



**GAS ASSIST
INJECTION MOLDING**

THE GAS ASSIST PROCESS

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THE PROCESS OF GAS ASSIST

Gas assist injection molding is a process enhancement to conventional injection molding, involving the injection of high-pressure nitrogen gas into the melt stream immediately after the injection of the resin. The intent is not to cause mixture of the nitrogen and resin, but for the nitrogen to displace resin in flow or gas channels and thicker sections of the molded product. The process is a high speed, low-pressure injection method. In most cases, a short shot method of resin fill can be used and the gas can be utilized to fill and pack out the remainder of the part. The nitrogen is typically shot into the process at relatively low pressures as compared to conventional molding.

There are four primary considerations for successful application of the technology:

- 1) A repeatable and accurate shot control on the injection-molding machine.
- 2) Precise control of time, pressure, and ramp of the nitrogen being injected.
- 3) Control of the nitrogen penetration within the molded product.
- 4) Proper tool design.

It is important to note that the flow path that the nitrogen gas takes is primarily controlled by the resin flow in the cavity. Resin flow is often dictated by the volume and viscosity of the resin, and not by the nitrogen gas injection.

Gas assist injection molding is also a method of pressurizing an injection molded part as it cools. The pressurization of a molded part during cooling can be the most difficult phase of the injection molding process. With conventional injection molding, pack-and-hold pressure is achieved by forcing more resin through the gates or material feeds within a part. When the gates cool and freeze off, pressure can no longer be applied to the part and the cooling phase begins. With gas assist, pressurized nitrogen gas is used in place of pack pressure from the molding machine. This pressurized gas can be distributed evenly throughout the part and held inside during the entire cooling phase.

The nitrogen gas is introduced into the mold cavity either through gas pins in the mold or directly through the injection nozzle via the following sequence:

- A controlled short shot of resin is injected into the mold.
- Nitrogen gas is injected into the mold. The gas enters the part and completes the filling of the cavity, leaving a void.
- After the cavity is filled, pressure is evenly distributed throughout the part from the void created by the gas. The part begins to cool from both the inside and the outside surfaces.
- After the part has cooled sufficiently, the gas is vented to atmosphere, allowing the part to be demolded. The part may be vented either by sprue break or back through a gas pin.

Benefits

- ✓ Lower clamping force is needed.
- ✓ Cycle times are reduced.
- ✓ Less material is used to produce the part.
- ✓ Parts have greater strength and rigidity.
- ✓ Dimensional stability is improved.
- ✓ Molded-in stress is greatly reduced.
- ✓ Sink marks are eliminated.

In addition to the benefits listed above, you should also find that the gas assist process is easier to control than conventional injection molding. We hope to take some of the mystery out of gas assist injection molding for you, and think you will find that gas assist can help with some of the problems you face each day as a part designer or as an injection molder.

Clamp Tonnage Reduction

Because the cavity of the mold is rarely completely filled, gas assist is a technology that allows for a reduction in the clamp tonnage requirements of an injection molding machine. Even in cases of what is referred to as “full-shot gas assist molding,” there is a vacancy somewhere in the part that allows gas to penetrate, even if it is only to take up volumetric shrinkage within the cavity.

For instance, consider a part 12 x 12 inches square, having a nominal wall thickness of .100 inch and a center sprue. When this part is packed out conventionally, it is impossible to achieve high pack pressures to the extremities of the part. Higher pressures at the point of injection apply direct deflection against the platen of the molding machine. It is not uncommon for a processor to attempt to transfer pressure to these areas by increasing pack pressures and times.

With the gas assist process, the tool is partially filled with resin. Designed-in gas channels are directed from the resin entry point toward the last area of the part to fill. In the case of the 12 x 12 inch part, we know center gating leaves the corners as the last areas to fill. To overcome this problem, we configure a series of channels leading from the gate to the extremities of the part. These channels act first as resin-flow runners, then as gas channels.

This design will allow for easy, low-pressure filling of the cavity and easy packing because the gas pressure travels rapidly through these thicker sections. Tonnage requirements are lowered because the packing pressure, which is the gas pressure, is distributed over the entire mold surface. This is accomplished by designing the flow channels, or gas channels, toward the last area(s) of the part to fill.

The success of any gas assist projects is directly related to proper tool design. Without proper tool design, clamp tonnages cannot be reduced to the fullest extent. When gas assist design is implemented correctly, we have seen clamp tonnage reduced as much as 70 percent, compared to the tonnage required in conventional molding.

The calculation for clamp tonnage in conventional injection molding is approximately 3 tons per square inch. With gas assist molding, the formula is approximately 1 ton per square inch due to pressure reduction within the mold cavity and a greater area of pressure deflection.

To understand better how clamp tonnage is reduced, we determine the short shot or resin dose to be used and introduce it to the process. We do this by taking the feed stroke to zero position, or bottom, every time. As long as the screw and barrel are within specified tolerance, the dosage of resin should remain equal every time.

It should be noted that most mold spread or flashing conditions occur when the cavity is filled and packing pressures are applied. With the gas assist process, the mold is not completely filled during the resin injection phase. A relatively low gas pressure replaces the extremely high packing pressure required in conventional molding. As a result, flashing is minimal.

Gas is introduced and follows the thick areas of the part easily, forcing the still-molten resin residing in the channels or thick sections to complete the fill. The gas is then held under pressure in these channels and performs a more efficient packing than conventional injection molding, because it is distributed evenly over the entire part surface.

When clamp tonnage is reduced, significant cost savings are realized. For example, if you are molding at capacity on a certain machine size in your plant, but have excess capacity on a smaller machine, you may be able to run a mold in the smaller press and reduce production costs. It is also possible to quote jobs that are beyond your current clamp tonnage capacity. It is not uncommon for gas assist molders to place tools that would normally run in a 1500-ton press into a 700-ton press.

Tool size is usually a limiting issue due to tiebar clearances. Think of being at capacity in your single 1500-ton press when your largest customer awards you another 1500-ton job. You can purchase a new press, juggle capacity schedules, or work more days per week, or you can use gas assist and employ your 1000- or 700-ton press with the open capacity. When you consider just the reduction in clamp tonnage, the cost of gas assist equipment is easy to justify. With gas assist, you have the potential to save a great deal of money by eliminating the purchase of a new molding machine and all its peripherals.

Cycle Time Reduction

Another important benefit that gas assist technology offers is cycle time reduction. Any time you can make a high-quality product faster you reduce capacity, thereby reducing production costs.

Cycle times can be reduced because the initial pack and hold times of your process are eliminated. It is also not uncommon for cooling time to be reduced because screw recovery occurs immediately after resin injection. Cooling occurs inside as well as outside the part, due to the void in the part created by the displacement of resin within the gas channel or thick areas of the part.

Thick walled parts are natural candidates for reductions in cycle times. The short-shot process reduces the amount of resin introduced to the mold. Gas travels easily through these thick walls. As it travels through the part, it extends the flow of resin, completing the fill, while evacuating resin from the thick areas. Absent the mass of material in areas of the part that would usually require additional cooling time, the cycle time is reduced. Using gas assist, cycle times of some thick-walled parts have been reduced by more than 50 percent.

When the amount of material is reduced, less time is required to cool the part internally, so stresses are at a minimum. When the tool is designed properly, gas occupies and pressurizes the part equally. A part made by gas assist may come out of the tool warmer to the touch than usual, but because of the reduction in stresses warpage is eliminated.

Resin Savings

With the cost of resins today, especially of engineered grades, who wouldn't like to reduce the weight of the parts they produce?

Most people think of thick parts as the only candidates for gas assist. As mentioned before, handles and similar parts are natural candidates for the process and offer more than 50 percent weight reduction in some cases. However, significant resin savings are possible in thin-walled parts as well.

Gas assist also plays a direct role in part-weight savings in the conversion of current tools. Structural foam tools are usually natural conversions. The main factor in reducing weight is that the part cavity is never completely filled. Whether you can save 2g or 200g per shot, the net result is a savings in material usage.

A major contributor to resin savings is scrap reduction. With proper tool design, gas assist allows scrap-free startups and production runs. The process is precisely controlled and the processing window is increased. Another commonly overlooked aspect of resin savings is excessive purging. Many times in conventional molding (even structural foam molding), the process is not easily repeatable upon startup. Molders often become frustrated with the startup process, run scrap, and then are forced to purge the machine.

Another common occurrence in startups that causes substantial downtime is the need to remove resin stuck in the tool around deep ribs and bosses. To prevent permanent damage, the tool often must be taken out of the press for the plastic to be removed properly. At that point, the machine must be purged again.

Gas assist tool startup procedures usually require only filling the barrel of the molding machine with resin, and then starting the cycle.

Quality Improvements

A conventional tool's design often limits the quality of the finished product. On products having certain dimensional criteria and appearance requirements, gas assist technology can improve quality dramatically.

More and more new designs have reduced nominal wall thicknesses and increased boss and mounting configurations. This typically results in added stresses and shrinkage, which can cause surface defects and imperfections. For example, a thin-walled part with heavy bosses usually experiences sinking. Properly applied, gas assist can make a noticeable improvement on the same product. In the case of a compact cover, sink marks were eliminated from the surface of the part.

Dimensional stability is also more difficult to achieve in some of today's designs. The tolerances for post-mold measuring are tighter and more crucial than in the past. Parts that come out of the mold at one dimension tend to shrink to a lesser dimension over time. This causes processors to face tighter processing windows and control methods.

As a molded product cools, it tends to shrink. This is a natural reaction of plastic. The molecular structure of the resin usually determines the amount of shrinkage. Using gas assist, the mold is never completely filled; gas pressure and time complete the fill. The part is uniformly packed out, eliminating the differentials of pressure within the cavity, which promotes a large reduction in postmold shrinkage and warpage. The evenly applied gas pressure can help eliminate many of the problems inherent to conventional injection molding.

For many years, the television industry has depended on gas assist to improve surface aesthetics while improving the strengths of CRT mounting bosses and ribbing. In the past, it was necessary for manufacturers to avoid designing ribs and boss features on nominal walls less than .200 inch to prevent stress and sinking conditions. As a result, secondary operations were required to attach these mounting features to a television cabinet. The attachment of these subcomponents led to weakness after the CRT was installed. Weakness meant possible failure in the field, which was unacceptable.

With gas assist, designers have been given the freedom to attach large bosses and ribs to the back side of the nominal wall. Typically, the design used is a gas channel that runs from the gate on top of the panel in both directions toward the bottom, or pan, of the cabinet. This channel connects and intersects heavy wall sections. When gas is applied it pressurized the areas, leaving a defect-free surface.

Many designers have applied this example. By designing a specific part for gas assist technology, they can add robust configurations to a product and overcome conventional injection molding defects.

Design Freedoms

The freedom gas assist technology offers a product designer may be difficult to measure but can certainly be appreciated. Heavy wall sections can intersect thinner ones, and secondary operations and mechanical movements used for coring can be eliminated. Hollow sections can be created in a part of virtually any size. In fact, hollow sections as small as 1 mm and as large as 3 inches have successfully been produced.

Another benefit gas assist can offer a designer is the possible elimination of a hot runner system. When the runner system is designed within the part, the added expense and complications associated with hot manifold systems are gone. Weld lines on the surface of a finished part are also eliminated.

All of these items are beneficial when designers are faced with reduced lead times and other time constraints. The critical path shifts from tool-design-engineering changes to tool delivery dates being met. Lead times for tools, and excessive tryout costs, can be greatly reduced with gas assist.

The design engineer now has a new option, and issues of previous concern often can be avoided. Secondary operations such as welding, painting, gluing, and locating a vendor to supply components can be reduced or eliminated.

Processing Using Gas Assist

Conventional molding process:

1. The mold closes.
2. Resin is injected, the cavity is filled, and a cushion is maintained.
3. Pack and holding pressure is applied by forcing molten resin into the gates.
4. Gates freeze off, and pressure can no longer be applied.
5. The screw returns for the next shot.
6. The part cools.
7. The mold opens.
8. The part is removed.

Gas assist molding process:

1. The mold closes.
2. A precise shot of resin is injected; the screw is usually bottomed out.
3. Gas is introduced at controlled pressure; the screw returns for next shot.
4. Gas pressure is held in the part for entire cooling phase.
5. Gas is vented from the part.
6. The mold is opened.
7. The part is removed.

Processing guidelines for gas assist

- Always use the least possible amount of resin.
- Always use the least possible amount of gas pressure.
- Always use a little gas injection time as possible.
- When starting a tool, a short shot is a recommended startup parameter.
- Ensure the gas pin is clear before starting a tool.
- Ensure the gas pin is clear after a production run is completed.
- Ensure the gas fitting is clear when using nozzle injection. Prior to starting up a tool, allow for appropriate soak time on the nozzle to reach desired temperature.

Processing guidelines for gas assist (continued)

- Part weight may be used as an accurate method of determining process stability.
- When using nitrogen cylinders as the gas supply, the use of a regulator is recommended. This will allow for accurate nitrogen supply for the process.
- When injecting gas through the machine nozzle, sprue break must be used to vent gas from the tool. Holding the barrel forward the longest possible time before the mold opens is highly recommended. Sprue break must occur prior to mold open.
- Balance of multicavity tool is crucial. Mold orientation is also important.
- Gas will always take the path of least resistance. If gas blowout occurs, resin dosage is insufficient or gas injection pressure is possibly too high.
- Gas will typically perform its function in 4 to 6 seconds. In poorly designed tools or conversion applications, more gas injection time may be necessary.
- NEVER ATTEMPT TO CHECK GAS FLOW BY PLACING ANY PART OF YOUR BODY IN FRONT OF THE GAS INJECTION STREAM.
- In some cases, gas can be used to take up volumetric shrinkage, thus eliminating sinks.
- A basic principle to remember is that gas assist improves a molding machine's capability. When a tool is designed for gas assist using channeling, gas pressure can pack out areas of a part that cannot be pressurized in conventional molding.
- The typical formula used for determining clamp tonnage requirements in conventional molding is 3 tons of clamping force per square inch of molding area. With a properly designed product using gas assist technology, the clamp tonnage requirement is reduced to 1 ton of clamping force per square inch.
- Mold startups become easier to perform because the gas assist process is based on a shot weight parameter. If machine parameters are documented from a previous run, they may be re-entered and an acceptable part should be realized on the second cycle after startup.

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