



Micro-MIM: 4 Best Practices for Precisely Making Micro Metal Parts

By Raghu Vadlamudi
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As medical devices become smaller, weighing less than a few milligrams, medical device manufacturers are increasingly switching from machining to micro-metal injection molding (micro-MIM). Think about parts like metal connectors in implantable pulse generators and gear pump components, as well as components for cardiac rhythm disease management, dental, ophthalmic, orthopedic, drug delivery, and the surgical ablation markets. Conventional machining cannot reliably maintain the extremely tight tolerances necessary to produce these components at high volumes with high quality. And, thanks to advances in technology, micro-MIM now can. These advances include:

- Finer particle sizes for material formulations make it easier to meet surface finish requirements;
- Improved molding and machining technologies allow micro-MIM to achieve tight tolerances and accuracy requirements; and
- Feedstock with smaller particle sizes enables micro-MIM to accurately create micro features.

Even though the initial investment costs are higher relative to other manufacturing processes, micro-MIM offers better accuracy, consistency and cost advantages for mass manufacturing. However, taking full advantage

of advanced micro-MIM capabilities to produce quality parts requires the following four critical areas or expertise.

1. Scientific process principles

A micro-MIM manufacturer must understand manufacturing process variability and the controls needed to minimize variation. The process needs to be developed using data to understand the relationships between process inputs (e.g., material, melt temperature, mold temperature, hold pressure) and process outputs (e.g., dimensions, surface finish) to create predictable manufacturing processes. This level of understanding of the MIM process helps minimize the risk of releasing non-conforming product into the field.

2. Materials

The feedstock composition determines the success of any micro-MIM project. Metal particle size distribution and binder type are important variables in determining the manufacturing cost and feasibility of consistent feature production.

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Keep in mind, material sourcing is often a challenge because of the limited number of material manufacturers for micro particle sizes in the United States. Selecting the right material for each part is critical. In some cases, a unique material may need to be developed to meet the performance and visual requirements of the component, which requires the expertise to identify needs and to work with material compounders to create the right material. If the correct material is not sourced, and if it doesn't meet the requirements or standards, the product produced will be inconsistent.

3. Equipment and technology

In addition to material control, equipment selection plays an important role in producing parts with minimal variation. With micro-MIM, a mold can be built to accommodate the features that require multiple machine tools. Once the mold is built, with little maintenance, you can produce hundreds of thousands of parts.

However, building molds for part sizes less than a millimeter can be challenging. It requires specialized machinery, innovative techniques, knowledge and experience in machining at the micro size. As such, a manufacturer should have the ability to identify the right size equipment to mold the micro

components, and the expertise in designing the manufacturing process as a whole system, considering downstream operations with the end requirements in mind.

4. Product requirements

Identifying the proper requirements for the product in terms of strength, surface finish, feature sizes and dimensional tolerances will help in selecting the correct feedstock, in addition to process parameters to mold, debind and sinter. Micro features demand specialized handling procedures through molding, debinding and sintering operations.

With the development of increasingly smaller medical devices comes the challenge of identifying the best manufacturing method to meet extremely tight tolerances. Millimeter-sized components with micron-sized features push the limits of traditional machining methods. As tolerances become tighter, machining is less consistent and costs increase. Thanks to technological advances, micro-MIM has become a highly efficient method for manufacturing micro parts with tight tolerances at high volumes and offers a reliable alternative for many parts that have historically been machined.

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About the author

Raghu Vadlamudi is our Chief Research and Technology Director. He has more than 25 years of experience in the medical device manufacturing industry managing process development groups, directing and coordinating process validation activities utilizing knowledge-based manufacturing practices. Raghu is an ASQ certified Medical Device Auditor, Certified Metal Cutting Professional, Certified Medical Device Compliance Professional, and a Certified Process Validation Professional.

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