Micro-MIM Succeeds At Making Precise Micro Metal Parts

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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.

Micro-metal injection molding (micro-MIM) is becoming a go-to process for micro metal parts. Due to technological advances, micro-MIM has become a highly efficient method for manufacturing micro parts with tight tolerances at high volumes.

Micro-MIM can be a viable manufacturing alternative for parts currently being machined such as: 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.

Traditional Machining Limitations

As components become smaller, weighing less than a few milligrams, the challenge with conventional machining is maintaining the extremely tight tolerances necessary to produce high-quality medical components efficiently at high volume.

Machining processes are unable to consistently produce micro features. Different types of cutting tools are needed to machine different features to produce a single part, and there may be a need to use more than one machine tool — making the manufacturing process expensive and inconsistent.

OEMs are increasingly switching from machining to micro-MIM in the medical device industry to manufacture smaller parts. Even though initial investment costs are high relative to other manufacturing processes, micro-MIM offers better accuracy, consistency, and cost advantages for mass manufacturing.

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. Thus, injection molding at high volume is much more economical and consistent than a machining operation.

Metal injection molding process flow diagram

- Feed Stock Preparation
- Injection Molding
- De-binding
- Sintering
- Finishing Operations

Advances In Micro-Metal Injection Molding

Micro-MIM is a traditional manufacturing method, but new capabilities are resulting from advances in technology. To understand why micro-MIM is now gaining attention for micro parts, consider some of the challenges that have been overcome:

Surface finish

The surface finish of the metal injection molded parts depends on the particle sizes and sintering conditions. It is important for the processor to understand the relationships between particle size distribution in the metal powder and the sintering temperatures to obtain the desired surface finish in micro parts.

With recent advances in material formulations with finer particle sizes, the surface finish can be improved. The surface finish can also be further improved by performing secondary operations such as electroplating after the molding.

Performance requirements

Another concern in the past was the differences in porosity of the material compared to machined materials. However, despite having more porosity, micro-MIM parts can meet the performance requirements of medical devices.

Furthermore, molding and machining technologies have improved, and mold-building has improved, all contributing to micro-MIM's ability to achieve tight tolerances and accuracy requirements.

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Feedstock improvements

Feedstocks are now being developed with much smaller particle sizes in the order of nanometers, enabling micro-MIM to accurately create micro features. The micro-MIM process is becoming more mainstream as more feedstock developers are investing in developing materials with finer particle size that are affordable in the manufacturing industry.

Considerations When Selecting A Micro-MIM Supplier

When considering micro-MIM suppliers, be aware of the critical capabilities needed to produce quality parts. Based on our work with medical device OEMs, we (Donatelle) identified four areas where micro-MIM suppliers can fail — causing delays, added costs, and often the need for a new supplier.

1. Using Scientific Principles to Develop Manufacturing Processes

Perhaps the most important consideration in choosing a micro-MIM supplier is finding one who understands manufacturing process variability and the controls needed to minimize the variation through the manufacturing process. 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 the MIM process helps minimize the risk of releasing non-conforming product into the field.

2. Materials Expertise

Materials play a critical role in the success of micro-MIM. Understanding 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.

Material sourcing is often a challenge because of the limited number of material manufacturers for micro particle size 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. This requires a supplier with 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.

Donatelle has developed proprietary materials to produce parts with specific requirements of corrosion resistance and electrical properties to mimic a commonly used material in the medical device industry.

3. Equipment and Technology Expertise

In addition to material control, equipment selection plays an important role in producing parts with minimal variation. With micro-MIM, building molds for part sizes less than a millimeter is a challenge. It requires specialized machinery, innovative techniques, knowledge, and experience in machining — at the micro size.

The supplier should not only have the ability to identify the right size equipment to mold the micro components, but the expertise in designing the manufacturing process as a whole system, considering downstream operations with the customer's end requirements in mind.

4. Understanding the 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.

Is Micro-MIM Right For You?

As medical devices continue to become smaller, conventional metal cutting processes are limited in producing micro features and meeting tight tolerances. If you have a high-volume product with tight tolerances or micro features, micro-MIM may be a solution. Even though the initial investment cost may be high, micro-MIM offers better accuracy, consistency, and cost advantages for high-volume manufacturing.

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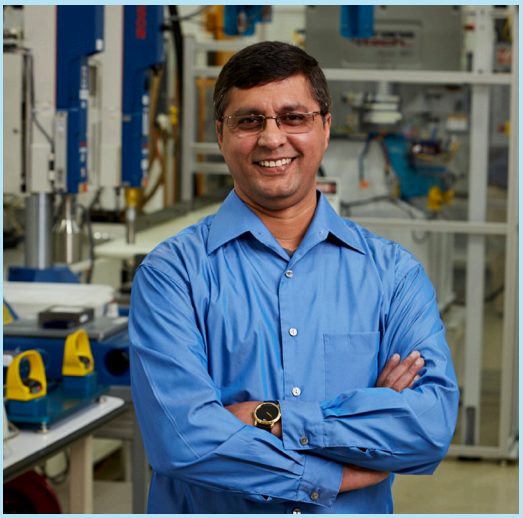

About the author

Raghu Vadlamudi is the Chief Research and Technology Director at Donatelle. 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.

About Donatelle Plastics Inc.

At Donatelle, we make products that enhance – and save – lives. We manufacture complex medical devices and components for low- and high-volume needs. That's all we do. And we do it with the utmost precision, consistency, and rigor, because for you – and your customers – **quality is essential. Reliability is a must. And delivering on what's promised is vital.**

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