STRESS RELIEF: UTILIZE READILY AVAILABLE TOOLS TO REDUCE STRESS IN YOUR PARTS (AND YOUR LIFE)

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OVERVIEW

Stress is a constant problem with injection molded parts. Whether it is a part that has warpage right out of the mold (Figure 1) or one that cracks in transit, it is a concern that continually faces molders and engineers.

Gas-assist injection molding is often not thought about for solving these problems. In fact, the gas-assist process automatically corrects many of the problems that cause molded-in stress (Figure 2).

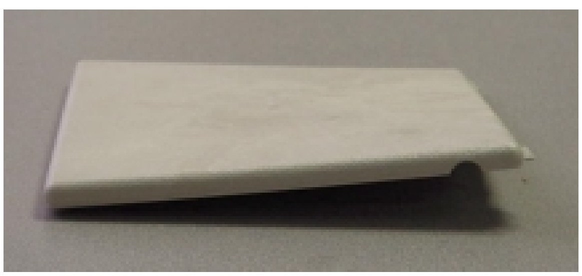

Figure 1: Part Molded Conventionally

Figure 2: Part Molded with Gas-Assist

Gas-assist finite element analysis aids in designing a low stress part and is useful in proving the benefits of the gas-assist process.

WHAT IS STRESS?

We often think of stress as a problem in terms of the in-use loading of a part. Virtually all molded parts will be stressed in use but more importantly – and to the point of this paper – they may also be highly stressed in the molding process. This manufacturing “pre-stress” can significantly affect the performance of the part. Often the structure of the part is sufficient to overcome molded-in stress when the part first comes out of the mold only to warp or crack over time or at elevated temperatures.

When a force is applied to a part it causes stresses that can be measured in pounds per square inch (PSI). If the stress is low enough then the effects may not be evident. However, if the stresses are high, maximum values for the material may be exceeded resulting in defects or in the worst case, breakage.

Many molding parameters will cause differential shrinkage and the resultant molded-in stress. Taken together they can add up to large pre-stress in the part.

GAS-ASSIST ANALYSIS

The list of potential causes of molded-in stress is almost as long as the number of measurable molding parameters. Fortunately, gas-assist analysis is able to provide visual and numerical results that allow us to design away the root causes of these stresses.

All of the following parameters have two things in common: using the gas-assist process will reduce them and they can be predicted with gas-assist analysis.

Melt-front problems
Excessive injection pressure
High Shear Stress
High packing pressure
Differential packing pressure
Hot spots and differential cooling

A 12” by 12” by .125” thick panel molded in GE Valox is compared below. For each pair of images the conventionally molded image is shown first and the gas-assist version is shown next.

Improved Melt-front Advancement

If the part design allows for large flow leaders, otherwise known as in-part runners, a much more robust molding process window will result. These flow leaders become gas channels as gas is introduced to the part.

Gas channels can often be added in inconspicuous areas such as at the base of ribs or at wall intersections. Unlike conventional flow leaders that often cannot be made large enough to significantly enhance flow, gas channels are commonly 2-3 times the nominal wall thickness.

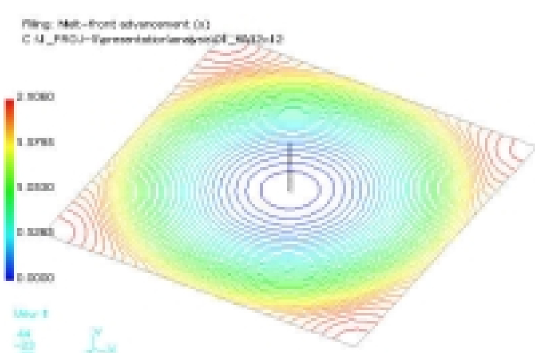

Figure 3: Conventional Melt-Front Advancement

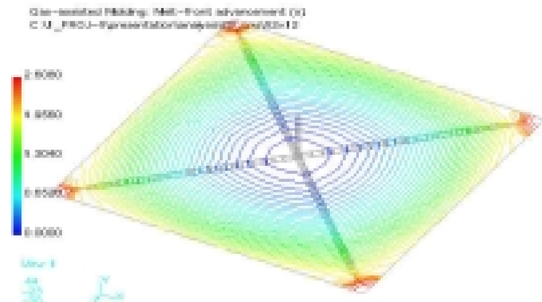

Figure 4: Gas-Assist Melt-Front Advancement

Figures 3 and 4 compare the melt-front advancement with and without gas.

For larger parts, the thicker gas channels often improve the melt-front pattern as seen by the enhanced flow to the corners of the part.

Gas-assist can also reduce the number of gates thus reducing the number of weld lines (Figure 5). This part was originally designed with multiple gates. With gas-assist it was filled with a single gate.

Figure 5: Gas-Assist Reduces the Number of Gates

With fewer gates the melt-front pattern also tends to be much more uniform. This is also a factor for filled materials where fiber distribution and orientation dimensionally affect the part.

Reduced Filling Pressure

During filling, the injection pressure is reduced in several ways. First, the flow leaders provide a path with less resistance. For this panel, the maximum injection pressures were 10,600 psi conventionally and 7960 psi with gas. Second, the gas can be used to complete filling of the cavity.

Peak injection pressures and maximum projected area occur at the end of filling (Figure 6).

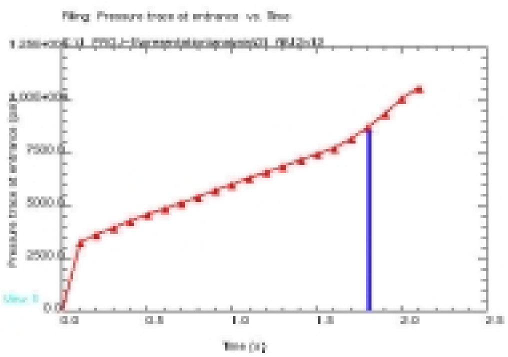

Figure 6: Maximum Pressure versus Time

With gas-assist, the shot size can be decreased which reduces pressure and projected area. With gas-assist, resin injection stops at the vertical line shown on Figure 6.

This panel was filled with a 97% short shot. The projected area was reduced since less of the part was filled with resin. Clamp tonnage is a product of injection pressure and projected area. Filling is completed with gas pressure often in the range of 25% of the maximum resin injection pressure. In this case, 2000 psi of gas pressure was used to complete the fill and for the packing phase. This had a dramatic effect on clamp tonnage reducing it from 325 tons to 150 tons.

<u>Decreased Shear Stress</u>

High shear stress results in greater polymer chain orientation. This can affect surface finish and increase shrinkage that may lead to warpage. By providing an easier flow path, gas-assist reduces shear stress in the part. This output is available directly from the analysis and can be compared against maximum recommended values. Figures 7 and 8 compare the shear stress.

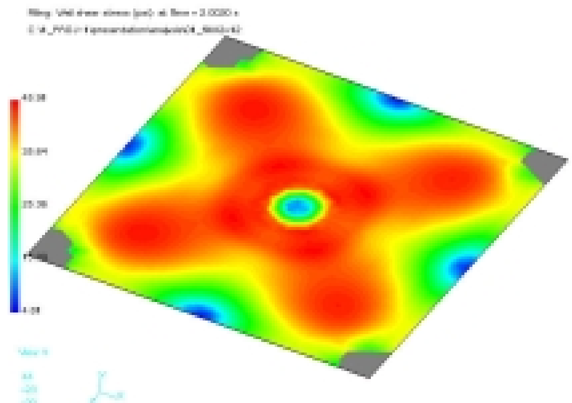

Figure 7: Conventional Shear Stress

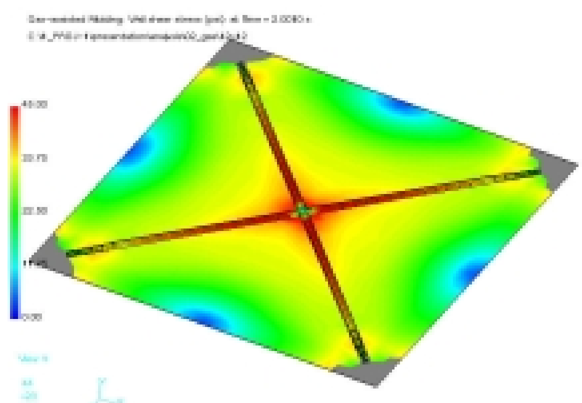

Figure 8: Gas-Assist Shear Stress

<u>Reduced and More Uniform Packing Pressure</u>

For a conventionally molded part there is often a wide distribution of packing pressure in the part (Figure 9). Pressure that might be required to pack difficult features can actually lead to over-packing others. With conventional molding it is common to use packing pressures of 80% of the maximum injection pressure. With gas, the pressure is often in the range of 25% of the maximum resin injection pressure.

Gas injection can start before the end of filling or during post-filling. As the gas enters the part it seeks the path of least resistance. Gas will hollow out thick regions and advance towards the last place to fill. In doing so, the gas forms a pressure manifold in the part that decreases the distance between where the packing pressure is applied and where it is required. Compare the distances shown on Figures 9 and 10.

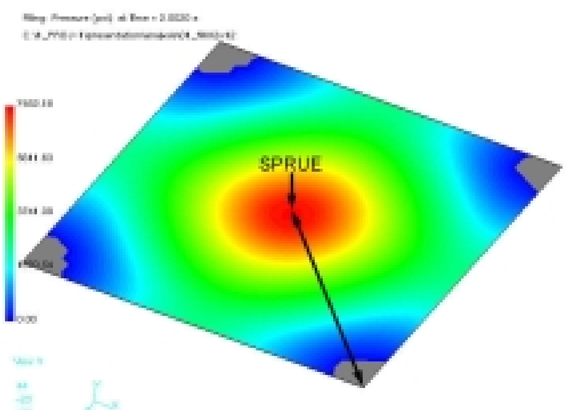

Figure 9: Conventional Pressure During Packing

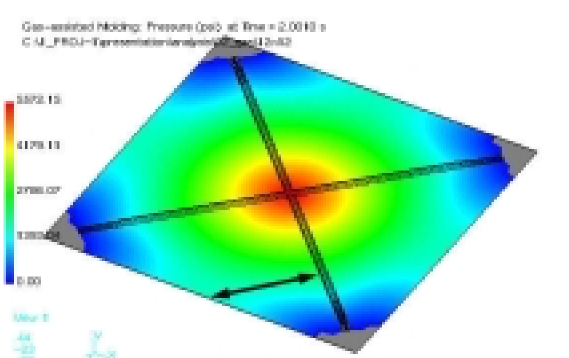

Figure 10: Gas-Assist Pressure During Packing

With a solid part the only packing path is through the resin. As soon as critical areas of the part freeze packing is no longer possible. With gas-assist, areas of the part between the gas inlet and area to be packed *can be frozen yet packing is still possible* because the path may be through the gas.

With gas-assist lower packing pressure is required, the distances are shorter, and it is possible to pack across thinner areas of the part for a longer time.

The coring and packing which result from gas-assist will also eliminate sink marks in thicker sections.

<u>More Uniform Temperatures</u>

Often a gas-assist part can be filled faster than the same part without gas-assist. The time difference, especially on a large part, can make a large difference with the temperature differences in the part at the end of filling. Hotter areas of the part will have greater shrinkage. Cooler areas of a conventionally molded part may impede packing. The gas channels often feed the entire part more uniformly resulting in more uniform temperatures at the end of filling.

Gas-assist analysis can include the actual cooling layout for the tool. This allows comparison of different layouts as well as prediction of cycle time.

Gas-assist will hollow heavy sections of a part. This will decrease hot spots and cooling time. The heavy sections are not only cooled from the outside but they are also cored via the gas on the inside of hollowed areas.

SUMMARY

Molded-in stress can cause numerous problems with an injection molded part. The effects of molding problems that cause differential shrinkage are cumulative and can ultimately lead to poor quality parts.

Applied to the proper parts, these problems are corrected when using the gas-assist process.

Gas-assist analysis accurately evaluates the root cause of these problems and assists in designing and proving the benefits of the process.