"Insert Micro Molding and Micro Over Molding for Medical and Electronic Micro Devices"

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Abstract

Micro Molding parts are defined as fractions of a plastic pellet, weight fractions of a gram, have tolerances with micron feature sizes and/or tolerances. Assembling micro devices onto other micro sized components or larger components requires high speed automation and/or tedious microscope assembly operations. This paper explores the method of insert micro molding and micro over molding and some challenges overcome to create minimally invasive surgical instruments and micro electronic devices.

Combining micro components in either metal to plastic or plastic to plastic can be challenging due to the size constraints of the components. Part handling, part degating, and joining strength methods of insert micro molded components will be explored and compared to other assembly alternatives.

Introduction

Miniaturization is important in the development of both medical devices and electronic components. The miniaturization of medical devices allows for minimally invasive or non-invasive procedures resulting in; increase in accessibility, improved ease of use, improved ease of delivery, reduced trauma, increased comfort, improved patient compliance with improved outcomes. As a result of miniaturization of medical devices, minimally invasive or non-invasive procedures can be performed on an outpatient basis or in the physician's office. This practice will benefit patients and healthcare providers worldwide as an effective means to control health care costs.

Miniaturization of electronic devices has been commonplace for decades. The miniaturization of electronic devices allows for the development of light weight and space saving technology used in cellular phones, personal electronic devices, and opto-electrical surgical instruments. As a result of the miniaturization of electronic devices, cost effective, disposable, and new technological advances are being made across many markets such as medical, aerospace, and industrial applications that use electricity to power them.

Micro molding is a manufacturing process that enables the creation of micro features and micro components. The development of specialized micro molding machines provides increased injection pressure and injection speed while keeping material residence times to a minimum. This advanced equipment technology has enhanced the ability to manufacture smaller, less invasive, and thinner walled devices.

Polymer material manufacturers publish material property data sheets based upon testing using macro molded samples in accordance with ASTM testing practices. While the data is useful for macro applications, a disconnect occurs as the data is extrapolated for thin walled micro molding applications.

Introduction (continued)

Since there is no accurate database of testing results, each new micro application requires experimentation to determine the limits of what is possible. There are little known and/or available or shared application libraries for micro molding applications. Accurately predicting material flow for micro molding applications is not readily available by mold flow analysis experts. Figure 1 shows a known consecutive mold fill. Mold flow analysis is done to determine how the polymer will flow through the mold using a mathematical mesh. In the case of micro molded components, the mesh has not been fully developed. As a result, a customized flow analysis was completed and the results in Figure 2 show the theoretical flow path which matches the actual flow path. Theory and practice can now be repeated on similar micro molded parts. This analysis works works as a preventive measure to predict micro mold flow in micro molds.

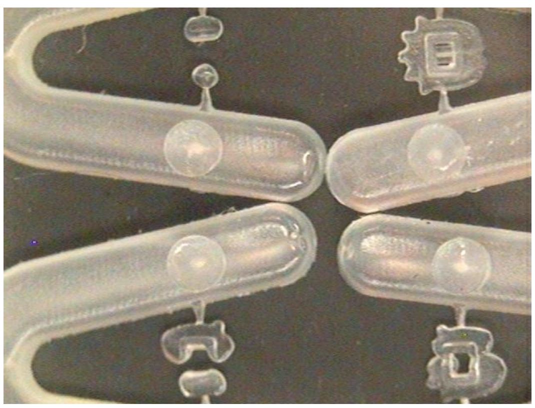

Figure 1

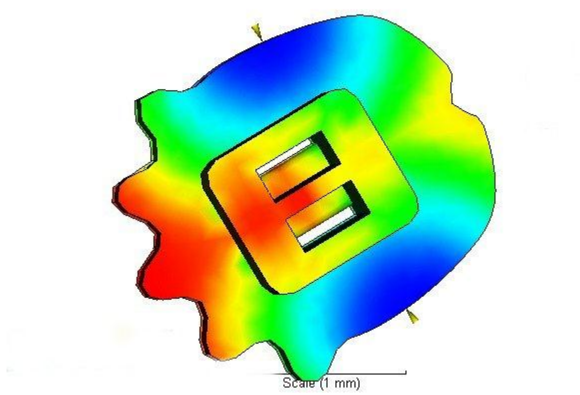

Figure 2

Since the flow property has not been accurately predicted then many of the other mechanical properties supplied in the material specification data sheets may not be useful for micro molding applications as well. This has been demonstrated numerous times with the successfully manufacturing of micro devices that are significantly smaller and thinner than the material manufacturers' databases predicted possible.

Introduction (continued)

A new series of standards, specifically designed for "micro" samples allow for the accurate prediction of material properties and accelerate the design and manufacture of thin- walled micro injection molded products for numerous commercial applications.

Another stumbling block for micro molding and miniaturization is through the addition of metal inserts and/or unlike materials in over molding or insert molding. With this added element, the insert of over mold most often times adds a flow splitter creating even thinner walls and/or an anomaly in the flow path.

Theory & Definitions

What defines a Micro Molded Component?

Although there is no standard definition of micromolded components, most define it in one or more of these attributes:

•Fractions of a plastic pellet

•Weighing fractions of a gram

•Having wall thickness of less than .005"(0.127mm)

•Tolerances of .0001" to .0002" (0.0025 to .0050mm)

•Having geometry seen only by the use of a microscope

In many micro molded applications, a combination of these attributes is employed.

Insert/Over Molded Component:

Insert or over molded components are defined of any metallic or polymer component that is inserted into an injection mold to produce a newly molded and integrated component. Improve adhesion quality and reduce tedious microscopic assemblies by using automated multi-component micro-molding.

(Figure 3 shows some examples of insert/over molded micro components)

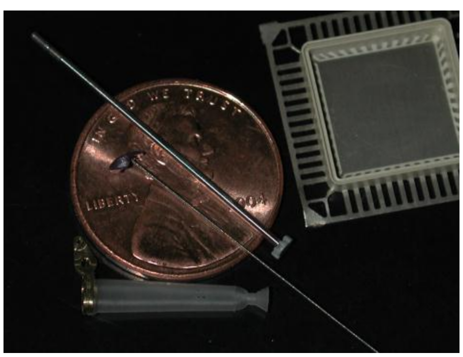

Figure 3

Technical Challenges

Thin-wall injection molding is a key technology for mass-producing complex medical, optical, portable electronic devices, automotive and life science devices with micro-scale features. However, thin-wall insert injection molding presents the following technical challenges:

(1) Process physics and material behavior are not fully understood under extreme processing conditions with high pressure and increased shear rates.

(2) Currently, commercial computer simulation tools fail to duplicate the experimental observations for thin-wall parts.

(3) Thin-wall parts have a more restrictive flow path compared to conventional injection molded parts which leads to a narrower processing window and reduced production yields.

(4) Thermal and material degradation induced by shear thinning may become significant during thin-wall molding. This results in a decrease in molecular weight and consequently, a loss in mechanical properties. [Table MW Distribution]

Injection molded parts have gates (Figure 4) that are at the point of entry from the mold into the actual part. The runner is the pathway that the polymer flows throughout the mold. Due to the small gate sizes (50-75 μ diameter), the polymer is subjected to a high level of shear stress. It is not uncommon to require injection pressures upwards of 30,000 Psi.

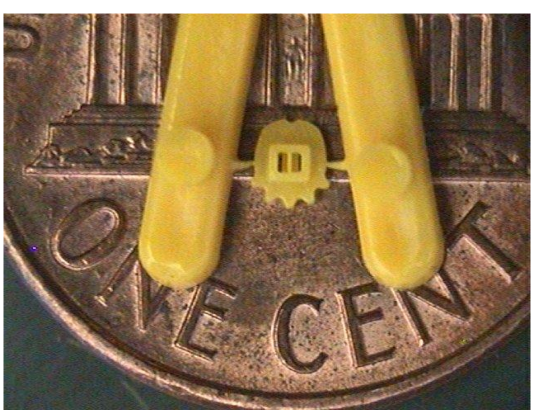

Figure 4

Technical Challenges (continued)

Figure 5 shows tiny micro molded filters have over [1000] 76 micron (0.003") squares with wall thicknesses of 0.006". These devices provide up to 36% open area for use in nylon and polypropylene filtration products.

Dispensing the smallest droplets of liquids is called "microfluidics". The current method of creating pre filters is done using a 7-8-step insert molding process which includes cutting, trimming, and insert molding the metal mesh and trimming and cutting as a post-molding process. Figure 6 shows a newly developed micro molding technology that addresses the multiple step process and replaces it with a one-step micro molding process. Dispensing through micro channels is used in biomedical, lab-on-a-chip, in-home testing blood analyzers.

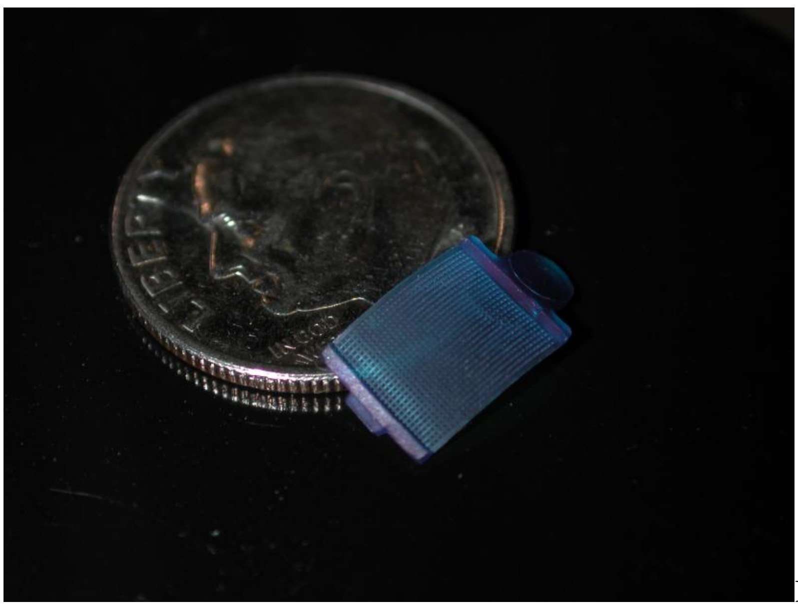
Figure 5

Technical Challenges (continued)

Part Handling

Miniaturized components require customized solutions to handle them. For example, sub-gated components that fall free from the injection molding machine require capturing devices or end of arm tooling as they work against gravity and static charges. Capturing these sub-gated components may require the following:

- Vacuum transport tubing to a clean, static-free container
- Deionized air wands to allow parts to gravity into conveyor containers
- Miniaturized end of arm tooling (grippers or suction devices) to pick some portion of the part out of the mold

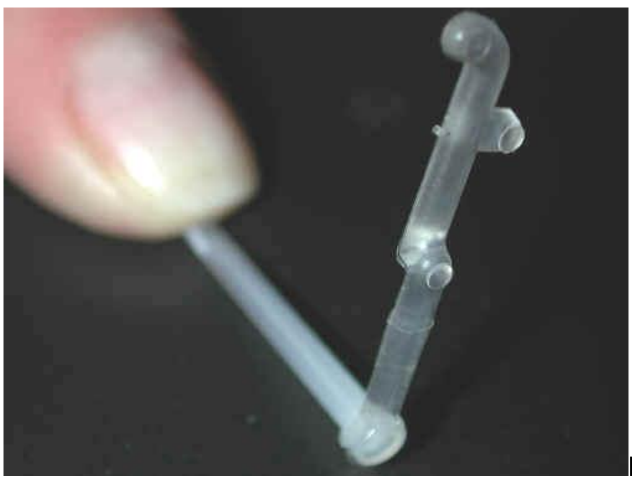

Figure 6

Degating

A large portion of micro molded components are created with edge-gates. The reason for this is that the runner and sprue can act as a positioning aid to assembly components to other assemblies downstream and then onto a final degating station. Degating is done in a variety of methods depending on part material, gate vestige allowance, and cycle time. Some of these methods are:

- Miniature hot knife cutting stations
- Ultrasonic degating stations
- Manual removal

Technical Challenges (continued)

During initial product development phases, design for manufacturability is an important step in brainstorming the gate removal. It may be determined that additional geometry is added to component to be removed at the last step. The successful implementation of miniaturized components relies on proper handling of the part throughout the process and using additional geometry to properly position micro molded components in micro assemblies. Figure 6 shows the use of runner and sprue geometry (steps, jumps in parting line, and added positioning aids that allow for ease of handling during assembly. These additions to the runner aid in assembly and part removal or degating at the very last step of the process prior to final packaging.

Pull Strength

Insert molded components must be tested for retention strength to insure the proper bond of the insert or overmolded components. A common method used in conventionally sized molded parts is a pull strength test using 5" long test specimens known as tensile bars. For micro molded parts, these parts are too large to simulate the pull strength of smaller components and new standards are being established with tensile bars that are 0.200" tall. Pull strength testing of actual micro insert molded components can be done using a similar test apparatus.