

PIM

Metal and ceramic powder injection molding

world of innovation



POWDER INJECTION MOLDING

A process for many different applications

Powder injection molding (abbreviated PIM) is a variant of plastic injection molding used to produce parts made of metal (MIM = metal injection molding) or made of ceramics (CIM = ceramic injection molding) with complex geometries.

Today, metallurgical powder injection molding is a cost-efficient mass production process to make small- to medium-sized parts ranging from 0.1 to about 300 g in weight. Main fields of application are precision apparatus engineering, measurement and control technology, medical technology, watch and household technologies, the lock and fittings industry, and the weapons industry.

The advantages

- » All metals can be processed, including aluminum, titanium and copper, as well as alloy steel and tungsten.
- » A wide range of ceramic materials can be processed, including oxide ceramics such as aluminum oxide or zirconium oxide, as well as non-oxide ceramics such as nitrides, carbides or borides.
- » Complex geometries can be produced without mechanical downstream finishing.
- » High precision and repeatability
- » High-quality surfaces possible without elaborate downstream finishing



Photo: Julius Blum GmbH

PROCESS TECHNOLOGY

Process chain under control

Wittmann

In close cooperation with a highly efficient network of partners, WITTMANN BATTENFELD provides advice and technical assistance across the entire process chain, from material preparation and processing all the way to downstream finishing.

» **Powder plus binder**

Superfine ceramic or metal powder is blended with a plastic binder system into an injection-moldable material compound (feedstock), and then granulated.

» **Injection molding**

The material compound is processed on injection molding machines with anti-wear-coated injection units. Here, geometries with similar complexities to those in plastic injection molding can be produced. The PIM injection-molded parts are known as green bodies.

» **Debinding**

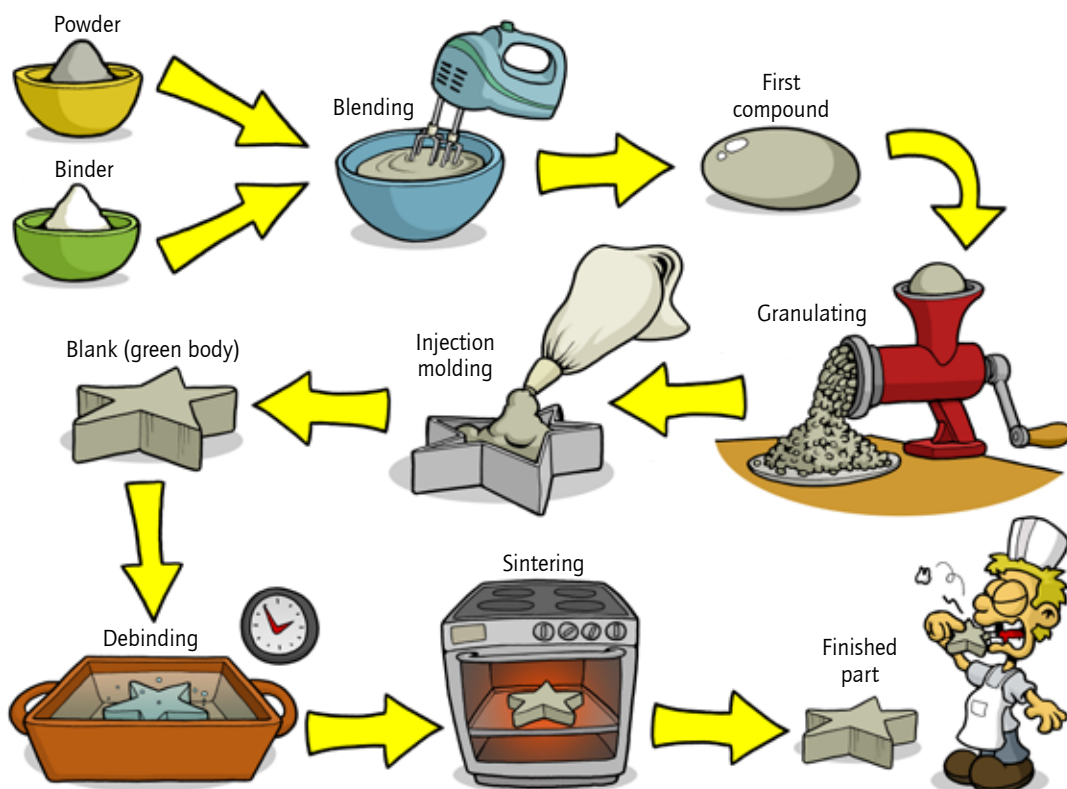
In the debinding process, the green body is transformed into a so-called brown body by dissolving the binder. Depending on the binder material, the dissolution is effected either by chemicals or thermally.

» **Sintering**

Following debinding, the brown body is compressed in a sintering furnace under a vacuum or shielding gas at temperatures from about 1300 °C (MIM) to 1700 °C (CIM). This reduces its volume by up to 30 %, depending on the material.

» **Downstream finishing**

Parts produced by powder injection molding stand out by their high surface quality and narrow dimensional tolerances. They require mechanical finishing only in special cases, and then primarily grinding or polishing.



MIM/CIM EQUIPMENT

The complete package ex-works



The material attributes of metal and ceramic powders require adequate adaptation of the injection unit and the mold technology.

The MIM/CIM equipment options from WITTMANN BATTENFELD

- » Injection unit with anti-wear coating for screw and barrel
- » Screw with optimized geometry
- » Check valve adapted to feedstock
- » Position control for the screw
- » Longer barrel nozzle with additional heating zone
- » Temperature control inside the feed zone of the barrel
- » Small-volume material hopper with anti-wear coating
- » Program "ejection with open machine door" for manual parts removal
- » Temperature controller for mold tempering
- » Vacuum pump integrated in the machine frame, incl. interface and software
- » "Mold evacuation" program
- » Expert Coining – injection embossing in combination with ejector or core pull
- » Automation equipment for parts removal
- » (MIM/CIM parts must not be demolded in free fall after injection molding, due to the brittleness of the green bodies.)

THE PIM MACHINE EQUIPMENT PACKAGE

Technology matured over the years

Wittmann



PIM

The highlights

» **Wear-resistant plasticizing unit**

The plasticizing system is subject to special strain from abrasion and adhesion due to the use of compounds containing up to > 70 % metal powder (MIM) or ceramic powder (CIM). For processing such feedstocks, all metaliferous components of the plasticizing aggregate are equipped with special anti-wear features such as bi-metallic barrels, screws made of abrasion-resistant steel alloy and a check valve geometry specially adapted to processing powder injection molding melts.

» **PIM check valve**

The check valves are particularly exposed to abrasive strain. Therefore they are made extremely wear-resistant and adapted to the specific flow attributes of the feedstock processed. The geometry of the screw tip and shut-off ring is a finely balanced compromise between a large flow cross-section and repeatable closing behavior.

» **Longer barrel nozzle**

To minimize flow paths and the associated pressure losses, longer, temperature-controlled machine nozzles are available for the barrel as an option. Especially in processes involving multi-cavity molds, the nozzles which enter the molds reduce the necessary shot volume during production and the sprue scrap for recycling after production.

» **Mold-media interfaces**

The standard equipment of MIM/CIM injection molding machines is adapted to the normal process media requirements for injection molding machines according to general experience. Optional extras besides the standard equipment are additional mold cooling circuits, a vacuum connection and connections to the hydraulic core-pull system, as well as electrical interfaces for limit switches and sensors.

» **Vacuum pump (optional)**

Injection into an evacuated mold cavity is an essential prerequisite to ensure even filling of the cavity without air pockets. Additional benefits are better sealing at the points of contact between flow fronts and minimization of segregation of binder from powder with resulting inhomogeneity of the material composition in the green body.

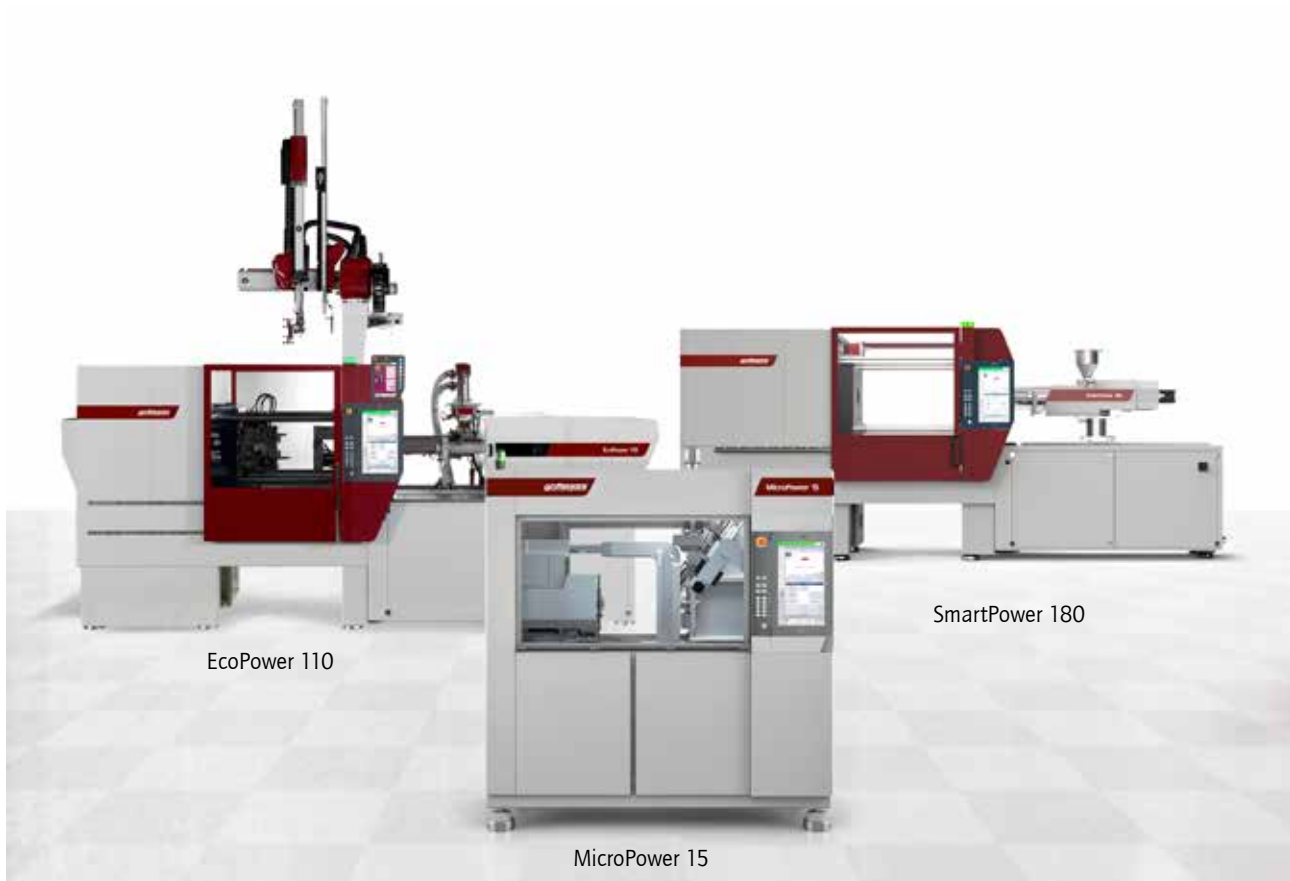
ALWAYS THE RIGHT MACHINE

MicroPower, SmartPower and EcoPower in the PIM-trim

For processing metal and ceramic powders, a wide range of specially adapted machines is available, based on the MicroPower, SmartPower and EcoPower machine series.

- » **MicroPower**
All-electric micro injection molding machine in clamping force size of 15 t
- » **SmartPower**
Servo-hydraulic all-round injection molding machine in clamping force sizes ranging from 25 to 400 t
- » **EcoPower**
All-electric, high-precision injection molding machine in clamping force sizes from 55 to 550 t
- » **Medical**
All LIM injection molding machines can also be delivered in a Medical version for clean room production (see special brochure WITTMANN BATTENFELD "Medical").

(* theoretical shot volume)



PIM APPLICATION TECHNOLOGY

A competent network of partners

Wittmann

WITTMANN BATTENFELD is not only a machine manufacturer, but, as part of a competence network, also offers solutions for application technology, selection of materials, feedstock development or prototyping in connection with mold design and construction.

Partner network

- » **Selection and handling of powder**
 - feedstock development
 - debinding technologies
 - sintering processes
 - downstream and surface finishing
 - pilot production possible

- » **Questions of materials and process technology**
RHP-Technology GmbH, Seibersdorf, AUT

- » **Mold construction**
Ernst Wittner GesmbH, Vienna, AUT
 - Mold making for MIM/CIM injection molding
 - Mold making for micro parts
 - High-precision finishing



Photo: CeraMedical GmbH

UNILOG B8

Control and process monitoring

The Unilog B8 machine control system is the WITTMANN BATTENFELD solution to simplify the operation of complex processes. To this end, the integrated industrial PC has been equipped with an enlarged, intuitive touch screen operating terminal. The visualization terminal is the interface to the new Windows® 10 IoT operating system, which provides extensive capacity for process control. In addition to the pivotable screen unit, a fixed panel/manual operating terminal is built into the central console of the machine.



The WITTMANN BATTENFELD Unilog B8 machine control system with its clear and largely self-explanatory logic offers a high level of operating comfort. This comfort is further enhanced by the option of displaying two segments of an injection molding process simultaneously.

» **Manual parts removal**

With the help of this option, which enables the release of the ejector and the core pull movements while the machine's front safety gate is open, the green bodies, which have not yet reached their final strength, can be removed from the mold without using automation.

» **Injection embossing – Expert Coining**

Due to its relatively high viscosity and low wall adhesion, the feedstock shows a tendency towards open jet formation during injection. To remedy this, temporary bottlenecks are created inside the cavities during the injection process by movable mold inserts or ejectors being pushed forward. To trigger these movements, core pulls are used in combination with injection embossing control.

General facts and figures about the WITTMANN BATTENFELD control system can be found in the special "Unilog B8 control system" brochure.

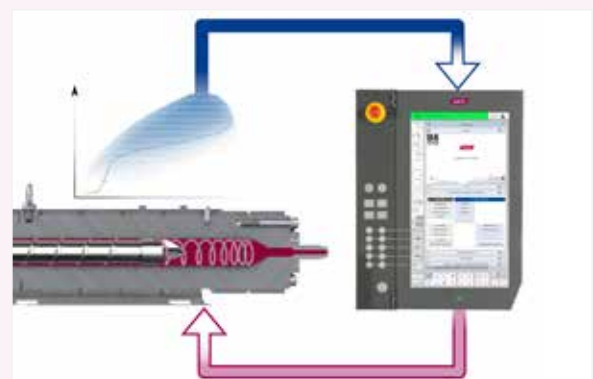
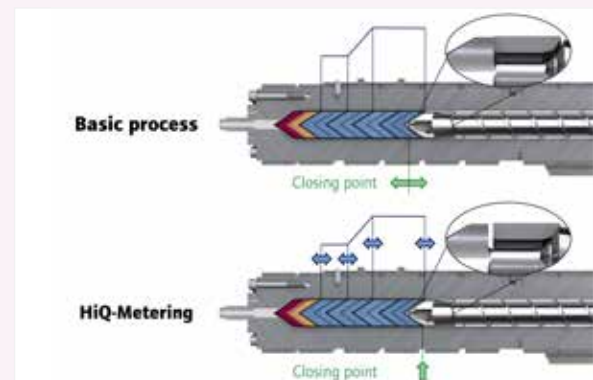
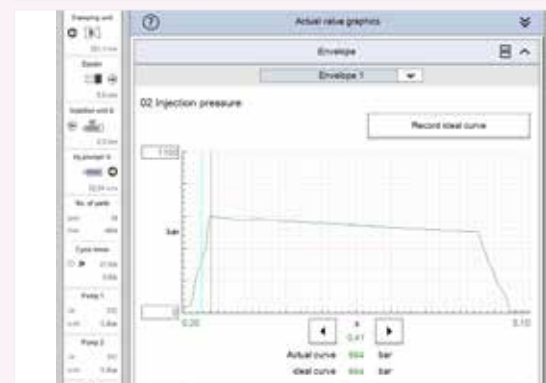
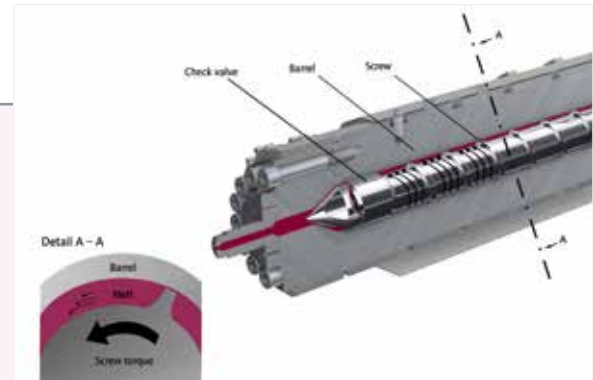
Like all other injection molding machines from WITTMANN BATTENFELD, the MIM/CIM injection molding machines can also communicate via the optional Wittmann 4.0 data exchange system internally with WITTMANN auxiliary appliances and via a specifically allocated IP address with external communication devices or production host computers as well.

HIQ-SYSTEMS

Controlling complex processes

Wittmann

- » **HiQ Melt: material quality monitoring**
HiQ Melt is a method of monitoring the material quality. The measured value is the amount of energy input in the plasticizing process. It is measured via the screw torque along the plasticizing stroke, shown as a value figure and monitored within a preset tolerance margin. This enables simple and easily understandable detection of deviations in material quality.
- » **HiQ Packing: continuous cavity filling via switch-over to holding pressure**
Injection molding to process metallic and ceramic feedstock requires a specific pressure curve to prevent inhomogeneity in the molded part. The HiQ Packing program supports continuous cavity filling beyond switchover to holding pressure, which is an essential prerequisite for high-quality green bodies free of cracks.
- » **HiQ Metering: balancing of the changeover point**
Between metering and the decompression stroke, the locking ring is released and brought into the "closed" position by targeted movements of the screw. So the check valve is already in the closed position before the start of the injection phase. Even minimal metering endpoint deviations are compensated by shifting the injection profile and the changeover point. This ensures that precisely the required quantity of material is injected with every shot with the result of absolute consistency in part weights.
- » **HiQ Flow: material viscosity-based injection control**
HiQ Flow uses the melt compressibility and the pressure data from the injection curve to calculate a parameter proportional to the component weight, the so-called **SMUV** injection volume (**SM**art **U**ncompressed **V**alue). The pressure and stroke data are recorded and the **SMUV** volume is calculated every 2 milliseconds along the injection stroke. The calculated **SMUV** volume is used to control the switchover point and/or the holding pressure phase. External material data is not necessary, since all necessary material parameters are determined during a production cycle. Viscosity fluctuations due to, e.g. the use of regrind or batch fluctuations can thus be compensated for and enable robust production and component quality



APPLICATION TECHNOLOGY

PIM injection molding

» Ceramic micro parts

The variety of micro parts made of ceramics is great. It ranges from medical technology components to small parts for thermal and electrical insulation in apparatus engineering and electronics. The WITTMANN BATTENFELD MicroPower injection molding machines are suitable for making all molded parts weighing less than 1 gram per unit.



» MIM parts for medical technology

Parts produced by the MIM process give manufacturers an extensive scope for parts design.

The possibility to form stainless chromium steel by a MIM process offers enormous advantages especially in medical technology.



Photo: RHP und HINMICO (EU-Projekt)

» Ceramic mass-production applications

One field of application with future potential is mass-production injection molding of ceramic parts, such as grinders in coffee machines, cogwheels or salt and pepper mills. The basic tools for competitive manufacturing of such products are machines from the SmartPower and EcoPower series with PIM equipment packages.



» **MIM parts in micro dimensions**

Injection molding and subsequent sintering offers cost advantages compared to mechanical or additive production above all for large batches, especially where parts in micro dimensions are concerned. With MicroPower injection molding machines, WITTMANN BATTENFELD offers the right basic equipment for this purpose.



Photo: Fraunhofer IFAM

» **Chipping tools**

Injection molding and subsequent sintering has established itself as an effective method of mass-producing high-precision tools for machining of metals. As examples, especially the hard metal versions of the following tools should be mentioned: milling cutters, drills and cutting inserts.



» **High-precision parts**

Machine components such as parts of electric motors demonstrate the rationalization potential of the PIM process. The functionality details integrated in these parts could only be produced by mechanical methods at enormously greater expense.



The Wittmann logo is located in the bottom right corner of the page. It consists of the word "Wittmann" in a white, italicized, sans-serif font, set against a dark red, rounded rectangular background.

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