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Micro MIM Europe GmbH

Talking About Powder — Even Now

Powder and Kneading: The Foundation of MIM Manufacturing

In English, the word “powder” covers everything, but in Japanese there are several terms such as kona, funtai, and funmatsu. MIM is officially referred to in JIS standards as Metal Injection Molding (MIM), and here we use the term powder.The powder we handle has an average particle size of 8 μm. In just 1 cm^3, there are approximately 3.7 billion particles, and a single 5 kg batch contains an astonishing 240 billion particles. When you consider that this is roughly 300 times the world’s population, the sheer scale is truly remarkable. In MIM, metal powder and resin powder are kneaded together—much like kneading flour when making udon noodles—to produce pellets for injection molding. The amount of resin used at this stage is a critical factor, as it directly affects material flowability, sinterability, and the final product’s dimensional accuracy. However, it is not only the formulation that matters; how uniformly the materials are mixed is equally important. Insufficient mixing can lead to voids after sintering, resulting in reduced quality. It is this careful attention to kneading—starting from a single particle of powder—that forms the very core of MIM manufacturing excellence.

Practical Aspects of Powder Evaluation

The basic MIM process involves heating and kneading metal powder and resin powder to form pellets, which are then injection molded to obtain the desired shape. In this process, evaluation focuses primarily on the properties of the metal powder rather than the resin, which does not remain in the final product. Powder evaluation can be broadly divided into static evaluation, such as particle shape and particle size distribution, and dynamic evaluation, which relates to how the powder behaves when mixed with resin and how this affects moldability. The main information available at the time of purchase includes chemical composition, particle size distribution (D50), and tap density. These parameters serve as indicators for predicting packing behavior and flowability. Particle size distribution is particularly important, and optical measurement using lasers is now the standard method. This technique requires only a very small sample—about 0.1 g—yet provides detailed distribution data quickly. However, questions remain as to whether such a small sample can truly represent powders purchased in 25 kg lots. Even so, it is not practical to inspect every particle using SEM, and in reality, manufacturing proceeds by trusting statistical distributions while continuing actual production.

Actual Resin Content in MIM

In Metal Injection Molding (MIM), it is ideal for the metal powder to be uniformly and thinly coated with resin powder. Therefore, the total surface area of the metal powder is an important factor in determining the required amount of resin. The BET method is the standard for calculating surface area, but a more practical approach on the production floor is the oil absorption measurement. This method is based on a JIS standard. A small amount of oil is gradually dropped onto the powder while kneading it with a spatula, and the total amount of oil added until the powder becomes completely paste-like is measured as the endpoint. During the test, the powder gradually forms clumps from its initial dry state, and just before the endpoint, a single drop of oil spreads over the entire powder, forming a glossy lump. This change allows an intuitive understanding that the powder surface has been uniformly wetted. In our experiments, we observed that the larger the average particle size of SUS powder, the lower the oil absorption, and different steel grades exhibited distinct behaviors. This reflects differences in powder shape and degree of agglomeration and provides useful insights for optimizing the amount of resin added. Although oil absorption is an analog method, it gives a tangible understanding that cannot be obtained from numbers alone and serves as an effective guideline for MIM manufacturing.

The Actual FS Evaluation

In evaluating feedstock (FS), which directly affects the moldability of MIM, flowability measurement using a melt indexer or capillograph is commonly employed. These methods indicate flow resistance under heating and pressure in terms of MFR or viscosity and are used to confirm the degree of mixing. However, they evaluate mass behavior at a macroscopic level and are insufficient for understanding micro-level phenomena, such as how well the metal powder is wetted by the binder resin. Therefore, we conducted a new approach using thermal conductivity and volume resistivity as evaluation parameters. First, for thermal conductivity, we focused on the differences in physical properties between metal and resin. Samples were extracted during the mixing process, formed into disks, and measured using the laser flash method. The results showed a significant increase from the initial stage to Step 2, followed by saturation, indicating that the two components had become uniformly mixed. Next, for volume resistivity, we utilized the difference in resistivity between metal and resin. Based on the hypothesis that if the metal powder is completely coated with resin, the system would approach insulating behavior, measurements were carried out. As mixing progressed, resistivity increased, enabling quantitative evaluation of the mixing degree. In particular, the volume resistivity method is simpler than the thermal conductivity method and shows strong potential as an effective evaluation technique in the future.