The *Fallacies of Injection Molding* as compared to MicroMolding.

*by Scott Herbert – Rapidwerks Inc.*

Over the years *MicroMolding* has become a hot bed for solutions to problems that have been plaguing companies for years. However there’s a fallacy that normal every day injection molding machines can mold micro-parts. They may try but there’s a price to pay!

As a MicroMolding Company we often see oversized machinery trying to injection mold micro-parts and are often asked to take tools that were fabricated for larger machines and try to incorporate them into a micro-molding systems. Which as you may know has a mixed bag of issues waiting to come out. The end result is unfortunate, a frustrated customer who is late on delivering product to market with a mixed set of problems to figure out.

A 30 ton machine attempting to mold a part that is micro in size presents a plethora of issues. Yet there are those who try to apply the same principles of injection molding to micro-sized parts. They fail and often don’t understand why. Typical symptoms are inconsistent part weights or short shots, yield issues, resonance problems, excessive material waste, parting line flash. All are serious problems and can be solved by Micro-molding.

There are complexities with both conventional injection molding and micro-molding. I respect knowing how much work goes into each for tooling and processing. However there are misconceptions as to the complexity and detail that needs to be addressed when creating a tool that produces a part half the size of a human hair. Yet most apply the 30 ton machine philosophy to the application and fail.

Below are two photos comparing shot weight, sprue/runner weight, part weight and cycle times. These photos clearly show differences based on the technology applied and truly will depict the savings in time and savings in money by not wasting material.

**Photos provided by: Wittmann Battenfeld Inc.**

<table>
<thead>
<tr>
<th>Conventional molding</th>
<th>Microsystem Micromolding (Rapidwerks Inc.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shot weight 0.230 g</td>
<td>Shot weight 0.109 g</td>
</tr>
<tr>
<td>Sprue/runner weight 0.165 g</td>
<td>Sprue/runner weight 0.044</td>
</tr>
<tr>
<td>Part weight 0.017g</td>
<td>Part weight 0.017g</td>
</tr>
<tr>
<td>Cycle time 6.3 s</td>
<td>Cycle time 2.7 s</td>
</tr>
</tbody>
</table>
Designing a micro-tool can be broken into four different categories for discussion. First: tool design and simulation or “Mold Flow”, second: tool fabrication, third: tool assembly, and fourth: test shots.

Tool Design: once a tool is complete simulation will help you understand material flow in your particular tool design and part. This may aid in such a way that you will identify problems before tool fabrication occurs, such as potential voids, sink marks, gate sizing to small freezing off prematurely or even incomplete filling of the cavity. Any of these issues will affect your part quality and dimensions. Some design software may provide condensed versions of this technology however are limited in options i.e.: Rheology data for specific materials, gate size options, material types, location of gate, cooling and or heating of tool. This will certainly aid in the successful creation of a tool that is near perfect before you cut steel.

Fabricating your tool using conventional machining practices such as machining centers, mills, lathes, grinders, wire-edm, and sinker edm technology is good and in most applications sufficient.

Some applications require an alternate process to be used, such as when the resolution of the edm is not fine enough to capture the fine detail of a cavity feature. In this case other options might be: laser, x-ray lithography, electroplating, silicon etching and photolithography. All are acceptable means of creating fine detail for your cavity geometry.

For the purposes of this article I will attempt to put some frame work around the general definition of micro-molding and small part molding.

- Micro-molding part weight could be .001 gram or the part size of .075 diameter or smaller. Requiring specialized machines for molding, specialized tooling, and custom part handling for part extraction and part packaging.
- A small part might be part weight of .1 g to 1.5 g or .250 diameter or larger, these are produced using a conventional molding machine and standard tooling practices with common part ejection and handling.

Typical concerns of injection molding a micro part with an incorrect machine are material plasticizing or plastification, and melt homogenization. This can be due to a number of issues, the first issue which may be glaring is the part and runner are sized (so small) such that the screw of the molding machine might not have enough material to move (rotate screw) before it has to switch over from injection to holding.
In many cases where this occurs the screw may move as little as .010 inch then switch from injection over to holding. This is very typical when using a large tonnage machine to mold a micro-part. When this occurs the next few shots typically are good then the tool could possibly flash and the process starts all over. This is evidence of an inconsistent process due to using the incorrect machine for the application.

Most solve the problem by making the runner diameter large enough to allow the machine to control the dosing or shot size (rotate screw). This is one solution that does work however it is not ideal and is extremely costly to the customer. Additionally it does not solve the residence problem that occurs due to excess material sitting idle in the screw. It does however allow the machine to function and mold continuously.

The issue surrounding processing and residence of material would be non existent for a micro-molder as they are well equipped to control small amounts of material while being very sensitive to shot size, runner size and resonance time. This becomes more of an issue when utilizing engineering materials that costs hundreds of thousands of dollars per kg. Implantable, absorbable or resorbable materials can not withstand the exposure to heat nor can your customer afford the material waste.

Additionally properly controlling the correct amount of material to be injected into the cavity all while holding extremely tight or close tolerances is a big problem. Inconsistent shot sizes (reproducibility), material freezing due to extremely small mass, material degradation, melt homogenization and static electricity issues all play a serious role in producing a quality part.

Conventional Molding System
- Long Runner  60:1 Runner / Part
- High Resonance Time
- Un-needed material costs
- Longer Cycle Times

Micro-Molding System
- Shortest Runner Possible 6:1 Runner / Part
- Low Resonance Time
- Minimal Runner Loss
- Short Cycle Times

Diagram provided by: Wittmann Battenfeld Inc.
Standard Injection Molding as compared to Micro- Molding show many clear reasons to move towards a micro-molder, especially when considering large volume runs where material costs and cycle times are extremely important. In many situations where a high volume part is being considered typically the material savings alone justifies the new tool expenditures.

Different approaches produce micro parts

<table>
<thead>
<tr>
<th>Standard Injection Technology</th>
<th>Micro Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slow process</td>
<td>High dynamic process</td>
</tr>
<tr>
<td>Large molds</td>
<td>Optimized mold technology</td>
</tr>
<tr>
<td>Large sprues</td>
<td>Small sprues</td>
</tr>
<tr>
<td>High energy consumption</td>
<td>Efficient energy consumption</td>
</tr>
<tr>
<td>Part free falling</td>
<td>Integrated part handling</td>
</tr>
<tr>
<td>Quality check afterwards</td>
<td>Automatic quality assurance</td>
</tr>
<tr>
<td>Peripheral technology oversized</td>
<td>Adjust peripheral technology</td>
</tr>
</tbody>
</table>

If you have a micro-sized part and truly compare the difference of standard injection molding and micro-molding the benefits will be clear and the path to good quality competitive parts will be realized.

In some situations we have seen the cost savings in material usage easily justifying the cost expenditures to re-tool if you already have a tool created for a larger system.
A Comparison of standard Injection Molding and Micro-Molding show a significant savings in raw material in addition to cycle times in most cases reviewed it is nearly ½ for micro-molding.

The diagrams below shows significant part to runner ratio for that of a standard machine, which shows increased costs to manufacture. Increase cycles times for processing, increased material usage due to process as compared to a micro-molding system.

**Single step system Standard technology – down scaled technology**

Thermal separation of sprue and melt cushion, creates each cycle a cold material slug at on the nozzle tip (Material Waste)

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Runner Waste typically 60:1 as compared to micro-molding at 6:1 Large material savings is realized.

- Large melt cushion
- Cold material slug on the nozzle
- Long flow length
- 1 mg shot weight needs 0.0056 mm stroke on a 14 mm screw
- Difficult to control small shot weight
The diagram below shows significant part to runner ratio reduction as compared to standard injection molding. Thus savings are realized from a material usage point of view, in addition cycle times are typically ½ of standard injection molding.

**Micro-Molding System-**

Small Part to Runner Ratio: Minimal Material Loss

No excess cold slug waste

Process Advantages:

- Tooling lower number of cavities required
- Material savings (Part to runner ratio very low)
- Very small melt cushion
- No cold material slug
- Very short flow length
- Short Cycle Times
- Low Resonance (great for implantable materials)
Summary,

In this article I’ve tried to point out some of the fallacies of injection molding as it compares to micro-molding.

We’ve learned when considering a micro-part to be molded there is more to it than meets the eye. If you choose to use a molding company who proposes an over sized machine to mold a micro-part there are many inherent issues that can be costly. Which can create process problems and part issues resulting in thousands of dollars lost, they range from inconsistent shot size to degradation of material to excessive flashing of the tool ultimately a process which won’t work.

Additionally we’ve learned there is a cost associated with using the wrong machine. A significant difference in tooling, material usage, part handling and cycle times all which add costs to the part.

If you have a micro-sized part the right molding company is critical, select one who’s “core” business is micro-molding. Ask questions, they will be happy to help you and educate you on there craft and technology. I know we do!

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