XII. Process Limits

- **Maximum Injection Pressure Limit**
- **Cushion Lower Limit**
- **Cushion Upper Limit**
- **Recovery Time Limit**
- **Back Pressure Limits**

Injection molding process limits are necessary alarms and must always be set.

We have observed that many in the injection molding industry ignore the process limits. Some of these limits are the maximum injection pressure limit, the cushion upper and lower limits, and the recovery time limit. These alarms protect the equipment and the quality of the molded parts.

Why are they ignored? Although some do it out of neglect, most operators ignore them because they do not know their benefits. There are many consequences; use these limits appropriately, and you will enjoy their benefits and savings.

What would cause the maximum injection pressure limit to be reached, and what could be its consequences?

Reaching the maximum injection pressure limit could be a result of a blocked cavity, either because a part was trapped in the cavity or there was a plugged gate If for some reason a cavity is clogged, the control has no way of knowing and will continue injecting, causing high injection pressures. These high pressures could cause flash in the parts, melt leaks into the hot runner system or melt leaks between the mold sprue bushing and the nozzle tip. Another possibility could be that the recovery position was increased, causing excessive fill during the injection stage, significantly higher than the 95% of the mold’s capacity.

What would cause the cushion lower limit to be reached, and what could be its consequences?

Reaching the cushion low limit is an indicator that the melt is seeping somewhere; it is typically the result of a dirty or defective check ring, and it could be that it is leaking somewhere in the mold or between the sprue bushing and the nozzle tip. This melt leak condition, if ignored for prolonged times, could cause the melt to reach some of the heater bands of the barrel, to reach the wiring of the hot runner system, to leak between mold actuators and damage the mold; in general, it could cause substantial damages. In addition, if the cushion position reaches zero (totally empty injection unit) it will nullify the hold stage, and part dimension changes could be observed.

What would cause the cushion upper limit to be reached, and what could be its consequences?

Reaching the cushion high limit is an indicator of a blocked cavity or clogged gate. Also, if it's a hot-runner mold, it could be that a hot tip is clogged or damaged. The consequences could be over-packaging of parts, which could cause parts jamming in the cavity and part’s dimensional changes.

What would cause the recovery time limit to be reached, and what could be its consequences?

Reaching the recovery time limit could be caused by a lack of material. The melt in front of the check ring is the one that pushes the screw towards the recovery position, and if the resin feed is interrupted, the recovery time will extend. Systems that integrate pigment dosing in the throat of the injection unit could observe variation in the color of the parts. Do not forget that if the recovery time extends the cooling time, it could trigger an alarm.

Inconsistent resin flow may be due to the barrel heat affecting the feed throat, causing material agglomeration. This problem can arise for several reasons, such as an excessively high barrel temperature or poor cooling of the feed throat.

What is an appropriate upper and lower limit for back pressure?

Before providing an opinion, let’s start with an overview. During recovery, the screw rotates, and the melt is pumped through the check valve toward the front of the screw. The accumulated molten mass at the front of the screw pushes it to the recovery position. Back pressure (*BP*) results from a controlled force opposing this displacement. The purpose of *BP* is to ensure consistently homogeneous melt (or improve additive dispersion in the melt) and to increase or decrease shear rate during loading.

Changing back pressure has multiple consequences. For example, when increased:

1. It enhances the mixing capacity of additives.
2. Degradation of sensitive materials and fiber breakage increase.
3. Screw and barrel wear intensifies.
4. Heat contribution from friction increases, or heat contribution from heater bands decreases.

5. The amount of molten mass increases; since molten thermoplastics are compressible, more plastic can be plasticized in the same volume. Consequently, more material is transferred to the mold during the injection stage.
6. Melt viscosity typically decreases due to heat from friction. As a result, machine rheology values change.

There are three typical options for *BP* limits:

1. Set *BP* without upper or lower limits.
2. Establish validated *BP* limits within a range.
3. No restrictions, allowing molders to decide.

Controlled industries, such as medical, usually work with one or two validated resins, often without regrind. Therefore, setting *BP* without upper or lower limits is justified. If, for any reason, they need to use *BP* limits (due to regrind usage), they should set tight, validated *BP* limits and maintain a consistent virgin-to-regrind ratio.

However, this doesn't mean that uncontrolled industries should have wide-open *BP* adjustments or leave it to the operator's discretion. In uncontrolled industries where multiple resin brands are used for the same product and the virgin/regrind ratio is not controlled, it doesn't make sense to establish narrow upper and lower *BP* limits.

Understand your material before setting *BP* limits. Ask yourself:

1. Is the material fiber-filled?
2. Does it degrade easily?
3. Does the material supplier change based on market prices?
4. Will additives like pigments or plasticizers be dosed?
5. Does the virgin/regrind ratio change due to warehouse limitations?

For uncontrolled industries, allowing operators to manipulate back pressure should not be the default option. Although melt index changes with material supplier and virgin/regrind ratio, a restricted upper and lower BP limit should be established and reviewed based on material changes.

Questions

1. A process fills 97% in the injection stage and creates flash. The procedure to verify and resolve the situation is:
   a) After turning off the holding stage, the flash continues, identifying that too much material is being filled in the injection stage. Gradually reduce the recovery position until the flash defect disappears. To prevent the situation from recurring, set a high recovery limit.
   b) After turning off the holding stage, the flash continues, indicating that too much material is being filled in the injection stage. Gradually reduce the transfer position until the defect disappears.

2. In a process, the maximum injection pressure alarm was triggered. The reason could have been
   a) a blocked cavity or the injection stage was set to fill too little, less than 95%.
   b) a blocked cavity or the injection stage was set to fill too much, more than 95%.

3. What would cause the cushion lower limit to be reached?
   a) Dirty or defective check ring, melt leaking between the sprue bushing and the nozzle tip, or the melt is leaking into the mold, either as flash leakage between mold actuators or within the hot runner system.
   b) The recovery position was set too high, causing over 95% filling in the injection stage, or the transfer position was set too high, causing over 5% filling in the holding stage.

4. What would cause the cushion upper limit to be reached?
   a) Blocked cavity or an obstructed runner, and if it is a hot runner mold, a hot tip could be obstructed or damaged.
   b) Dirty or defective check ring, melt leaking between the sprue bushing and the nozzle tip, or the melt is leaking into the mold.

5. What would cause the recovery time limit to be reached?
   a) Melt leaking between the sprue bushing and the nozzle tip.
   b) Inconsistent resin flow due to the feed hopper running out of resin. Additionally, it could be because the barrel heat is affecting the feed throat, causing material agglomeration.