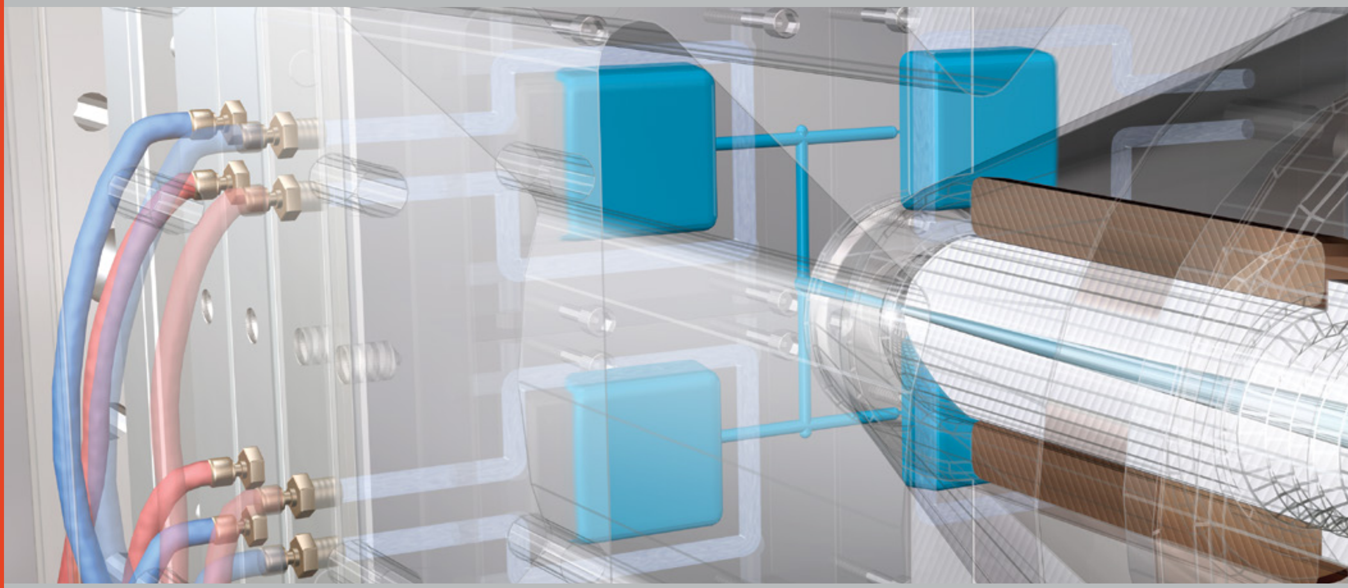
REFERENCE SERIES: PROCESSING

Scientific Troubleshooting: Part Warpage



nexeo plastics

Created exclusively for **Nexeo Plastics** by Routsis Training, this free guide contains excerpts from Routsis's ***Scientific Molding Courses***.

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TROUBLESHOOTING PART WARPAGE

A warped part is deformed and does not match the shape and form of the mold cavity. In longer parts, warpage will appear to have a twist or bend.

Warpage is most often the result of inconsistent stresses in the part – resulting in uneven shrinkage across the part. When investigating this defect, it is good practice to measure the part dimensions across the entire part before making any process adjustments.

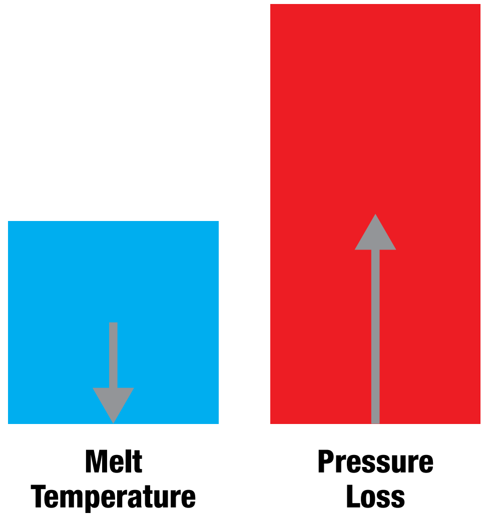
In many cases, the molded part dimensions are actually larger or smaller overall — or at the gate, or at the end of fill. In such a case, a scientific troubleshooter should troubleshoot these dimensional faults first since the solution may also correct the part warpage.

Part Warpage can be caused by one of five major factors:

- Material Temperature
- 1st Stage Injection
- 2nd Stage Packing
- Mold Temperature
- Mold Design

Material Temperature

With respect to material temperature, warpage can result from a low Melt Temperature, a high Melt Temperature, or degraded material.



If a low-temperature polymer is injected into the mold, large pressure losses can occur. These pressure drops can prevent consistent packing from taking place across the entire part. A lower temperature polymer will also exhibit less shrinkage during cooling which can affect the dimensional stability of many parts.

If a high temperature polymer is injected into the mold, excessive shrinkage can occur as the material cools. This additional shrinkage can create excessive internal stresses — especially in parts with varying thicknesses.

Excessive Melt Temperature and Back Pressure often cause the material additives to burn and degrade. This degradation results in a breakdown of the polymer chains which can reduce both the mechanical strength and shrinkage of the polymer.

When troubleshooting part warpage, ensure that the **Melt Temperature** measurement and **Back Pressure** settings match the documented standard.

1st Stage Injection

With respect to 1st Stage Injection, Part Warpage can result from a low Injection Velocity, a high Injection Velocity, or insufficient material injection.

If a low **Plastic Flow Rate** is being used during injection, then pressure losses will increase — often causing variable shrinkage across the part. If a high Plastic Flow Rate is used, then the pressure loss within the mold cavity will be reduced, which can also cause variable shrinkage and part warpage.

If insufficient material is injected into the mold during injection, the part will encounter more shrinkage near the end of fill than at the gate.

Turn off 2nd Stage Packing and ensure that the **1st Stage Fill-only Part Weight** and the **1st Stage Injection Time** match the documented standard.

This free reference guide contains excerpts from Routsis Training's Scientific Injection Molding courses. Click here for more information.

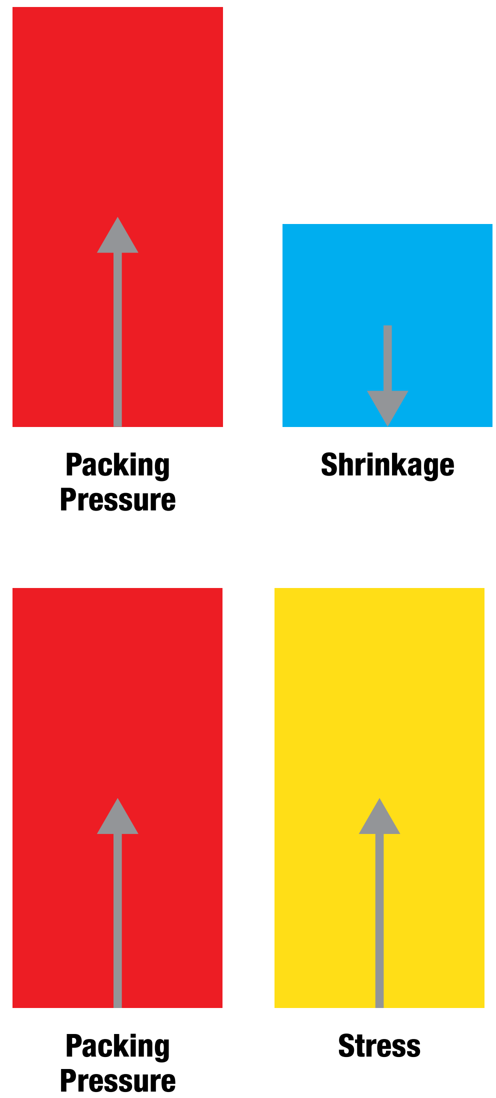
2nd Stage Packing

Low **2nd Stage Packing Pressure** can result in excessive part shrinkage as the polymer cools; causing dimensional instability and warpage.

However, high 2nd Stage Packing Pressure can force too much material into the mold and result in excessive molded-in stresses. Warpage typically occurs after the part is molded and the internal stresses are relieved. Although some parts may start to relieve this stress immediately, others may warp for hours, weeks or even years after being molded.

If the **2nd Stage Time** is insufficient, material will flow back through the gate before it seals. This polymer backflow can result in excessive shrinkage near the gate and result in part warpage.

Verify that both the 2nd Stage Packing Pressure and 2nd Stage Packing Time match the documented standard.



Mold Temperature

Part Warpage can result from a Mold Temperature that is either too low or too high.

Although a low Mold Temperature tends to provide more dimensional stability at the time of part ejection, it can often cool the material too quickly. This rapid part cooling may result in excessive molded-in stresses which may cause part warpage after the part is produced. Molded-in stress relief most often occurs when the part is exposed to heat, stresses, or a corrosive chemical.

A high Mold Temperature causes the polymer to cool at a slower rate which increases part shrinkage. High Mold Temperatures may also prevent the material from becoming cool enough to maintain the desired dimensions at the time of part ejection.

Verify the coolant temperatures entering and leaving the mold, and the Cooling Time.

Mold Design

Part warpage can be caused by mold design flaws in which thick sections receive the same or less cooling than thin sections. Unevenly distributed cooling lines or large gaps between the lines will create hot spots which also contribute to warpage due to uneven cooling and shrinkage.

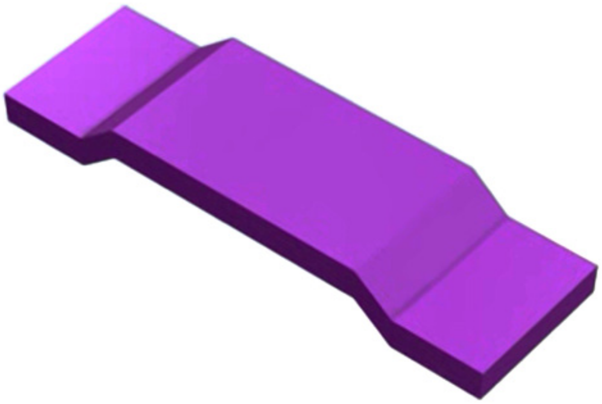
Sharp thickness transitions create sharp shrinkage differentials which contribute to warpage. Sharp corners will create additional stress concentrations which often cause the part to buckle as it cools and shrinks.

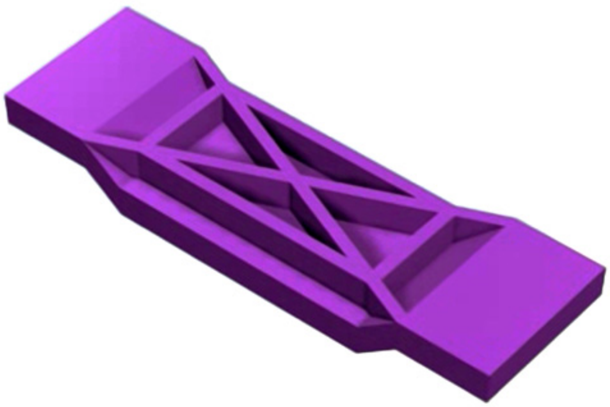
In many cases, thin gates freeze too early, preventing adequate material flow before the gate freezes off. It is also more difficult to pack out thick sections when the gate is located at a thinner section of the part.

When the part thickness is even, cooling lines should be evenly placed across the part cavity. Additional cooling should be placed in thick sections and areas where complex part features are present.

Smooth transitions from thin to thick sections should be used whenever possible to promote better dimensional stability. Coring out thick sections and adding strengthening ribs can also be a great method of avoiding part warpage.

Fillets and chamfers should be added to sharp corners to reduce stress concentrations. Gussets and strengthening ribs can also provide dimensional stability in these areas.





Gating into thick sections of the part will often improve the molder's ability to properly pack out the part. Increasing the size and number the gates used may also improve overall dimensional stability.