned}$$

Important, always guarantee that cooling time is longer than recovery time. It was explained in previous chapters that, when cooling time expires, permission to open the mold will only be allowed if recovery has finished. In other words, the mold will be closed until the recovery is complete, regardless of whether cooling time has finished. Consequently, cooling time will be extended and, depending on the machine, you may not realize this is happening.

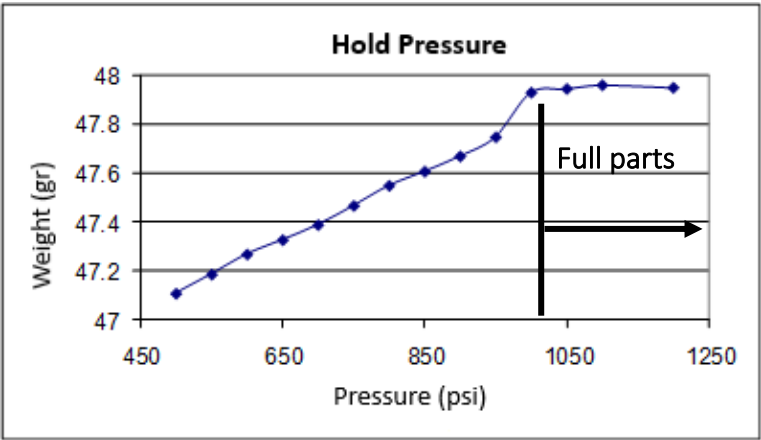
3. Perform a weight study of the parts at different hold pressures. Start the experiment with a lower pressure than required. For example, start with 10% of the injection pressure acquired at the time of transfer; then increase the pressure until you get completely full parts or the desired weight. Take two or three samples per pressure and calculate the average of the weight of the parts. Tabulate the data and plot the weight of parts

against hold pressure. Weigh only the molded parts; do not include the runner.

Pressure (psi)	Average weight (gr)
500	47.11
550	47.19
600	47.27
650	47.33
700	47.39
750	47.47
800	47.55
850	47.61
900	47.67
950	47.75
1000	47.93
1050	47.95
1100	47.96
1200	47.95

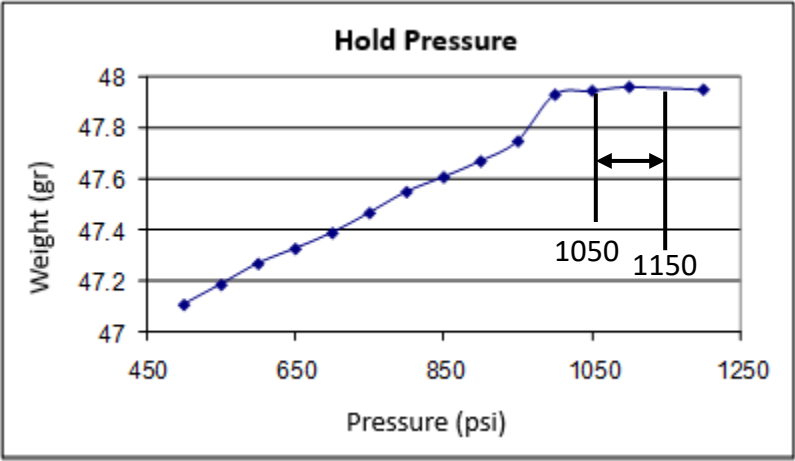
X-3. Table of the effect of hold pressure on the weight of the parts

In the graph below, we see that the pressure stopped contributing to the weight of the parts after 1000 psi of hold pressure.



X-4. Graph of the effect of hold pressure on the weight of the parts

4. Select a pressure where the weight is relatively constant. This example used a minimum hold pressure of 1050 hydraulic psi, a machine parameter. The norm would be to select a pressure range, for example from 1050 to 1150 psi.



X-5. Graph indicating hold pressure range

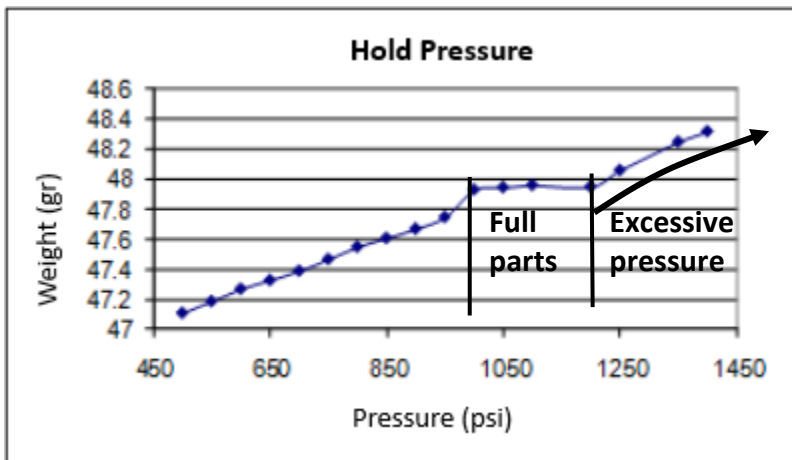
5. Once you select your hold pressure range, convert to Universal parameters.

In this example the injection unit used had an intensification ratio of 12.2, and its corresponding Universal parameters are:

$$\begin{aligned} \text{Universal hold pressure} &= \text{Hydraulic pressure} \times R_i \\ \text{Minimum pressure} &= 1050 \text{ psi} \times 12.2 = \mathbf{12810 \text{ psi}} \\ \text{Maximum pressure} &= 1150 \text{ psi} \times 12.2 = \mathbf{14030 \text{ psi}} \\ \text{Average pressure} &= 1100 \text{ psi} \times 12.2 = \mathbf{13420 \text{ psi}} \end{aligned}$$

Notes:

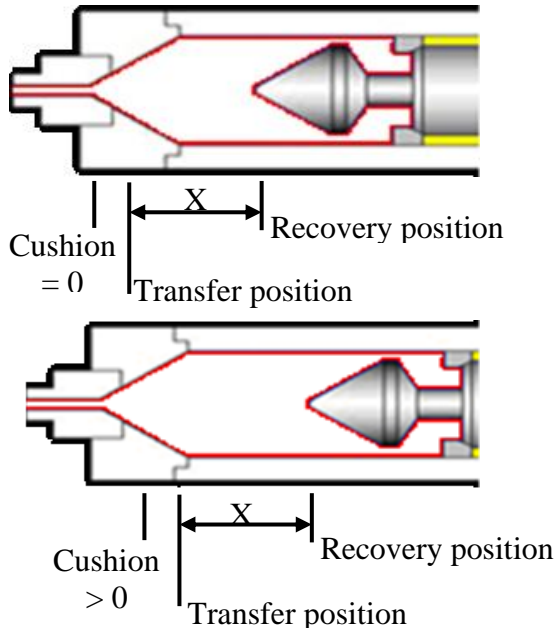
- Although the objective is dimensions and not weight, for now you must work with the weight of the cavities. After unmolding, the parts will undergo multiple changes in dimensions due to shrinkage.
- Only weigh the molded parts, not the runner.
- Avoid opening the mold or forcing melt to sneak into unwanted spaces as a result of excessive pressure. An easy way to find out if the pressure is excessive is by looking at the graph of pressure versus weight of the parts.



X-6. Graph indicating excessive hold pressure

In the graph, after 1200 psi a new tendency was started, indicating that the mold is opening, or plastic is oozing.

- The cushion must be greater than zero. If it reaches zero, injection volume will have to be increased. Assuming there are no defects in the injection unit, such as a leaky check ring, increase the recovery position and transfer position by the same amount until the final position (after hold) is greater than zero.



X-7. Correction when cushion is zero

If the cushion becomes zero as a result of a defective injection unit, such as a leaky check ring, talk to the maintenance department to have the defect repaired.

Always ensure that the cooling time is longer than the recovery time.

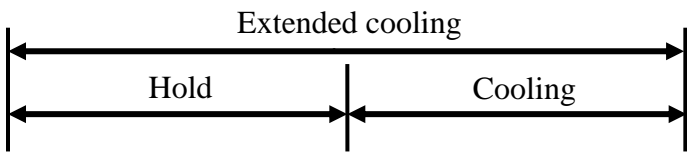
Laboratory II - Determining Hold Time

Hold time is determined by the gate freeze test. While the gates are liquid, hold pressure keeps the melt in the cavity. Once the gates freeze, the melt cannot escape even when hold pressure is removed.

1. Adjust to the previously determined hold pressure.

2. Without changing the hold pressure found, decrease the hold time in intervals until the weight of the parts begins to decrease due to soft gates, which are unable to keep the compressed melt inside the cavities.

In order to maintain a constant total cycle, the sum of cooling time and hold time must be kept constant. For each interval that is subtracted from hold time, the same amount should be added to cooling time.



X-8. Extended cooling time

3. Tabulate the times with their corresponding total weights of the parts and make a chart of the weight of the parts against hold time.

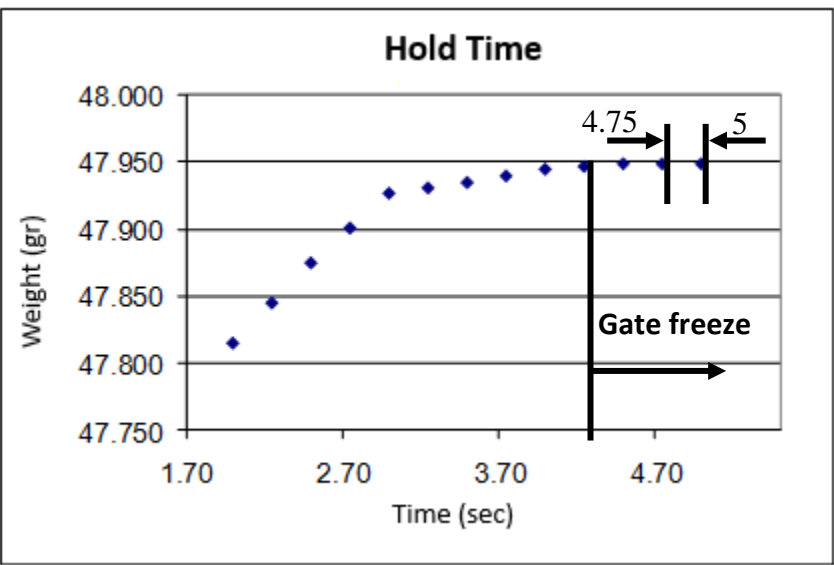
Hold time (s)	Average weight (gr)	Cooling time (s)
5.00	47.949	23.00
4.75	47.949	23.25
4.50	47.949	23.50
4.25	47.947	23.75
4.00	47.945	24.00
3.75	47.940	24.25
3.50	47.935	24.50
3.25	47.931	24.75
3.00	47.927	25.00
2.75	47.901	25.25
2.50	47.875	25.50
2.25	47.845	25.75
2.00	47.815	26.00
1.75	23.908	26.25

X-9. Table of the weight of the parts and their respective hold and cooling times

Although the cooling time column is not graphed, include it. It will help you when entering the times during the experiment.

Notes:

- For each hold time setting, take two to three samples and average the total weight of the parts.
 - Only take the weight of the molded parts without the runner.
 - Always ensure that the cooling time is longer than the recovery time.
4. On the graph, find the time where the weight of the parts begins to decrease. It is clearly shown that hold times longer than 4.5 seconds will be required to ensure gate freeze.



X-10. Graph of the effect of hold time on the weight of the parts

The hold time range selected in this example is 4.75 to 5 seconds.

Summary of parameters

Once the hold parameter determination is complete, summarize them:

- determined hold time and its operational range
- determined hold pressure (Universal and machine parameter) and its operational range
- remaining extended cooling time

- volume position or recovery position
- cushion or final position of the screw after hold and its operational range.

Finally, verify that the machine control has been programmed with the determined hold parameters.

Hold Stage for Molds with Hot Runners and Gate Valves

With molds that include hot runners, the procedure is similar; we will have to guarantee gate freeze.

Now, if the mold also includes gate valves, those will do the function of gate freeze. These are programmed so that valve closure occurs when the adjusted hold time is met. In addition to creating a good finish at the injection site, these valves reduce hold time, since you don't have to wait for gate freeze.

Notes:

- If the valves close prematurely you will probably end up with incomplete parts.
- If the valves close too late, they may encounter hardened material in the valve seat, which could damage the gates in the cavities. Consequently, this defect would be reflected at the injection point of the parts.

During the hold stage, we guarantee measurements that are a function of mass. Do not attempt to correct thermal measurements in the hold laboratory.

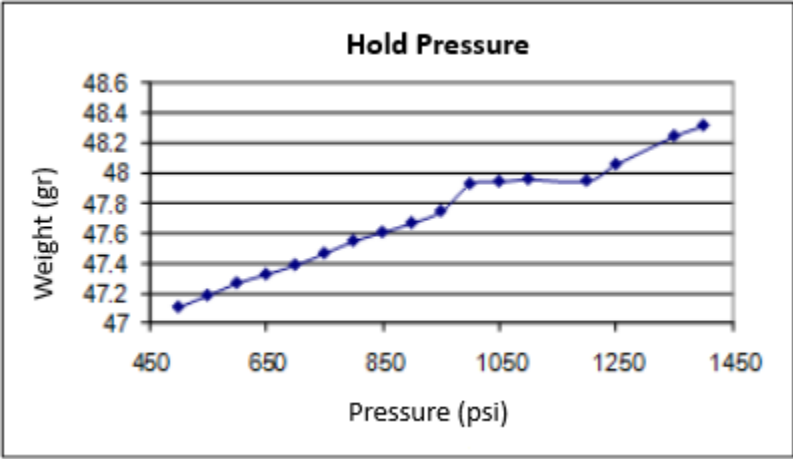
Amorphous	Semi-crystalline
Problems with over-packing due to low shrinkage	Problems of incomplete pack due to high shrinkage
Problems with flash	Sink marks
Breaks during demolding	Easy demolding
The transition from softened melt to solid is gradual	The transition from liquid melt to solid is sudden

X-11. Mechanical characteristics of materials which should be considered during hold

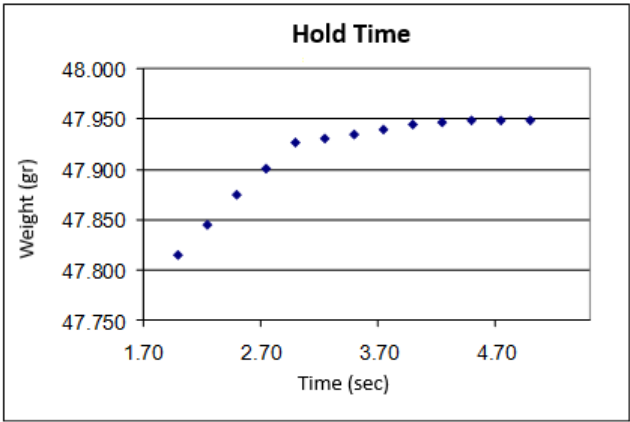
Questions

- 1) Increasing hold pressure increases the weight of the parts. Assuming the mold does not open, eventually a pressure will be reached where the weight of the parts will stop increasing.
 - a. True
 - b. False
- 2) A hold pressure graph is created by using hold pressures and the total weights of the parts with runners.
 - a. True. The weight of the parts and runners is used.
 - b. False. Only the weight of the parts without the runners is used.
- 3) The dimensions that are the effect of shrinkage are evaluated when determining hold pressure.
 - a. True. During hold we consider the mass dimensions.
 - b. False. During hold we only consider the mass dimensions and not the shrinkage.
- 4) The hold time is used to
 - a. determine thermal dimensions.
 - b. improve the operating cycle.
 - c. determine gate freeze.
- 5) In one process a hold time of 6 seconds was found. The corresponding Universal hold time would be
 - a. 6 seconds.
 - b. $6 \text{ second} \div \text{Intensification ratio}$.
 - c. $6 \text{ seconds} \times \text{Intensification ratio}$.

6) Using the graph below, select all the correct statements.



- a. In the graph, after 1200 psi a new tendency begins, indicating that the mold is opening, or plastic is oozing as a result of excessive pressure.
 - b. In the graph, using a hold pressure of 850 psi will give us complete parts.
 - c. In the graph, a selection of 1050 psi is an adequate hold pressure.
- 7) Using the illustrated graph, select the correct statement.



- a. We get gate freeze with a hold time of 2 seconds.
- b. We can see that we will need hold times greater than 4.5 seconds in order to guarantee gate freeze.